MARLBOROUGH DISTRICT COUNCIL

State of the Environment Surface Water Quality Monitoring Report

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Executive Summary

There are 54 river and stream sites that are monitored to assess the state of water quality in Marlborough's surface waters. Of these 34 are monitored on a monthly basis for a variety of physical/chemical parameters and 51 are monitored annually for macroinvertebrates. Twenty of the sites have a telemeted flow station either at the site or in the near vicinity, such that flow data can be used to interpret the results of the physical, chemical and biological data. The catchment in which the sites are located range from 100% indigenous forest to 100% urban environment.

Water quality results from 2007-11 are analysed to assess the current state of water quality at each of the sites. Sites are compared using box plot analyses and are compared against relevant guideline values. Water quality from each site is summarised and a water quality index and/or biotic index is calculated. A water quality grade is then determined based on the calculation for each site. Sites are graded along a continuum of: Excellent-Good-Fair-Poor-Very Poor.

Water quality is assessed against various catchment characteristics as described in the Freshwater Ecosystems of New Zealand (FENZ) Geodatabase (Leathwick *et al.*, 2010). Poor water quality was found to be highly correlated with the increasing percentage of pastoral land in the catchment, in addition water quality deterioration was shown to accelerate when more than a quarter of the catchment was in pastoral land. Springs such as Spring Creek, Murphys Creek and Mill Stream have better water quality than would be expected given the surrounding land use because of the buffering effect from groundwater. However these streams are still susceptible to deterioration in water quality from the input of sediment from stream bank erosion and/or runoff from the surrounding land and *E. coli* where stock have from direct access to the waterway. Promoting riparian management in the form of fencing and/or planting is a common and known way to improve water quality and may be especially beneficial to spring fed streams.

Half of all monitored sites were graded as 'Excellent' or 'Good' using the water quality index and a further 20% were graded as 'Fair'; whilst approximately 70% of sites were graded as 'Excellent' or 'Good' using the biotic indices (MCI and SQMCI).

Trend analysis was carried out for 24 sites; all of these sites had at least 45 samples over a 5 year period (i.e. from 2007 to 2011). There was a significant reduction in nitrates at a number of sites across the region; however there was also a significant increase in phosphorus concentrations and *E. coli* numbers across the region.

Contents

1. Introduction

Surface water sampling of rivers and streams is carried out in order to assess the current state of water quality in our surface waters and to allow for changes or trends in water quality to be detected over time. Monitoring water quality for the region is a requirement of the Resource Management Act (RMA) 1991. Regional Plans must be consistent with the RMA. Monitoring and reporting on water quality for the region helps inform our Regional Policy Statement and Resource Management Plans. Our policy and plans serve to manage our water resources in a sustainable way. Monitoring and reporting on our water quality also allows us to: 1) assess the effectiveness and efficiencies of our plans and policies; 2) to identify degraded water bodies which require active management; 3) to identify rivers and streams at risk of deterioration and 4) to ensure water quality is maintained in a 'good' state where appropriate. Currently there are two monitoring programmes which assess surface water quality in Marlborough, these are;

1. State of the Environment (SoE) surface water quality monitoring
2. Recreational water quality monitoring

Each of these programmes have been set up with specific objectives. These objectives determine the frequency, type and location of monitoring that is required. This report discusses the objectives and analyses the results of the State of the Environment (SoE) surface water quality monitoring programme. Details of the recreational water quality monitoring programme can be found in the report 'Marlborough's Freshwater Recreational Water Quality 2011-12'. The two **core objectives** of SoE monitoring are:

1. to define the state of water quality for the region
2. to detect changes in water quality for the region

SoE monitoring of surface waters in the region is based on dividing the region into water resource units; these units are primarily based on the hydrological catchments. A full description of the water resource units used to establish the surface water quality monitoring is given in '*State of the Environment Surface Water Quality Monitoring Report, 2010'*, (MDC, 2010).

Seventy two water resource units (WRU) have been identified in the region (Appendix 1). Water quality is monitored for 54 WRU's, covering a broad range of catchment types and developments, from pristine native bush catchment to 100% urbanised catchments. Monitoring consists of monthly monitoring of physical/chemical parameters at 34 sites and annual monitoring of macroinvertebrates at 51 sites. Two of the sites (on the Wairau River) are monitored by NIWA. Where possible, monitoring of biological, physical and chemical components are carried out at the same site.

This report analyses the results of monitoring from February 2007 to December 2011. Trend analysis has been carried out for sites that have 5 years of data. Monitoring based on WRU began in 2007 with 20 sites (two of which are monitored by NIWA), since then an additional 14 have been added to the network. Scarsbrook and McBride (2007) recommend 5 years as the minimum time period for carrying out trend analysis. Monitoring results are assessed against the relevant guidelines to determine the current state of water quality for the region. Water quality data is summarised and the sites scored and graded according to the water quality index devised for the region (MDC, 2010).

2. Sites Monitored

Monitoring occurs monthly for physical/chemical parameters and annually for biological (macroinvertebrate) parameters.

2.1. Marlborough's Water Resource Units

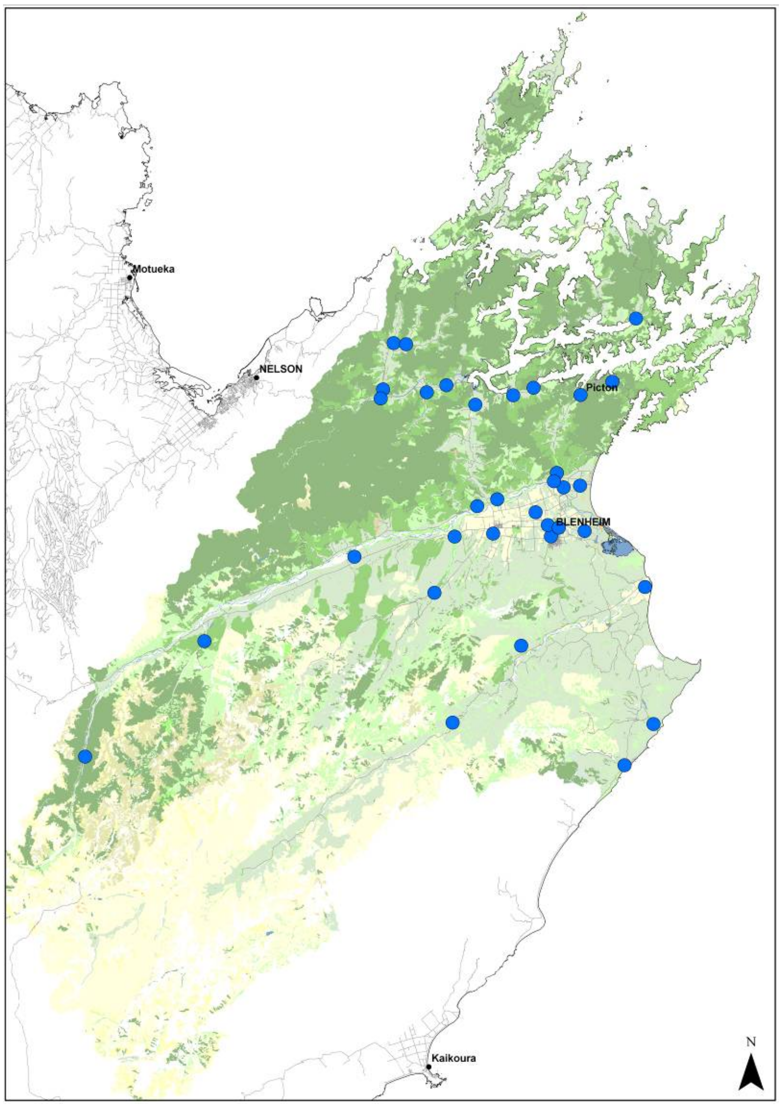
There are 72 water resource units (WRU's) used to assess surface water quality for the region. Appendix 1 lists each of the water resource units, the monitoring site associated with them and the characteristics of the catchment upstream of the monitoring site. These WRU's fall into nine geographical regions as shown in Table 1 and Appendix 1.

Table 1: Geographical regions of Marlborough based on water resource units.

Geographic Region	Description
Pelorus	High rainfall area, large areas of native forest. Dairying is main land use activity.
Marlborough Sounds	High rainfall, small order streams. Large areas of native forest. Pastoral and exotic forests.
Wairau	High rainfall and large areas of native forest in upper catchment. Pastoral farming, exotic forests and vineyards.
Waihopai	Dry, hill country, predominance of pastoral farmland, viticulture increasing in the region.
Omaka	Dry lowland area, dominated by vineyards.
Awatere	Dry mountain and hill country. Pastoral farming predominates, viticulture in the lower reaches.
South East Marlborough	Dry lowland areas, low order streams, sparse vegetation.
Clarence	Mountainous area, pastoral farming.
Small Coastal Catchments	No water catchments have been described in NIWAs database. Most likely ephemeral waterways predominate.

2.2. Monthly Monitoring

There are 34 sites that are monitored on a monthly basis (figure 1). A water sample is taken each month which is then analysed for its physical and chemical properties. Where possible these sites are located at the bottom of catchments and/or where flow monitoring is carried out. Flow information is central when interpreting water quality data, particularly when analysing trends over time and relative loads of contaminants. Two of the sites are monitored by NIWA; the Wairau at Dip Flat (WRR-6) and the Wairau at State Highway 1 (WRR-2). Data from the NIWA sites are supplied to the Council on an annual basis.



Site ID	Site Name	Easting (NZTM)	Northing (NZTM)
ARE-3	Are Are Creek	1668891	5409150
AWR-1	Awatere (lower)	1695945	5393096
AWR-3	Awatere at Awapiri	1660707	5368307
BBS-001	Black Birch Stream	1673268	5382346
BNR-1	Branch River upstream of Hydroelectric dam	1615310	5383200
CUL-3	Cullens Creek	1671802	5428178
DNC-002	Duncan Stream (Linkwater)	1675552	5429552
DRC-1	Doctors Creek	1678538	5403700
FLX-1	Flaxbourne at limestone quarry	1697479	5368033
GRR-001	Graham River at road bridge	1689949	5430629
KNR-1	Kenepuru upstream of NIWA flow site	1694287	5442220
KTR-005	Kaituna at Readers Road	1664877	5426463
MST-21	Mill Stream at flow site	1642747	5398630
MUR-1	Murphys Creek	1678585	5404340
OMR-1	Omaka River at Hawkesbury Road	1668150	5402871
ONR-1	Onamalutu	1665221	5407894
OPO-1	Opouri	1652204	5437502
OPR-1	Opawa at Swamp Road	1684887	5403319
OPR-3	Opawa at Hammerichs Road	1675898	5406769
PLR-4	Pelorus at Fishermans Flat	1659571	5430016
PLR-5	Pelorus at Kahikatea Flat	1647585	5427613
RAR-1	Rai at Rai Falls	1648018	5429266
RON-4	Ronga	1649966	5437711
SPC-1	Spring Creek at flood gates	1681052	5411335
TMR-1	Tuamarina at Wairau confluence	1680588	5412144
TYR-1	Taylor River at Riverside	1680148	5403948
WaiM	Waima upstream of SH bridge	1692178	5360509
WDV-1	Wairau Diversion at Neals Road	1684047	5411651
WHR-1	Waihopai at SH bridge	1661086	5402329
WHR-5	Waihopai at flow site	1657397	5392054
WKR-1	Wakamarina upsteam of SH bridge	1656011	5428720
WRR-2	Wairau at SH1 Bridge	1680623	5412041
WRR-6	Wairau at Dip Flat	1593486	5362089
WTS-009	Waitohi at SH1 bridge	1684133	5428227

Figure 1: State of the Environment surface water quality (physical/chemical parameters) monitoring sites.

2.3. Annual Monitoring

There are 51 sites that are monitored on an annual basis (figure 2). A macroinvertebrate sample and a habitat assessment are carried out at each of the sites at the time of monitoring. The habitat assessment incorporates elements of protocols 1 and 2 from the SHAP protocols (Harding *et al*., 2009).

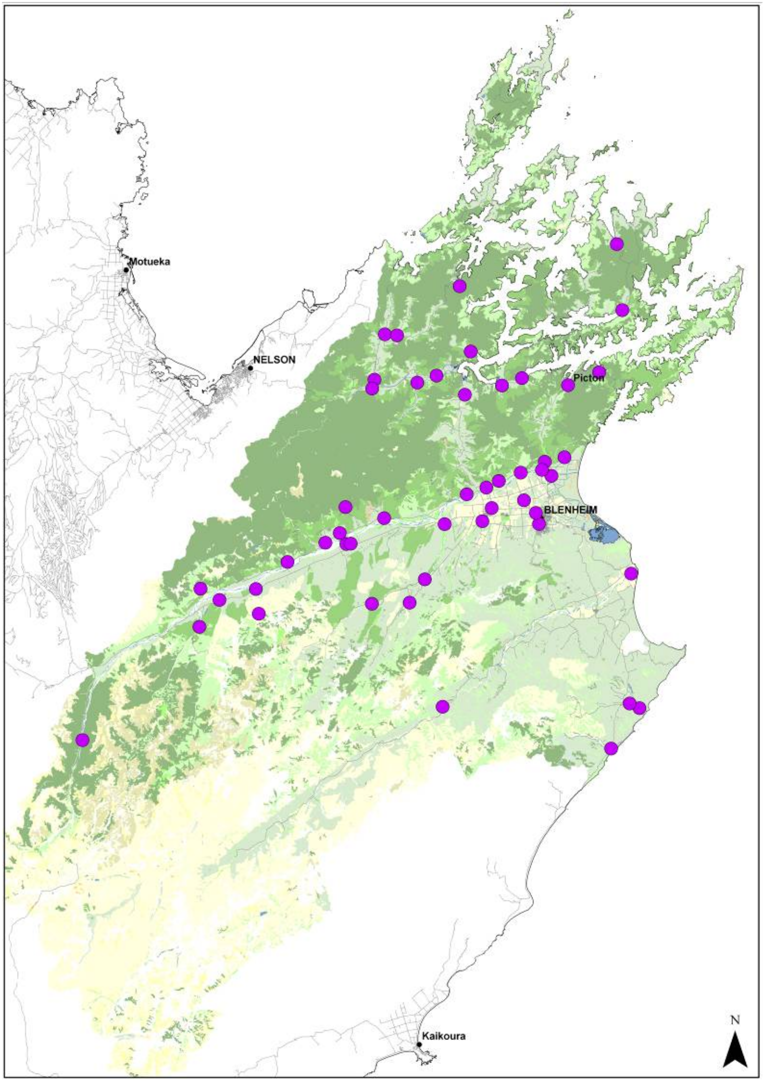


Figure 2: State of the Environment monitoring sites sampled annually. A macroinvertebrate sample and a habitat assessment are carried out at each site.

Site ID	Site Name	Easting (NZTM)	Northing (NZTM)
ANS-1	Anakoha Stream	1693260	5454525
ARE-3	Are Are Creek	1668891	5409150
AVR-1	Avon River	1654552	5387697
AWR-1	Awatere (lower)	1685073	5401815
AWR-3	Awatere at Awapiri	1660707	5368307
BBS-001	Black Birch Stream	1673268	5382346
BNR-1	Branch River upstream of Hydroelectric dam	1615310	5383200
BRC-1	Bartletts Creek	1649816	5403453
CTG-1	Cabbage Tree Gully Stream	1625856	5390229
CUL-3	Cullens Creek	1671802	5428178
DNC-002	Duncan Stream (Linkwater)	1675552	5429552
DNC-1	Duncan Bay Stream	1663894	5446691
DRC-1	Doctors Creek	1678538	5403700
ENS-1	Enchanted Stream	1631755	5395282
FLX-1	Flaxbourne at limestone quarry	1697479	5368033
GBC-1	Gibsons Creek	1669880	5405340
GLT-1	The Goulter River	1615505	5390310
GRR-001	Graham River at road bridge	1689949	5430629
KNR-1	Kenepuru upstream of NIWA flow site	1694287	5442220
KTR-005	Kaituna at Readers Road	1664877	5426463
KUS-1	Kaiuma Bay Stream	1665963	5434503
MST-21	Mill Stream at flow site	1642747	5398630
MUR-1	Murphys Creek	1678585	5404340
NED-3	Needles Creek	1695638	5368880
OMR-1	Omaka River at Hawkesbury Road	1668150	5402871
ONR-1	Onamalutu	1665221	5407894
OPO-1	Opouri	1652204	5437502
OPR-3	Opawa at Hammerichs Road	1675898	5406769
PLR-4	Pelorus at Fishermans Flat	1659571	5430016
PLR-5	Pelorus at Kahikatea Flat	1647585	5427613
PNV-01	Pine Valley Stream	1642598	5405503
PUK-5	Pukaka Stream	1683488	5414797
RAR-1	Rai at Rai Falls	1648018	5429266
RON-4	Ronga	1649966	5437711
SPC-1	Spring Creek	1681052	5411335
SWC-1	Salt Water Creek	1619068	5388223
SYC-1	Storeys Creek	1671220	5410389
TMC-1	Timms Creek	1641504	5400735
TMR-1	Tuamarina at Wairau confluence	1680588	5412144
TVR-1	Top Valley Stream	1638848	5398855
WaiM	Waima upstream of SH bridge	1692178	5360509
WHR-1	Waihopai at SH bridge	1661086	5402329
WHR-2	Waihopai River above Dam	1647510	5387498
WHR-5	Waihopai at flow site	1657397	5392054
WKK-1	The Waikakaho	1675301	5411934
WKR-1	Wakamarina upsteam of SH bridge	1656011	5428720
WRR-2	Wairau at SH1 Bridge	1680623	5412041
WRR-6	Wairau at Dip Flat	1593486	5362089
WST-5	Walkers Stream	1643573	5398609
WTS-009	Waitohi at SH1 bridge	1684133	5428227
WYE-1	Wye Creek	1626403	5385627

3. Results

A set of water quality parameters, which best define waterways and the health of waterways and which reflect human influence on water quality, have been chosen for analysis. A full list of the parameters analysed for on a routine basis is shown in Appendix 2. Temperature and dissolved oxygen measurements are carried out on site at all sites using a YSI meter. The YSI meter is calibrated prior to use on site on all occasions. A core set of water quality parameters are measured at all sites whist a sub-set are measured at a selection of sites where the risk of contamination is seen as moderate to high (metals) and where a greater understanding between surface water and groundwater interactions is required (ions). Twenty of the 34 monthly monitored sites also have flow measured at the site or in the vicinity of the site such that flow measurements can be used when assessing flow adjusted data for trends.

3.1. Physical/Chemical Parameters

Water quality data for 34 SoE sites from 2007 to 2011 (inclusive) was analysed using STATISTICA 7.0. Summary statistics for each parameter measured at each site are shown in Appendix 3. Some parameters, at some sites e.g. *E. coli* at Rai Falls have >48 samples due to the increased frequency of sampling associated with other programmes (e.g. bathing water sampling). In the absence of water quality standards the results are compared with various appropriate guidelines (Table 2) in order to place the results in context.

Table 2: Guideline values used to assess the state of surface water quality in Marlborough.

Parameter	Guideline Value	Purpose	Reference
Nitrate	1.7mg/L	Aquatic ecosystem toxicity	Hickey and Martin (2009)
	0.444mg/L	Prevent nuisance algal growth in lowland rivers	ANZECC (2000)
	0.167mg/L	Prevent nuisance algal growth in upland rivers	ANZECC (2000)
DRP	0.01mg/L	Prevent nuisance algal growth in lowland rivers	ANZECC (2000)
	0.009mg/L	Prevent nuisance algal growth in upland rivers	ANZECC (2000)
Ammonia	0.9mg/L*	Aquatic ecosystem toxicity	ANZECC (2000)
	0.021mg/L**	Lowland river ecosystem health	ANZECC (2000)
	0.01mg/L**	Upland river ecosystem health	ANZECC (2000)
E. coli	550 n/100mL	Contact recreation (action level)	MfE (2003)
	260 n/100mL	Contact recreation (alert level)	MfE (2003)
	126 n/100mL	Contact recreation (median level for surface waters)	McBride *et al.* (1991)
Turbidity	5.6 NTU	Lowland rivers	ANZECC (2000)
	4.1 NTU	Upland rivers	ANZECC (2000)
Suspended Solids	10 mg/L	Ecological guideline	CCREM (1991)
Dissolved oxygen	80% saturation	Ecological guideline	RMA (1991)
Copper	0.0014mg/L	95% protection of freshwater aquatic life (slightly to moderately disturbed systems)	ANZECC (2000)
Zinc	0.008mg/L	95% protection of freshwater aquatic life (slightly to moderately disturbed systems)	ANZECC (2000)

* The ANZECC guidelines specify a toxic guideline level of 0.9mg/L for total ammonia (NH_3 plus NH_4^+)
** In addition the guidelines give a limit for ionised ammonia ($NH4^+$) of 0.01mg/L for upland rivers and 0.021mg/L for lowland rivers for the protection of ecosystem health

An exceedance of a guideline does not always imply an effect; rather they are thresholds at which management options need to be considered to prevent further degradation of water quality.

3.1.1. Nitrate

Nitrogen is found in several different forms in surface waters, one of which is nitrate. Nitrate is a compound of nitrogen and oxygen ($NO3^-$). In well oxygenated waters nitrate is the dominant form of nitrogen. Nitrate concentrations in rivers typically show strong seasonal trends, being low in summer and high in winter. Nitrate concentrations are strongly correlated with the amount of pastoral land in a catchment, with increasing concentrations associated with increased pasture in the catchment. Nitrate is not readily adsorbed to particles and therefore excess nitrate on land will readily leach into surface waters.

Nitrogen is an important nutrient for plant growth and nitrate is the form in which it is most readily available to plants. This can be a problem when excess nitrate enters waterways causing excessive plant and algae growth. The ANZECC guidelines identify 0.167mg/L as the concentration above which nuisance plant growth will occur in upland rivers and 0.444mg/L as the concentration above which nuisance plant growth will occur in lowland rivers. Recent research has shown that nitrate toxicity for aquatic organisms can occur at levels above 1.7mg/L (Hickey and Martin, 2009).

The median, interquartile range, non-outlier range[1], outliers and extremes[2] for nitrate are shown in Figure 3. The relevant guideline values are shown to the right of the boxplot.

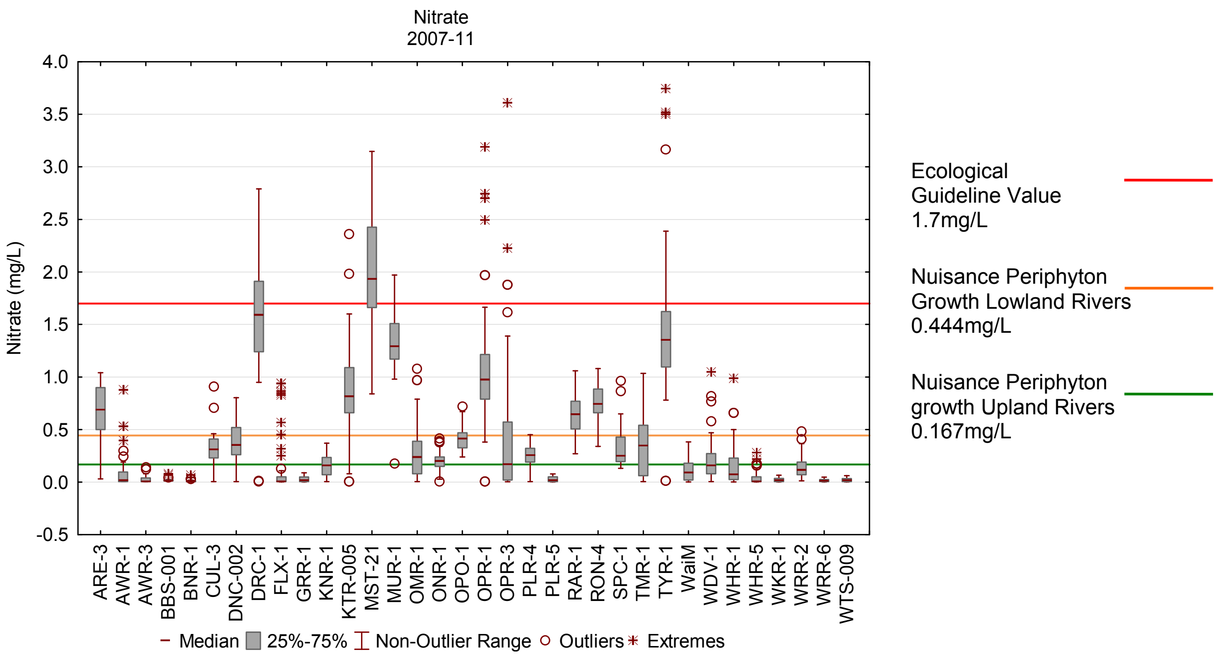


Figure 3: Boxplot showing the summary statistics for nitrate for the 34 monthly monitored SoE sites in relation to the relevant guideline values. Figure 1 gives the reference for each of the site IDs.

Doctors Creek and Mill Stream have the highest nitrate concentrations. Mill Stream and Doctors Creek are also two of the longest spring fed streams in Marlborough. Nitrate concentrations at these sites are consequently heavily influenced by groundwater nitrate concentrations. Groundwater in the Wairau Plains

[1] The non-outlier range is the range of values that fall below the upper outlier limit and above the lower outlier limit

[2] Values that are "far" from the middle of the distribution are referred to as outliers and extreme values. Outliers are atypical, infrequent observations; data points which do not appear to follow the characteristic distribution of the rest of the data. These may reflect genuine properties of the variable, or be due to measurement errors or other anomalies which should not be modelled. Typically, outliers represent a random error. Outliers not only artificially increase the value of a correlation coefficient, but they can also decrease the value of a "legitimate" correlation. The calculation is further defined in Statistica 7.0.

is important as a drinking water supply and thus must comply with the New Zealand Drinking Water Standards (NZDWS, 2005). The drinking water standard for nitrate is 11.3mg/L; the groundwaters of the Wairau plains generally comply with this standard. Groundwater nitrate concentrations within the drinking water standards but above the threshold for ecological toxicity (1.7mg/L) (Hickey and Martin, 2009) are a concern where groundwater quality determines the water quality of spring fed streams thereby influencing their life supporting capacity. Spring fed streams support a sensitive ecological community as water quality (in particular temperature and conductivity) tends to remain very stable; small changes in water quality can stress the aquatic life of spring fed streams. In such case in may be appropriate to define nitrate standards for groundwaters in relation to any spring fed streams.

Nitrate concentrations are also elevated in some agricultural catchments e.g. Are Are Creek, Kaituna, Rai and Ronga Rivers. The lowest nitrate concentrations are found in the Wairau at Dip Flat, the Branch River, the Waitohi River, the Wakamarina and the Upper Pelorus.

3.1.2. Dissolved Reactive Phosphorus (DRP)

In rivers and streams dissolved reactive phosphorus (DRP) is the most bioavailable form of phosphorus available to plants and algae and is the dominant form of phosphorus found in the water column. Whilst phosphorus is an essential nutrient for plant growth, an excess of it will lead to increased plant growth which can lead to algal blooms and eutrophication.

The amount of phosphorus in a riverine system is largely determined by the geology of the area. Rock weathering produces most of the natural phosphorus entering waterways. In soils, phosphorus will sorb to clay particles and organic material, thereby slowing its movement through the subsurface. Phosphorus enrichment of rivers and streams commonly occurs through diffuse sources such as fertiliser runoff from agricultural land and point sources such as wastewater treatment works and stormwater runoff.

The median, interquartile range, non-outlier range, outliers and extremes for DRP are shown in Figure 4. The relevant guideline values are shown to the right of the boxplot.

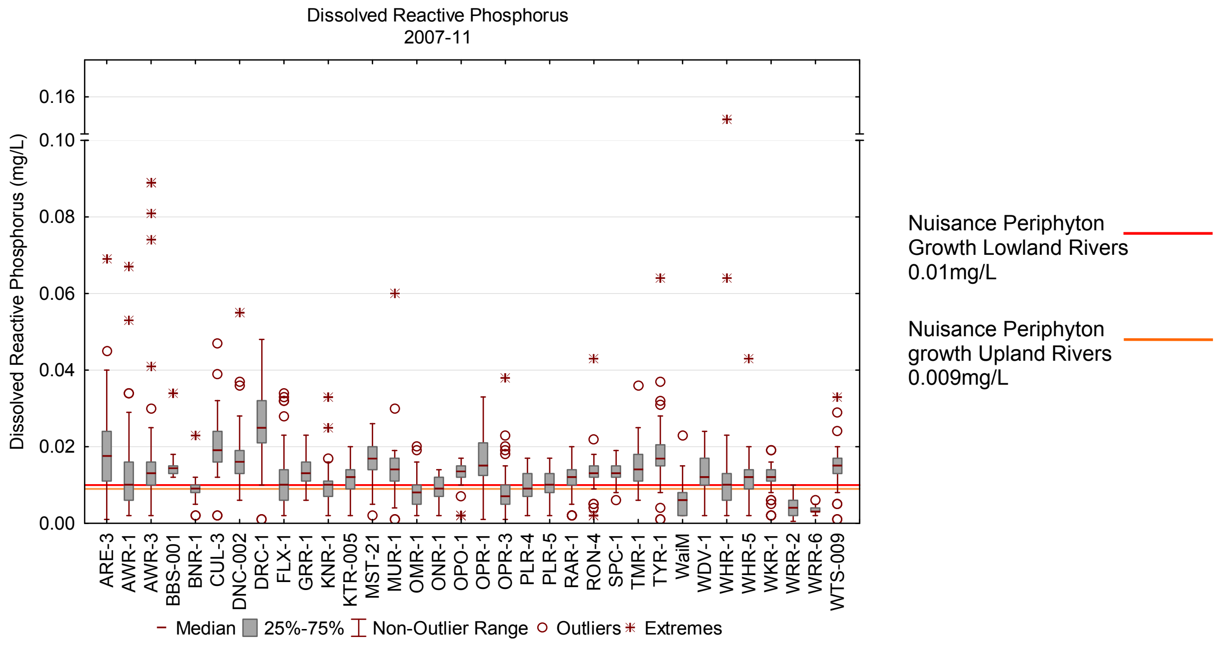


Figure 4: Boxplot showing the summary statistics for DRP for the 34 monthly monitored SoE sites in relation to the relevant guideline values. Figure 1 gives the reference for each of the site IDs.

Doctors Creek has the highest DRP concentration, followed by Are Are Creek, Cullens Creek, the Opawa River at Hammerichs Road, the Taylor River, Mill Stream and Duncan Stream (Linkwater). Extreme concentrations are recorded in the Awatere and the Waihopai. The extreme values at the Awatere at

Awapiri do not coincide with extreme values in the lower Awatere or with rainfall/flow. The extreme value recorded at the Waihopai at SH63 does not coincide with an extreme value further upriver but does coincide with heavy rainfall and high flows.

Twenty one of the thirty four sites had median concentrations above one or both of the guideline values (0.01mg/L and 0.009mg/L). Despite this it is difficult to say if all of these rivers experience nuisance algal growth as a result of elevated phosphorus levels. Lack of instream shading allowing more sunlight on the streams will also help drive plant and algal growth and therefore nutrient (nitrate and DRP) concentrations need to be correlated with other factors that contribute to algal growth (such as sunlight) in order to determine the real impact of elevated DRP concentrations at over 60% of monitored sites. As with nitrate, the lowest DRP concentrations are measured in the upper Wairau at Dip Flat (WRR-6).

3.1.3. Ammonia Nitrogen

The term 'ammonia' or 'total ammonia' refers to two chemical forms of ammonia that are present in water; the un-ionised ammonia (NH_3) form and the ionised ammonium form (NH_4^+). The ratio of the two forms is determined by temperature and pH, however the ionised form is generally the dominant form. River waters typically have a stable pH range of 6.5 to 8.5 whilst temperature increases from winter to summer and can range from 2^{o}C to 22^{o}C. The un-ionised form is the form which is more toxic to aquatic life. In well oxygenated waters ammonia is quickly converted by nitrifying bacteria to nitrite and nitrate, nitrate is the dominant form of nitrogen in surface waters. Ammonia is excreted by animals and is produced during the decomposition of plants and animals. Ammonia is also present in sewage, agricultural fertilisers, landfill leachate, storm water runoff, industrial wastewaters and runoff from animal feed areas.

The ANZECC guidelines specify a toxic guideline level of 0.9mg/L (95% protection level) for total ammonia (NH_3 plus NH_4^+). In addition the guidelines give a limit for ionised ammonia ($NH4^+$) of 0.01mg/L for upland rivers and 0.021mg/L for lowland rivers for the protection of ecosystem health. At normal river pH and temperature the majority of total ammonia will be in the ionised ($NH4^+$) form of ammonia and thus these upland and lowland river levels can be used for state of the environment purposes when assessing rivers against guideline values for the protection of aquatic life. The median, interquartile range, non-outlier range, outliers and extremes for ammonia are shown in Figure 5. The relevant guideline values are shown to the right of the boxplot.

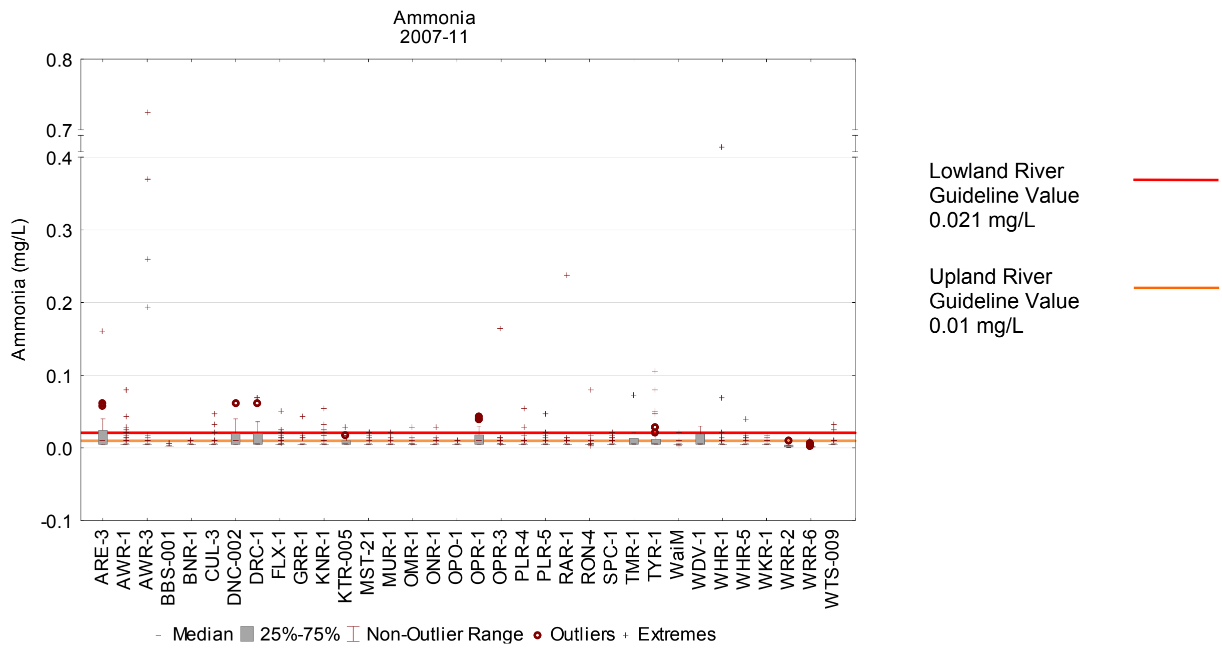


Figure 5: Boxplot showing the summary statistics for total ammonia for the 34 monthly monitored SoE sites in relation to the relevant guideline values. Figure 1 gives the reference for each of the site IDs.

Ammonia concentrations are low throughout the region and in most cases ammonia concentrations are recorded as being below the detection limit. This is a consequence of there being very few point source discharges of effluent to rivers and streams and a result of its rapid degradation in the environment in well oxygenated waters. The lowland river guideline (0.021mg/L) is rarely exceeded (<5% of samples). Figure 6 shows the number of times the lowland guideline was exceeded at each site (blue column) and the highest concentration recorded for that site (red column). The highest concentrations were recorded for the Awatere at Awapiri (AWR-3) and the Waihopai at SH 63 (WHR-1). The highest number of exceedances of the lowland guideline were for Are Are Creek (ARE-3) and the Opawa River at Swamp Road (OPR-1).

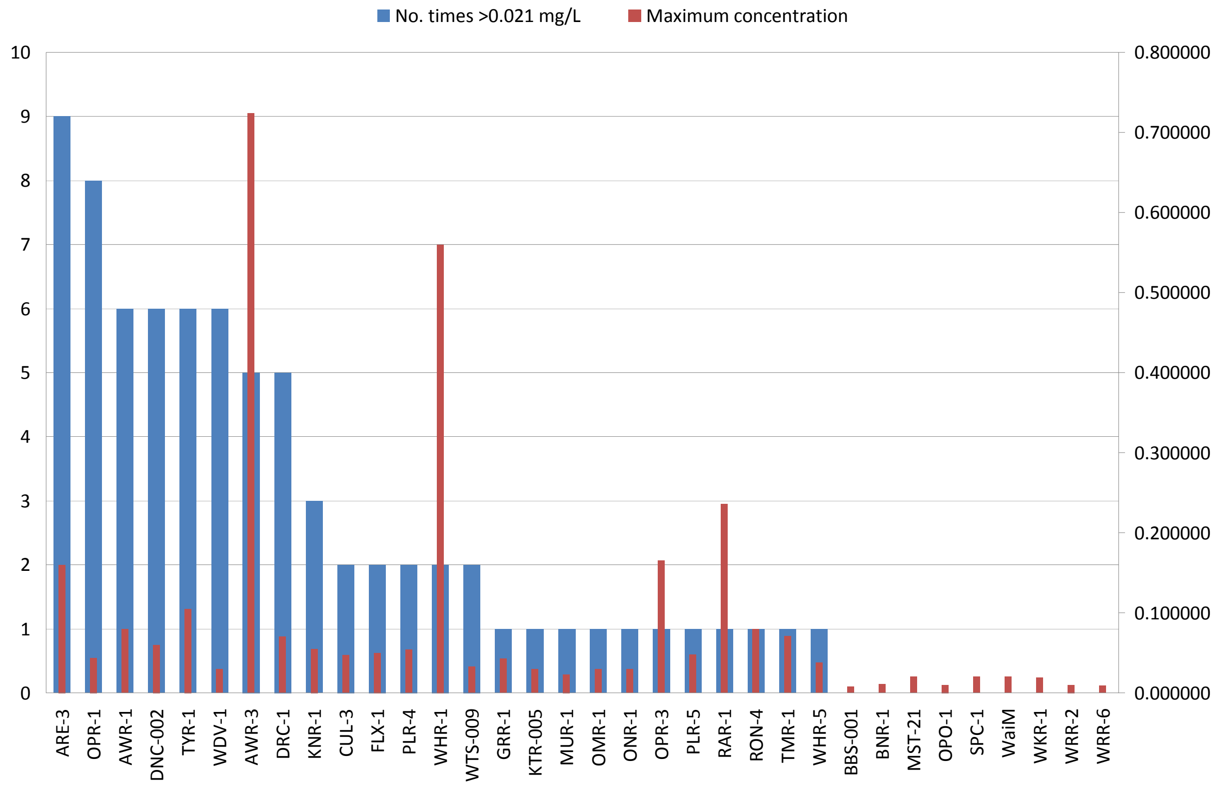


Figure 6: The number of times the lowland river guideline for ammonia was exceeded and the highest concentration recorded at each site.

3.1.4. E. coli

E. coli is a bacterium found in the gut of all warm blooded animals (including humans, mammals and birds). Its presence in water indicates the recent contamination of the water by faecal matter. *E. coli* will survive for a period of time outside the gut of warm blooded animals but cannot multiply in numbers; UV rays from sunlight will reduce their numbers over time.

The median, interquartile range, non-outlier range, outliers and extremes for *E. coli* are shown in Figure 7. The relevant guideline values are shown to the right of the boxplot.

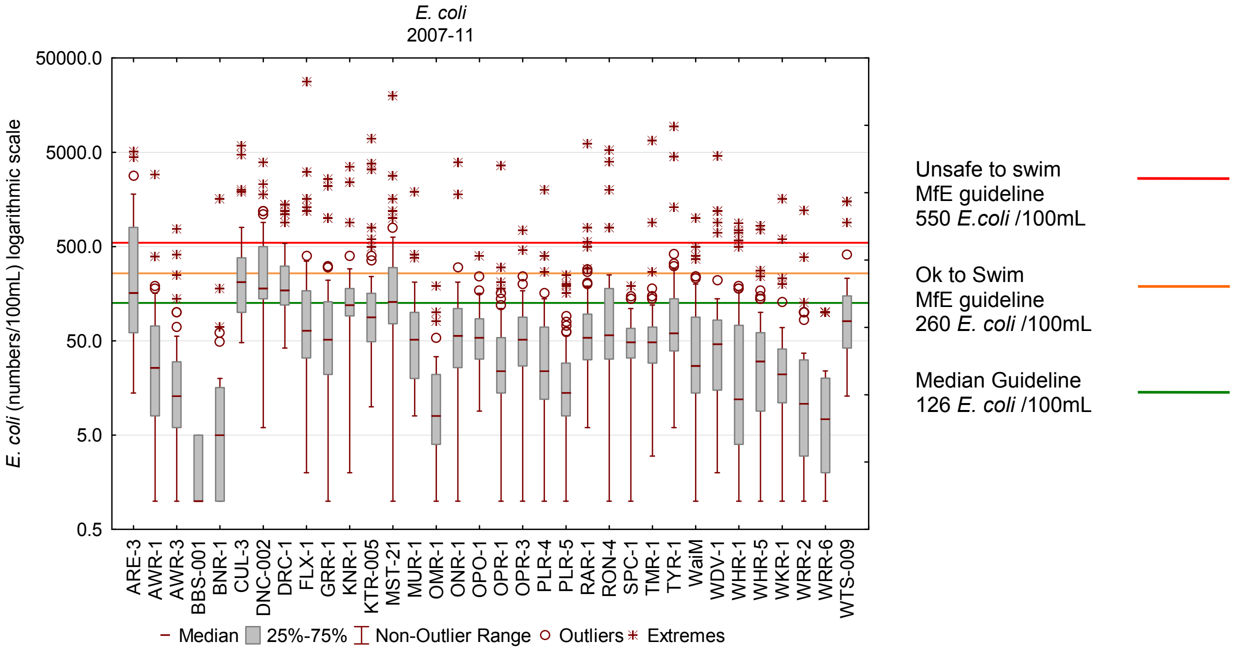


Figure 7: Boxplot showing the summary statistics for *E. coli* for the 34 monthly monitored SoE sites in relation to the relevant guideline values. Figure 1 gives the reference for each of the site IDs.

Rivers in lowland farmed areas and urban areas have the poorest water quality in terms of bacteria numbers, with numbers being particularly high during and after heavy rainfall (MDC, 2008, 2009). Rivers that exceed the median guideline of 126 *E. coli*/100mL include: Are Are Creek, Cullens Creek, Duncan Stream (Linkwater), Doctors Creek and Mill Stream. Rivers with the lowest numbers include the Awatere River, the Omaka River, Upper Pelorus and the Wairau. Extremely high numbers (>5000/100mL) have been recorded for Are Are Creek, Cullens Creek, Flaxbourne, Kaituna, Mil Stream, Rai, Ronga, Tuamarina and Taylor rivers.

3.1.5. Turbidity

Turbidity is an optical property that shows the amount in which light is scattered and absorbed by particles in the water. Turbidity is a good measure of water clarity with low levels reflecting good water clarity and higher levels indicating poorer water clarity. Turbidity in rivers can result from the input of fine sediments as a result of stream bank erosion, algal blooms and glacial/snow melt. Some rivers have naturally high turbidity e.g. rivers draining alpine or glacial wash areas, where large amount of fine sediment is eroded from the land and washed into the river. The Awatere River has naturally high levels of suspended sediment which results in high turbidity levels.

The median, interquartile range, non-outlier range, outliers and extremes for turbidity are shown in Figure 8. The relevant guideline values are shown to the right of the boxplot.

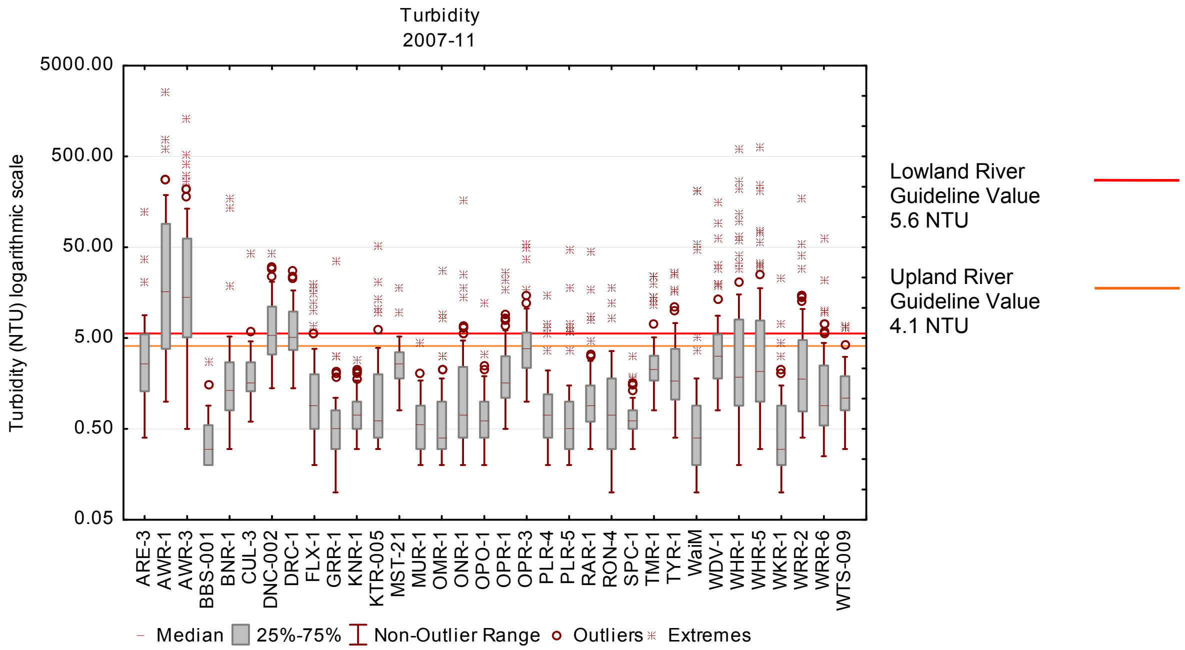


Figure 8: Boxplot showing the summary statistics for turbidity for the 34 monthly monitored SoE sites in relation to the relevant guideline values. Figure 1 gives the reference for each of the site IDs.

Rivers and streams in Marlborough generally have low levels of turbidity and consequently very good clarity with median levels for nearly 90% of monitored sites within the ANZECC guidelines for upland rivers.

The highest median turbidity levels (excluding the Awatere River) are recorded at Duncan Stream (Linkwater) and Doctors Creek. The lowest (90%ile < 2NTU) turbidity levels have been recorded at Spring Creek, Murphys Creek, Black Birch Stream, Kenepuru River, Opouri River and the Graham River.

3.1.6. Suspended Solids

Total suspended solids (TSS) are a measure of the mass of suspended material in a given volume of water. It is can be comprised of mineral matter (sediment or soil), phytoplankton, plant and animal debris. Suspended solids can transport contaminants, such as metals, toxicants and pathogens in rivers. High concentrations of suspended solids will absorb light and consequently increase water temperature. The higher the water temperature the less oxygen it can hold.

The median, interquartile range, non-outlier range, outliers and extremes for total suspended solids concentrations are shown in Figure 9. The relevant guideline values are shown to the right of the boxplot.

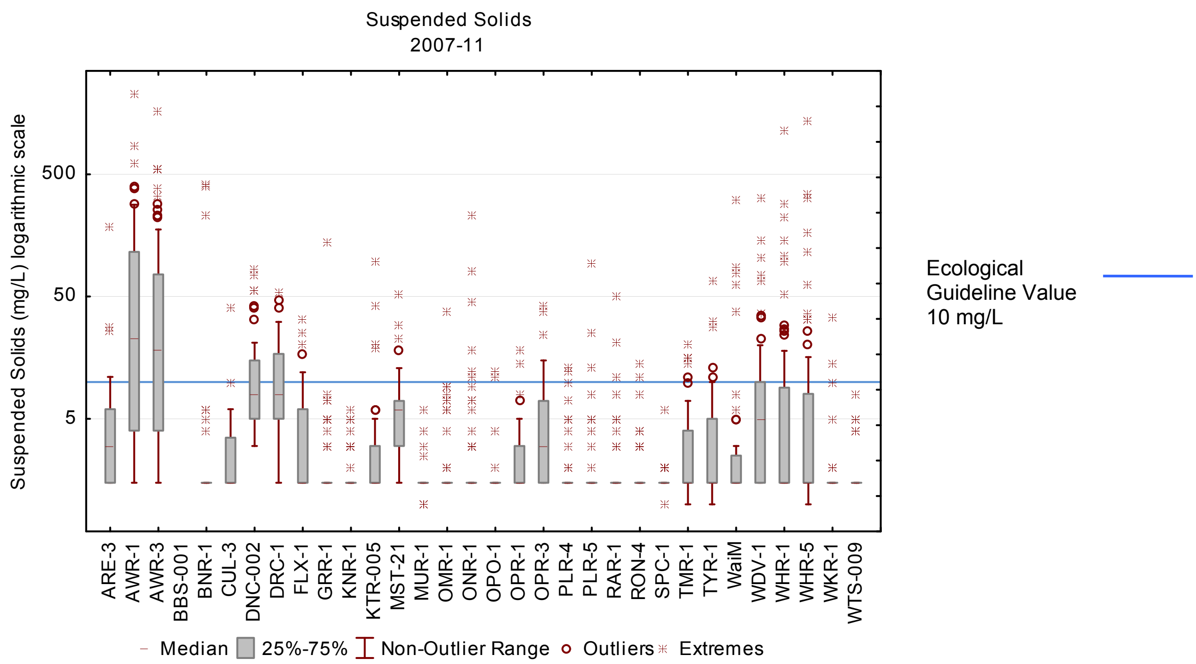


Figure 9: Boxplot showing the summary statistics for total suspended solids for 32 of the monthly monitored SoE sites in relation to the relevant guideline values. Total suspended solids are not routinely monitored by NIWA and therefore there is no data for suspended solids for the Wairau at Dip Flat (WRR-6) or State Highway 1 (WRR-2). Figure 1 gives the reference for each of the site IDs.

Suspended solids concentrations are generally low in the rivers and streams of Marlborough, with the exception of the Awatere, where levels are naturally high due to the geology of the catchment. Suspended solids concentrations are relatively high for Doctors Creek and Duncan Stream. Doctors Creek has a highly modified and cultivated catchment. There is little or no riparian vegetation along its length which makes it prone to bank erosion and sediment run-off from the surrounding land. The creek has little flushing capacity and so much of this sediment will remain in-situ, being periodically re-suspended resulting in poor visual clarity. Similarly the cutting down of riparian vegetation at Duncan Stream (Linkwater) to allow for a walkway and stream bank erosion from cattle access to the stream has resulted in increased suspended solids in the stream. Figure 10 shows the time series for each of these sites.

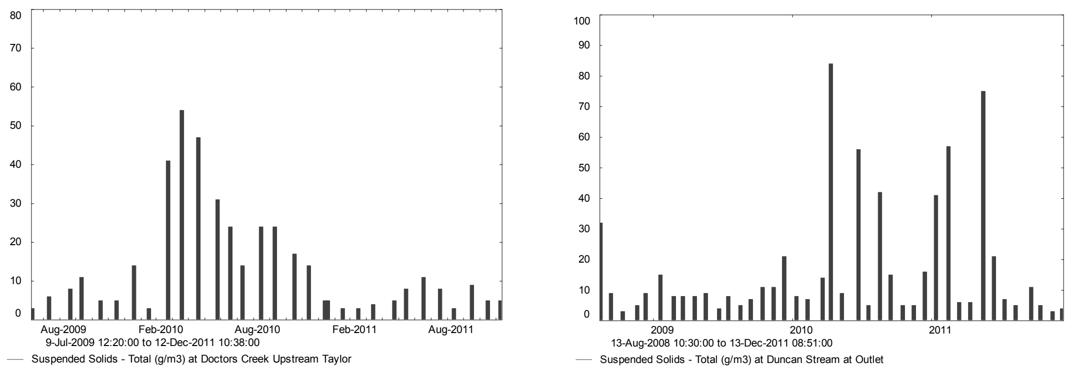


Figure 10: Suspended solids concentrations at Doctors Creek and Duncan Stream.

3.1.7. pH

Stream water usually ranges from a pH of 6.5 to a pH of 8 (ANZECC, 2000); this range is considered to be an optimal range for most aquatic life. The natural pH of a river will vary from river to river but the pH range of a river will generally remain stable. The ANZECC guidelines state that pH limits for individual rivers and streams should be set using the 20th and 80th percentiles based on seasonal medians of reference sites; changes of more than 0.5 from the seasonal minimum and maximums should be investigated (ANZECC 2000). The natural pH range of a river is largely determined by the geology and soils of the area, for example limestone areas will result in rivers and streams having naturally higher pH levels and peat areas will have naturally low pH levels. pH has a diurnal cycle i.e. it fluctuates between night and day as a result of plant respiration and photosynthesis.

The median, interquartile range, non-outlier range, outliers and extremes for pH are shown in Figure 11. Guideline values for pH have not been shown on the plot as guidelines for pH are specific to individual water bodies i.e. some water bodies have a naturally high pH e.g. the Waima, Awatere and Flaxbourne rivers due to the geology of the area, whilst other water bodies can have a low pH e.g. some areas of the west coast have naturally low pH values, as low as 4 due to humic acids or young sedimentary geologies with a pyrite component (WCRC, 2005).

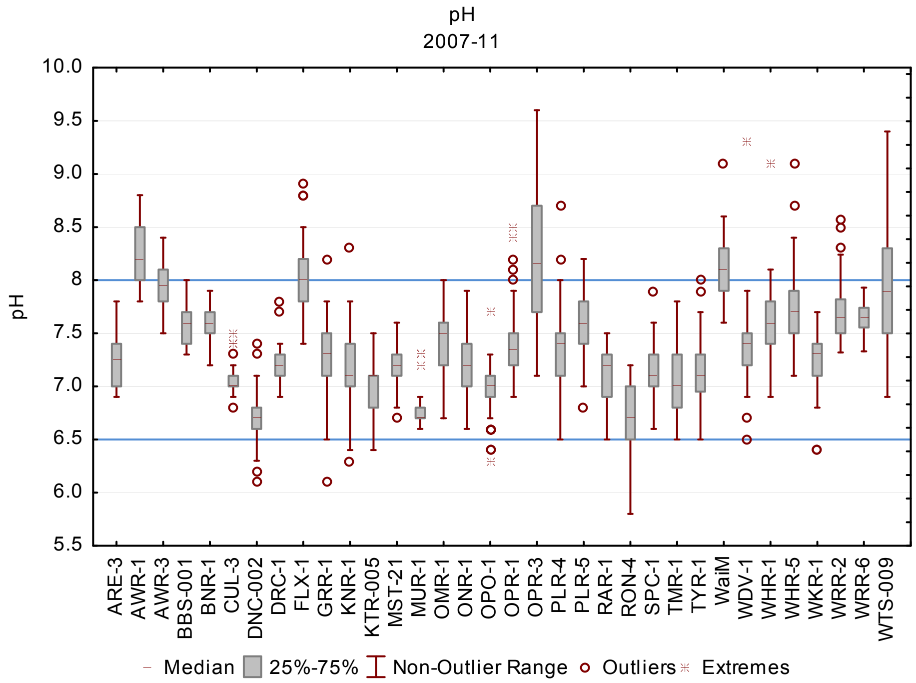


Figure 11: Boxplot showing the summary statistics for pH for the 34 monthly monitored SoE sites. Figure 1 gives the reference for each of the site IDs. The blue bands depict the 'normal' range for rivers as defined by the ANZECC guidelines.

High pH values recorded from the Opawa and the Waitohi can not be completely explained by the underlying geology and anthropogenic influences may be influencing the pH of these rivers. For the Waitohi River, there appears to a pattern of pH increasing in the summer/autumn months and decreasing during winter. This may be a reflection of increased plant growth during the summer months.

3.1.8. Specific Conductivity

Specific conductivity is conductivity measured at 25°C. Conductivity is a measure of the ability of water to conduct an electrical current. The temperature of water influences the conductivity values with warmer waters having lower conductivity values; this is why conductivity is commonly measured at a standard temperature of 25°C; to allow for comparisons throughout the year and between different water bodies. Conductivity gives an estimate of the amount of dissolved inorganic solids such as chloride, sulphate, sodium, calcium etc. present in the water. The conductivity of a river will principally be determined by the geology and soils of the catchment through which the river flows. Catchments comprised of 'hard' rocks such as granite will have rivers with low conductivity values whilst catchments with 'soft' rocks such as limestone and clay soils will have higher conductivity values. The conductivity of a river will tend to remain within a specified range. Conductivity is often used as a surrogate for water pollution as a gradual increase in conductivity over time can be an indication of pollution. Urban runoff and industrial pollution are characterised by high conductivity. Organic compounds such as oil are not good electrical conductors and thus oil spills will tend to lower the conductivity of water. The median, interquartile range, non-outlier range, outliers and extremes for specific conductivity are shown in Figure 12. The Flaxbourne and the Waima have the highest conductivity, reflecting the soft sedimentary geology of the catchments. The lower Opawa and the Wairau Diversion have a high degree of variability reflecting the influence of saline water from the coast.

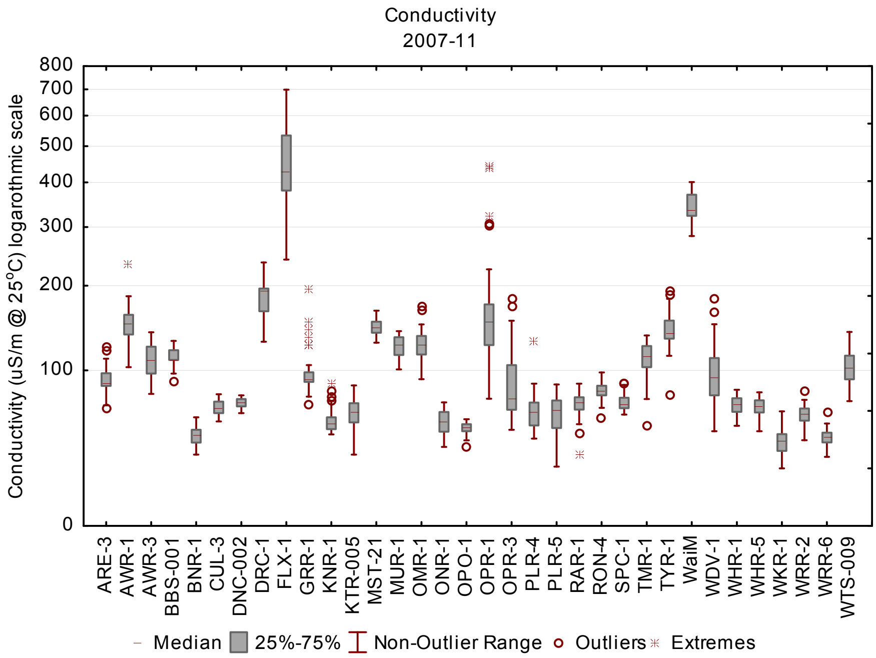


Figure 12: Boxplot showing the summary statistics for specific conductivity for the 34 monthly monitored SoE sites. Figure 1 gives the reference for each of the site IDs.

High rainfall and floods can result in reduced conductivity at some sites and increased conductivity at other sites e.g. floods lower conductivity in the Upper Pelorus and raise conductivity in the Opawa.

3.1.9. Dissolved Oxygen

Healthy aquatic ecosystems depend on a good supply of oxygen being dissolved in the water column. Faster flowing sections of rivers and streams will have better oxygenated waters than slow flowing sections of rivers or rivers that have been modified as straight channels. The amount of dissolved oxygen in the water is also dependent on temperature, with cooler waters having more dissolved oxygen than warmer waters. Spring fed streams will often have lower oxygen levels as the amount of oxygen dissolved in groundwaters will be less than that of surface waters. Aquatic plants will add oxygen to the water but their overabundance can lead to oxygen super saturation during the day and consequently very low levels at night when photosynthesis ceases but respiration (which uses oxygen) continues. This fluctuation in oxygen can stress the aquatic communities living there. A common cause of low oxygen waters is where organic material (from wastewater treatment works, agricultural runoff etc.) is added to the water. Bacteria break down this material and in so doing use up the available oxygen in the water to the extent that waters can become severely depleted of oxygen or anoxic. Whilst most species require well oxygenated waters in order to survive e.g. stoneflies are only found in cool, well oxygenated waters, some species thrive in low oxygen waters. The presence or the abundance of these species can be an indicator of organic enrichment.

The median, interquartile range, non-outlier range, outliers and extremes for dissolved oxygen are shown in Figure 13. The Resource Management Act (1991) stipulates a minimum saturation of 80% for good ecosystem function. Factors such as salinity, temperature, groundwater inflow, the presence of organic matter and plant life all have an influence on dissolved oxygen concentrations. Dissolved oxygen exhibits diurnal and seasonal variations in concentrations. In order to accurately assess the health of a river with regard to dissolved oxygen, continuous monitoring during the critical summer months when dissolved oxygen is likely to be at its lowest, should be carried out. Spot measurements, such as those carried out for the analysis in Figure 13 are a useful way of identifying where dissolved oxygen levels are likely to have a detrimental effect on aquatic life and where further more intensive monitoring can be carried out.

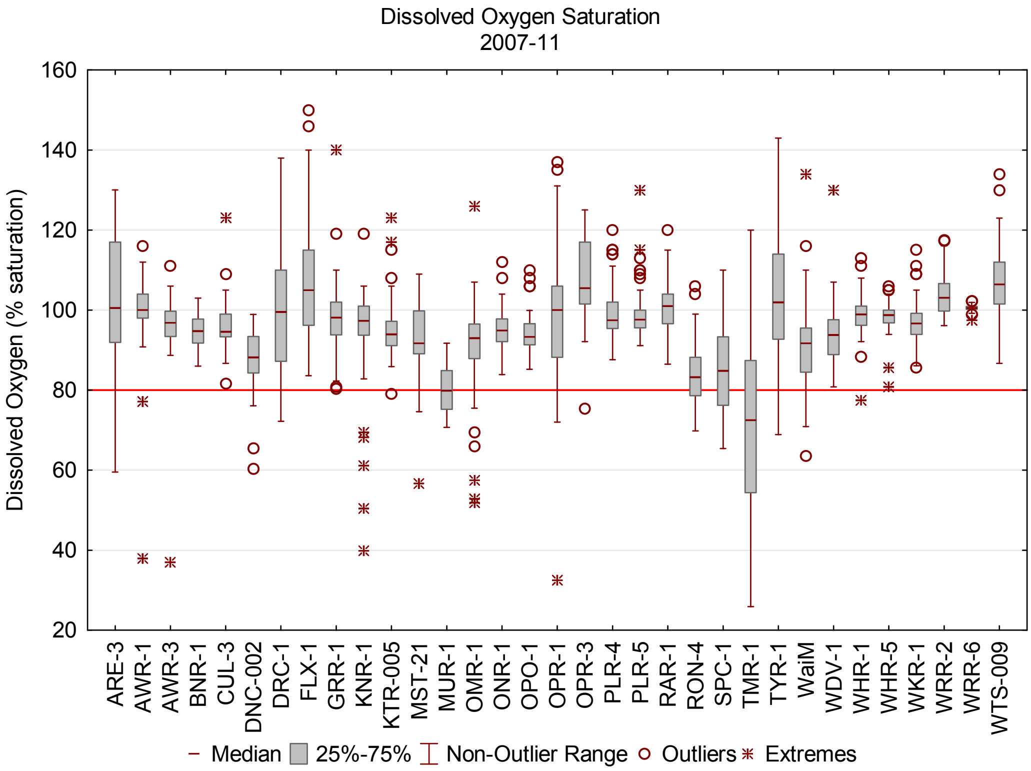


Figure 13: Boxplot showing the summary statistics for dissolved oxygen for 33 monthly monitored SoE sites. Figure 1 gives the reference for each of the site IDs. The blue band depicts the dissolved oxygen range expected for normal healthy rivers.

A narrow dissolved oxygen range such as that seen for the Waihopai River, the Wairau, the Wakamarina and the Opouri is a good indication that oxygen levels within the river are stable and thus unlikely to have a negative impact on aquatic life. Large dissolved oxygen ranges as seen for Doctors Creek, the Opawa, the Flaxbourne and the Taylor for example indicate the potential for the ecosystem to become stressed due to low oxygen levels, eventhough for the most part the concentrations lie within the normal range.

3.1.10. Temperature

The median, interquartile range, non-outlier range, outliers and extremes for temperature are shown in Figure 14. Temperature changes from season to season with warmer temperatures occurring in the summer months and colder temperatures during the winter months. Some of the factors that influence the degree to which temperatures increase in surface waters during the summer months include:

- Altitude; upland rivers and streams are generally cooler than lowland rivers and streams
- Degree of shading e.g. from riparian vegetation, cliffs, tall buildings etc.
- Groundwater inflow
- Substrate type and degree of exposure to sunlight e.g. gravels within a braided rivers system absorb and retain heat thereby acting as radiators heating up the surrounding water, fine sediment within a river or stream will act in much the same way.

The narrowest temperature range is observed in spring fed system where the temperature of the water largely reflects the temperature of groundwater e.g. Murphys Creek and Spring Creek. Some aquatic organisms such as stone flies, some mayflies and trout are sensitive to elevated temperatures and can become stressed or disappear completely where elevated temperatures persist. Elevated temperatures (above 20°C) are generally not a problem in Marlborough's rivers and streams.

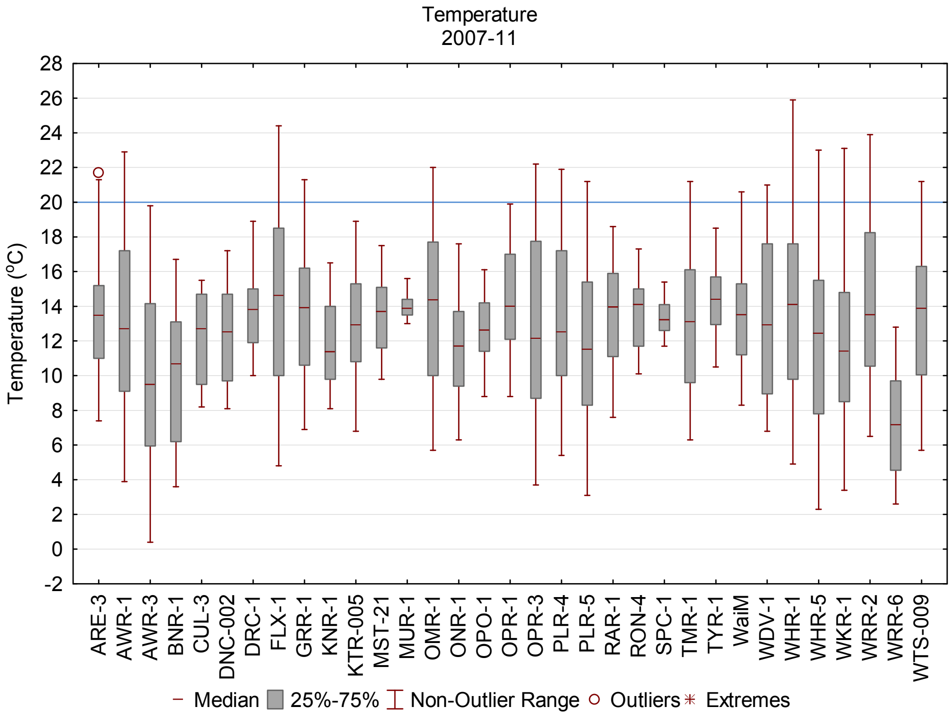


Figure 14: Boxplot showing the summary statistics for temperature for 33 monthly monitored SoE sites. Figure 1 gives the reference for each of the site IDs.

3.1.11. Metals

Copper, lead and zinc are three of the most common metal pollutants from runoff in urban areas of New Zealand (Zander, 2005), however lead concentrations are in decline due to the phasing out of lead based paints and petrol (Suren and Elliott, 2004). Vehicle brake emissions and buildings account for sources of copper whilst tyre wear and catchment roof run-off are common sources for zinc. Copper is also commonly used in horticulture as a pesticide. Arsenic has been found in some groundwaters in the Wairau plains and is mainly associated with current or historic wetlands where redox conditions cause it to become soluble. These same reducing conditions exist in deep aquifer systems beneath the Wairau Plains and it is likely that arsenic exists naturally in these groundwaters (Callander and Loomer, 2002; Robinson *et al.*, 2004). Arsenic is also commonly used for the treatment of vineyard posts. Vineyards now account for just less than 24,000 hectares of the Marlborough region. Copper, zinc and arsenic are analysed for at the following surface water monitoring sites:

- Are Are Creek ARE-3
- Doctors Creek DRC-1
- Murphys Creek MUR-1
- Opawa (upper) OPR-3
- Opawa (lower) OPR-1
- Taylor River TYR-1
- Waitohi River WTS-009

Both total and dissolved metals are analysed for completeness. The ANZECC guidelines do not specify the form (whether dissolved or total) to which the guidelines refer to, commonly it is the dissolved phase of a metal which can have the greater ecological impact, however measuring the total metal concentration gives a more complete picture of metal concentrations.

Results are shown in Appendix 4. Arsenic has not been recorded above the guidelines at any of the sites. Low concentrations of arsenic have been recorded from the Taylor River; the upper and lower Opawa; Are Are Creek and Murphys Creek.

Zinc has been recorded above the guideline at all monitored sites. Copper has been recorded above the guideline at all monitored sites with the exception of Murphys Creek. Figures 15 and 16 compare zinc and copper concentrations at the Blenheim sites.

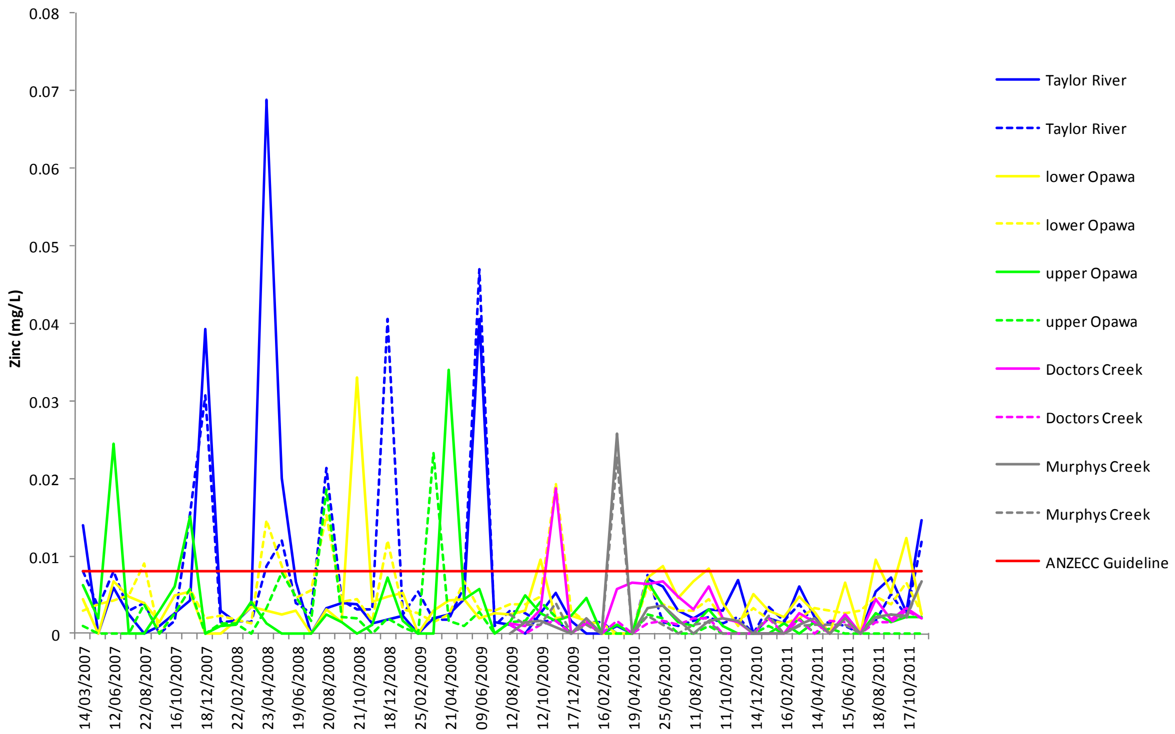


Figure 15: Zinc concentrations for the Blenheim sites. Total concentrations are shown as continuous lines and dissolved concentrations are shown as broken lines.

The highest recorded copper concentration (0.064mg/L) was from Doctors Creek on the 17th November 2009 (Figure 16). This coincided with a peak in zinc concentrations. The zinc guidelines are regularly exceeded in the Taylor River, the upper and lower Opawa and the Waitohi. Doctors Creek, Murphys Creek and Are Are Creek have exceeded the guideline on one occasion. On occasion the dissolved metal concentration is higher than the total metal concentrations. In most cases this is due to the different detection limits for the two test methods (detailed in Appendix 3) and the error associated with each test (approx. ± 10%). However there are occasions when the dissolved concentrations are significantly higher than the total concentrations. Due to the very low concentrations of metals in the water samples, it is possible that the samples could have been contaminated somewhere between taking the sample and analysing the sample at the laboratory. Filtering during the testing for dissolved metal concentrations can contaminate samples and may have been responsible for some of the anomalous results.

Copper concentrations have remained stable in the Taylor River, exceedances of the guidelines occur several times per year. Zinc concentrations appear to have dramatically declined from mid 2009 in the Taylor River, prior to August 2009 exceedances were common, since then there have only been two exceedances. This pattern is also seen in the upper and lower Opawa sites and the Waitohi Stream, where copper concentrations appear stable and zinc concentrations have declined dramatically.

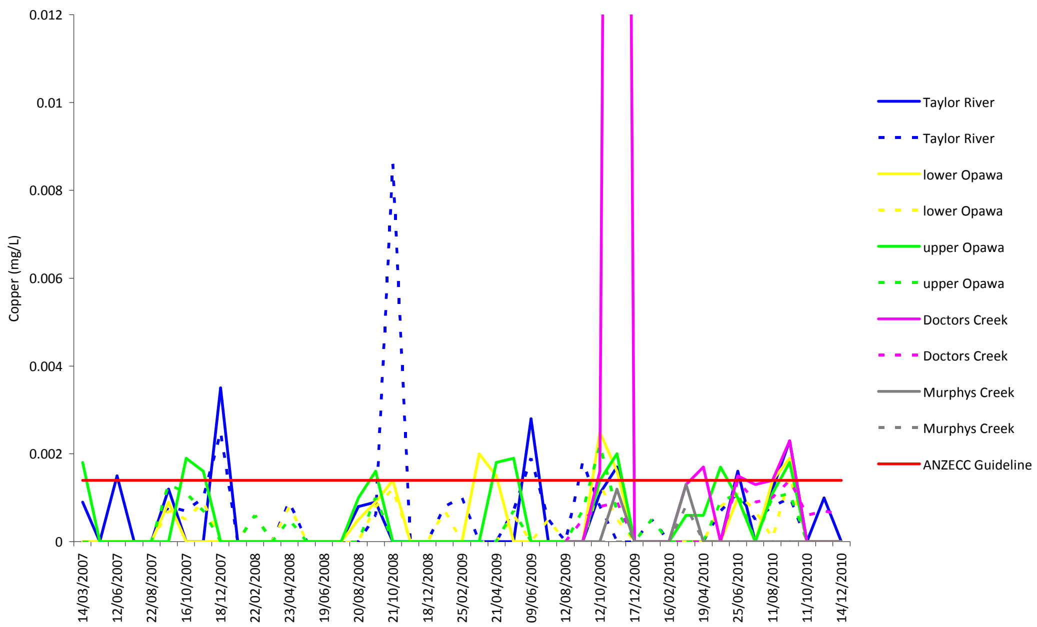


Figure 16: Copper concentrations for the Blenheim sites. Total concentrations are shown as continuous lines and dissolved concentrations are shown as broken lines.

3.2. Water Quality Index (WQI)

A water quality index is a way of summarising differing amounts and types of water quality data into a simple, single score. For example, the calculation of a single score can be based on results from 180 samples. By its nature the score is somewhat subjective but the derivation of the score is based on actual data and assessed against known quality criteria (guidelines). An index is most useful for comparisons, communications and general questions. More specific questions and decisions should be made based on the analysis of the original water quality data. The water quality index (WQI) presented here is unitless and ranges from 1 to 5. A higher number is indicative of poorer water quality. Limitations with using a WQI are 1) the index is based on a set of predefined water quality parameters and thus poor water quality as a result of a parameter that is not measured (or not incorporated into the index) will not be reflected in the WQI score and 2) because the score is an aggregation of data it can either mask or over emphasise short–term water quality problems. The derivation of the WQI is shown in Appendix 5.

Figure 17 shows the water quality index scores for the 34 sites and the corresponding category into which they fall. Half fall into the ‘Good’ or ‘Excellent’ categories, whilst about a quarter are classed as ‘Poor’ or ‘Very Poor’. Water quality data from 2007 onwards has been used in the derivation of the scores. In order to make comparisons between sites the number of samples per site must be comparable, therefore scores have been defined as complete or incomplete depending on the number of samples used to derive the score. A score is complete when at least 30 samples have been collected over a three year period. The calculation of the scores is shown in Appendix 6. Sites marked in grey (figure 17) have insufficient data to calculate a complete score; these scores are classed as interim until at least 30 samples over a 3 year period have been collected. Only 3 sites have interim scores; namely Black Birch Stream, Branch River and Cullens Creek.

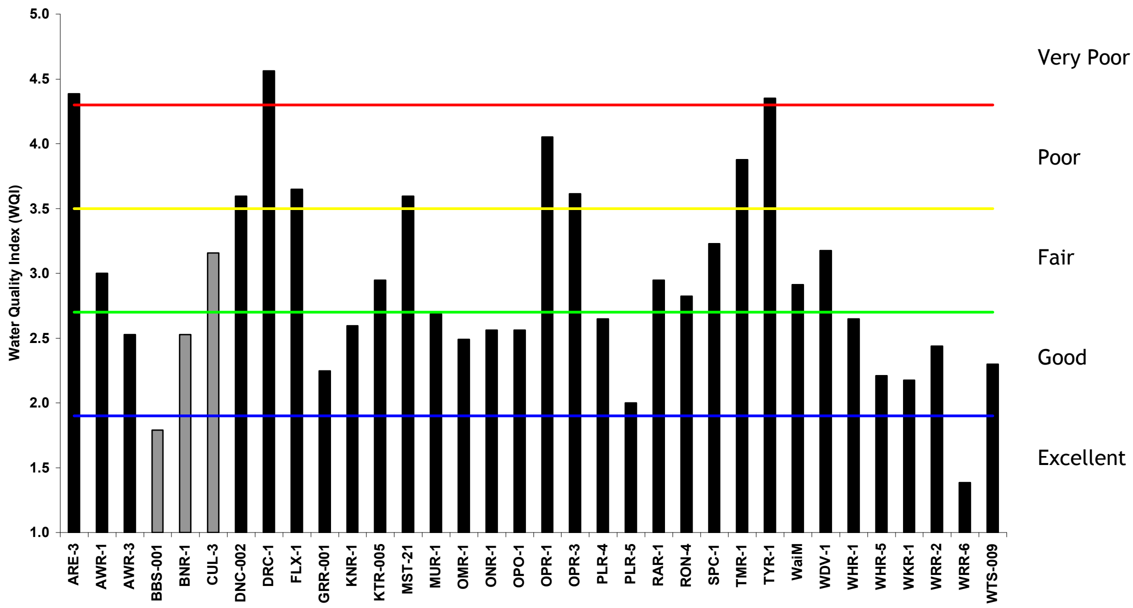


Figure 17: Water Quality Index scores for the 34 SoE sites based on data from 2007 to 2011.

Doctors Creek has the poorest water quality, followed by Are Are Creek and the Taylor River. The Opawa (both upper and lower sites), the Tuamarina, the Flaxbourne, Duncan Stream (Linkwater) and Mill Stream all have poor water quality. Table 3 compares the water quality index scores calculated over the last three years.

Table 3: WQI scores calculated in 2010, 2011 and 2012.

Site ID	WQI Score 2010	WQI Score 2011	WQI Score 2012	Score Change	Grade Change
ARE-3	3.7	4.1	4.4	0.3	**Poor → Very Poor**
AWR-1	2.7	2.7	3.0	0.3	No change
AWR-3	2.3	2.5	2.5	0.0	No change
BBS-001	n/a	1.9	1.8	-0.1	**Good → Excellent**
BNR-1	2.8	2.3	2.5	0.2	No change
CUL-3	2.6	3.0	3.2	0.2	No change
DNC-002	3.6	3.6	3.6	0.0	No change
DRC-1	4.1	4.5	4.6	0.1	No change
FLX-1	3.4	3.9	3.6	-0.3	No change
GRR-001	2.4	2.2	2.2	0.0	No change
KNR-1	2.9	2.6	2.6	0.0	No change
KTR-005	3.1	3.0	2.9	-0.1	No change
MST-21	3.1	3.1	3.6	0.5	**Fair → Poor**
MUR-1	3.3	2.9	2.7	-0.2	No change
OMR-1	2.5	2.5	2.5	0.0	No change
ONR-1	2.1	2.4	2.6	0.2	No change
OPO-1	2.2	2.2	2.6	0.4	No change
OPR-1	4.0	4.3	4.1	-0.2	**Very Poor → Poor**
OPR-3	3.6	3.6	3.6	0.0	No change

PLR-4	2.8	2.7	2.6	**-0.1**	**Fair → Good**
PLR-5	2.3	2.0	2.0	0.0	No change
RAR-1	3.0	3.0	2.9	**-0.1**	No change
RON-4	2.8	2.8	2.8	0.0	No change
SPC-1	3.0	3.2	3.2	0.0	No change
TMR-1	3.9	3.9	3.9	0.0	No change
TYR-1	4.3	4.1	4.4	**0.3**	**Poor → Very Poor**
WaiM	2.6	2.9	2.9	0.0	No change
WDV-1	3.4	3.1	3.2	**0.1**	No change
WHR-1	2.6	2.6	2.6	0.0	No change
WHR-5	2.2	2.2	2.2	0.0	No change
WKR-1	2.1	2.1	2.2	**0.1**	No change
WRR-2	2.4	2.4	2.4	0.0	No change
WRR-6	1.2	1.6	1.4	**-0.2**	No change
WTS-009	2.2	2.5	2.3	**-0.2**	No change

The change in water quality grade should be compared with statistical trends in water quality data for the site in order to correctly interpret the results.

3.3. Aquatic Macroinvertebrates

Aquatic macroinvertebrates are used worldwide for assessing water quality in rivers and streams. Their usefulness lies in the variety of species found and the relative tolerance of each species to different forms of disturbance, such as organic enrichment. Macroinvertebrates have relatively short life cycles and are relatively immobile and are therefore a good indicator of localised disturbance.

3.3.1. Sampling Methods

Aquatic macroinvertebrates are sampled annually at 51 sites in Spring/early Summer. Sampling occurs under stable flows, high and low flows are avoided. Sampling is carried out in stony riffle areas where possible. The substrate is disturbed upstream of the D-net for a period of 3 minutes. Samples are taken using Protocol C1 and analysed in the lab using Protocol P1 (Stark *et al*., 2001). The sample is then washed and sorted and stored in 95% ethanol before being transported to Stark Environmental Ltd for analysis.

3.3.2. Macroinvertebrate Indices

The Macroinvertebrate Community Index (MCI) and its quantitative variant (QMCI), used to assess organic enrichment in wadeable stony streams, was first proposed in the early 1980's (Stark, 1985). Later work looked at the performance and precision of the indices (Stark 1993) where a national dataset was used to investigate the influence of sampling method, water depth, current velocity and substrate on the MCI and QMCI. The results showed that the indices were independent of depth, velocity and substrate; attributes necessary when assessing water pollution. Stark later developed a more cost-effective variant of the QMCI called the Semi-Quantitative Macroinvertebrate Community Index, or SQMCI (Stark 1998). The SQMCI uses a five-point scale of coded abundances (i.e. Rare, Common, Abundant, Very Abundant, Very Very Abundant). This index produces values very similar to the QMCI, but at a much reduced cost.

3.3.3. Calculating the MCI and SQMCI

The MCI is calculated from **presence-absence** data as follows:

$$\mathrm{MCI} = \frac{\sum_{i=1}^{i=S} a_i}{S} \times 20$$

S = the total number of taxa in the sample
a_i = the pollution tolerance value for the ith taxon (i.e 10 = highly intolerant, 1= highly tolerant).

The SQMCI is calculated from the **abundance** of various taxa, coded abundances are used i.e. R = Rare; C = Common; A = Abundant; VA = Very Abundant; VVA = Very Very Abundant. The score is calculated as follows:

$$\mathrm{SQMCI} = \sum_{i=1}^{i=S} \frac{(n_i \times a_i)}{N}$$

S = the total number of taxa in the sample
a_i = the pollution tolerance value for the ith taxon (see above)
n_i = the coded abundance for the ith scoring taxon (i.e. R = 1, C = 5, A = 20, VA = 100, VVA = 500)
N = the total of the coded abundances for the entire sample.
MCI values range from 0 to 200 (Stark 1985) whilst SQMCI values range from 0 to 10 (Stark 1998). However most MCI values are in the range of 50 – 150 and most SQMCI values are in the range of 2.5 to 7.5. Values of zero indicate that no macroinvertebrates are present, the higher the score the better the water quality.

3.3.4. Interpretation of the biotic indices scores

The interpretation of biotic index scores was initially based on levels of enrichment or pollution (Stark, 1998) as shown in Table 4. However it is now widely recognised that biotic indices respond to a number of environmental variables, including, but not limited to enrichment. This has led to the descriptors Excellent, Good, Fair, Poor as shown below (Stark and Maxted, 2004, 2007).

Table 4: Interpretation of the biotic indices scores (Stark (1998); Stark and Maxted (2007))

Interpretation	Class	MCI score	SQMCI score
Clean Water	Excellent	> 119	> 5.99
Doubtful quality or possible mild pollution	Good	100 – 119	5 – 5.99
Probable moderate pollution	Fair	80 - 99	4 – 4.99
Probable severe pollution	Poor	< 80	< 4

The MCI and SQMCI have an accuracy of approximately ±10% from a single hand-net sample (Stark, 1998). For example, an MCI score of 105 taken at face value would assign a site to the "good" quality class, but given the ±10% error associated with the sampling method, the actual MCI could range from 95 to 115, however the balance of probability is such that the true MCI class would lie in the "good" class, but it could also possibly be classified as "fair". The MCI is less sensitive to subtle changes in community composition than the SQMCI as it is principally a tool to assess changes in community composition (i.e. presence/absence of taxa) and not numerical (or abundance) composition. Stressors in an environment (such as organic enrichment) will often lead to a change in community structure with regard to the relative abundance of taxa, if the stressors persists then eventually the community structure will change with regard to the presence/absence of taxa.

3.3.5. Macroinvertebrate Results

The full results from the macroinvertebrate sampling are shown in Appendix 7. The MCI scored 72% of sites in the Good to Excellent category whilst the SQMCI scored 74% of sites in the Good to Excellent category. Figures 18 and 19 show each of the sites and the Quality Class into which they fall.

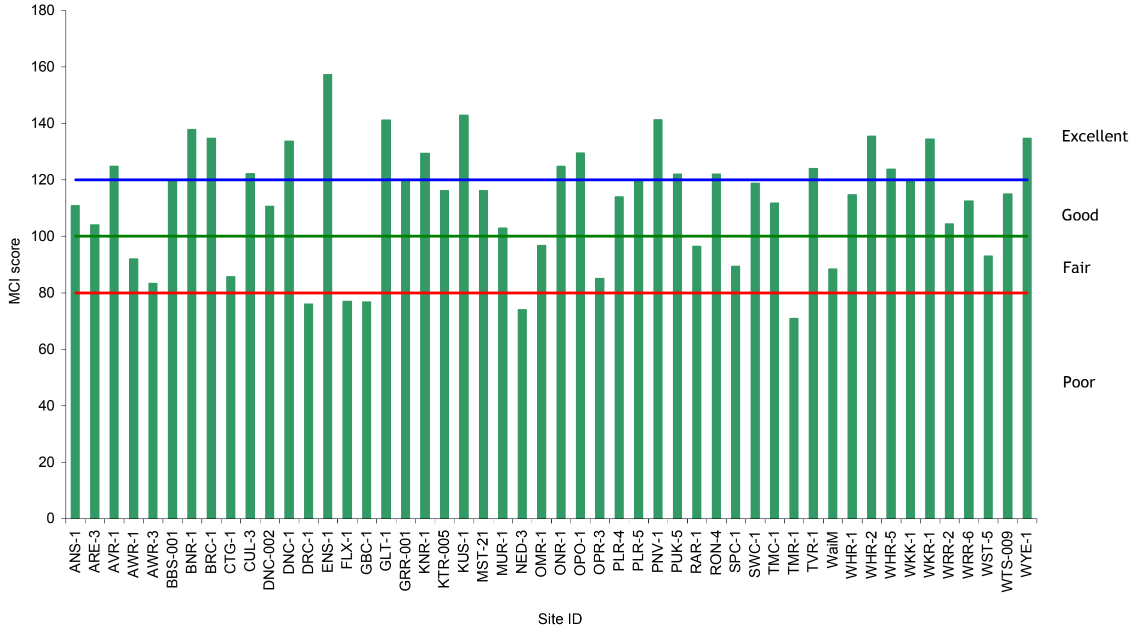


Figure 18: MCI scores for macroinvertebrate samples taken in spring/summer 2010/11.

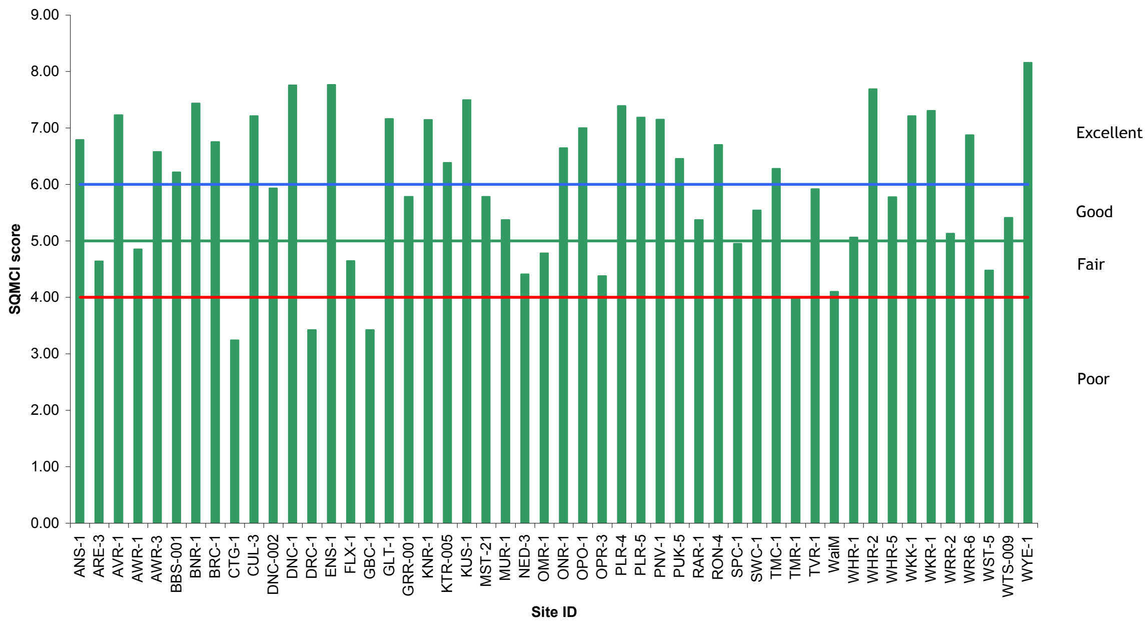


Figure 19: SQMCI scores for macroinvertebrate samples taken in spring/summer 2010/11.

The rivers with the highest MCI scores were Enchanted Stream, Kaiuma Bay Stream, Pine Valley Stream and the Goulter River (all >140). The rivers with the highest SQMCI were Wye Creek, Enchanted Stream, Duncan Bay Stream, the Upper Waihopai and Kaiuma Bay Stream (all >7.5).

All of the sites sampled except for AWR-3 (the Awatere at Awapiri) showed MCI scores and SQMCI scores in the same Quality class, taking into account an accuracy of approximately ±10% for the sampling methodology. Figure 20 shows the correlation between the MCI and SQMCI.

It is important to identify the natural distribution of macroinvertebrate communities for particular catchments/geographic regions i.e. the natural reference conditions, in order to accurately assess stream health and to establish stream rehabilitation programmes (Weigel *et al*. 2003). The MCI scores can then be 'benchmarked' against the relevant reference condition scores.

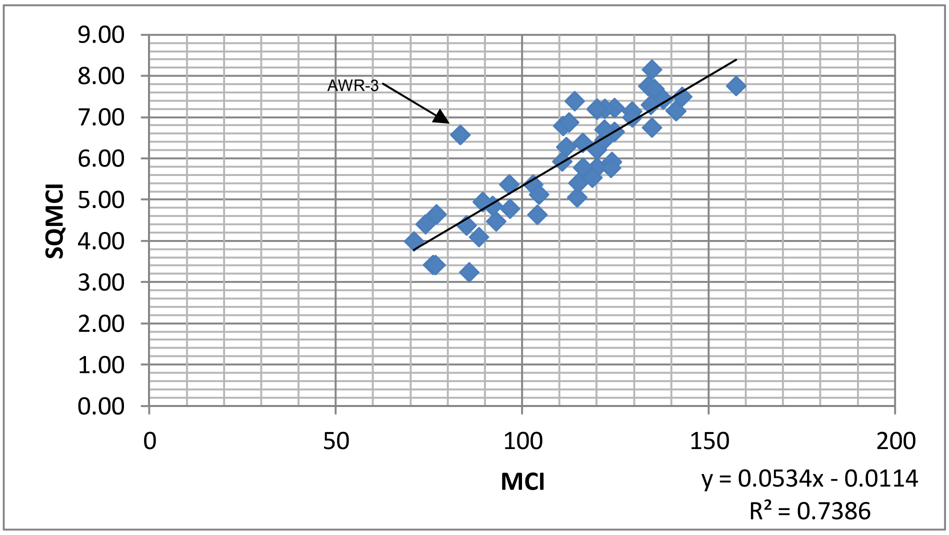


Figure 20: Correlation between MCI and SQMCI scores for spring/summer 2010/11

3.4. Land Use effects

Table 5 below shows the correlation between the macroinvertebrate and water quality indices and a number of catchment characteristics as defined by Leathwick *et al.* (2010). Spearman rank correlations (r_s) were calculated using STATISTICA 7. The MCI and the SQMCI are highly correlated (r_s=0.81). The correlation between the MCI and the SQMCI compares favourably with those made by Wright-Stow and Winterbourn (2003) where 230 sites in Canterbury were analysed giving an r_s=0.86. The WQI does not show as high a correlation with the MCI and SQMCI as that seen in 2011 (MDC, 2011).

Table 5: Correlation between the water quality index (WQI) and the macroinvertebrate indices (SQMCI and MCI) with catchment characteristics as defined by Leathwick *et al.* (2010). Statistically significant correlations (p<0.05) are marked in red.

	WQI	Number of taxa	MCI	SQMCI	EPT_{taxa} (excluding *Oxyethira)*
WQI	1.00				
Number of taxa	-0.04	1.00			
MCI	-0.57	0.36	1.00		
SQMCI	-0.61	0.22	0.81	1.00	
EPT_{taxa} (excluding *Oxyethira)*	-0.54	0.29	0.70	0.71	1.00
CATCHMENT CALCIUM	0.32	-0.23	-0.31	-0.39	-0.29
CATCHMENT HARDNESS	-0.42	0.25	0.30	0.32	0.17
CATCHMENT PHOSPHOROUS	0.10	-0.19	-0.23	-0.22	-0.13
CATCHMENT PROPORTION ALLUVIUM	0.43	-0.04	-0.32	-0.28	-0.31

CATCHMENT PROPORTION BARE LAND	-0.38	-0.53	-0.02	0.18	0.17
CATCHMENT PROPORTION EXOTIC FOREST	0.43	0.12	0.08	0.05	-0.03
CATCHMENT PROPORTION INDIGENOUS FOREST	-0.41	0.32	0.53	0.57	0.26
CATCHMENT PROPORTION MISCELLANEOUS LANDCOVER	-0.12	-0.17	0.03	0.15	-0.02
CATCHMENT PROPORTION PASTORAL FARMING	0.66	-0.01	-0.48	-0.50	-0.41
CATCHMENT PROPORTION SCRUB	-0.17	0.12	-0.09	-0.27	-0.07
CATCHMENT PROPORTION TUSSOCK	-0.36	-0.27	-0.12	-0.10	0.17
CATCHMENT PROPORTION URBAN	-0.05	-0.31	-0.05	-0.08	0.10
CATCHMENT RAINFALL VARIABILITY	0.25	-0.01	-0.52	-0.42	-0.23

All of the indices show a significant correlation with the percentage of indigenous forest in the catchment and with the percentage of pastoral land in the catchment suggesting that these two land uses have the greatest impact (positively and negatively respectively) on water quality.

The appropriateness of the index being used should account for the scale at which the analysis is being done. The SQMCI is commonly used to assess localised or short term effects on water quality e.g. for compliance monitoring. Stark and Maxted (2007) recommend the use of the MCI for SoE reporting.

Figure 21 shows there are no sites that are rated as excellent (MCI >120) where the catchment has > 30% pastoral landcover, in addition there are no sites rated as Good (MCI >100), with the exception of some spring fed sites, where the catchment has > 30% pastoral landcover.

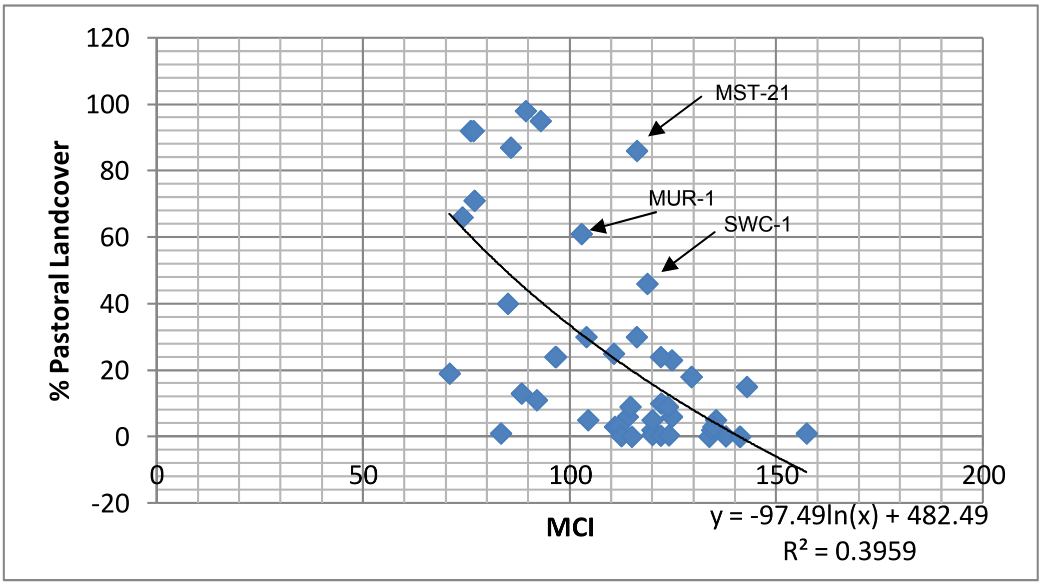


Figure 21: Scatter diagram showing the percentage of land in pastoral landcover versus the MCI score.

There are no sites that are rated as excellent (SQMCI >6) where the catchment has > 30% pastoral landcover, in addition there are no sites rated as Good (SQMCI >5), with the exception of some spring fed sites, where the catchment has > 30% pastoral landcover (Figure 22).

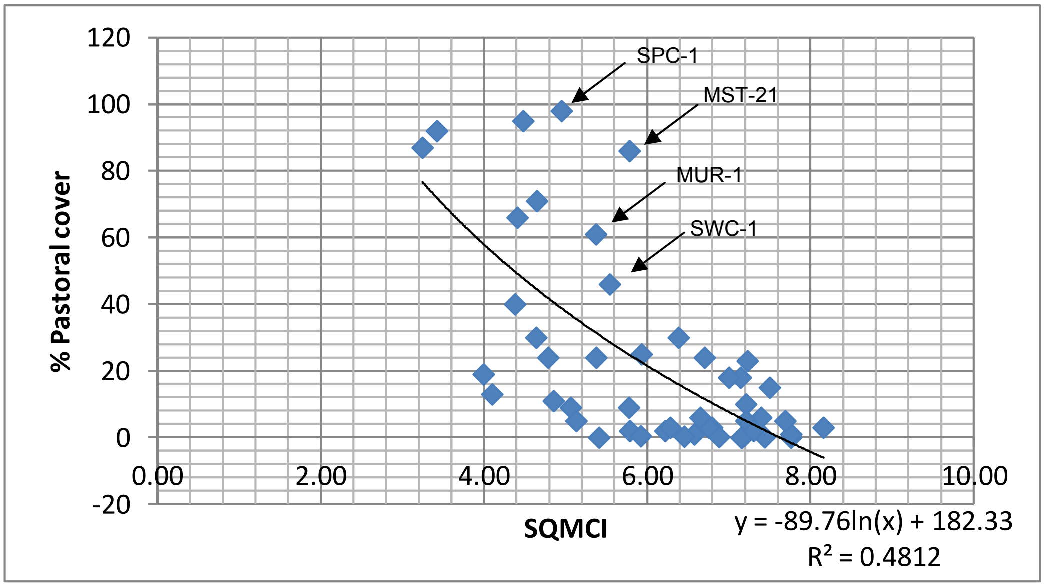


Figure 22: Scatter diagram showing the percentage of land in pastoral landcover versus the SQMCI score.

There are inconsistencies with some of the landcover calculations, as provided by Leathwick *et al.* (2010), particularly in the lowland and springs areas. The springs catchments are further complicated by the fact that they receive much of their water from groundwater that lies outside of the immediate topographic catchment.

The water quality index shows a similar pattern with most of the worst sites (Poor and Very Poor >3.5) located in catchments with >30% pastoral landcover (figure 23).

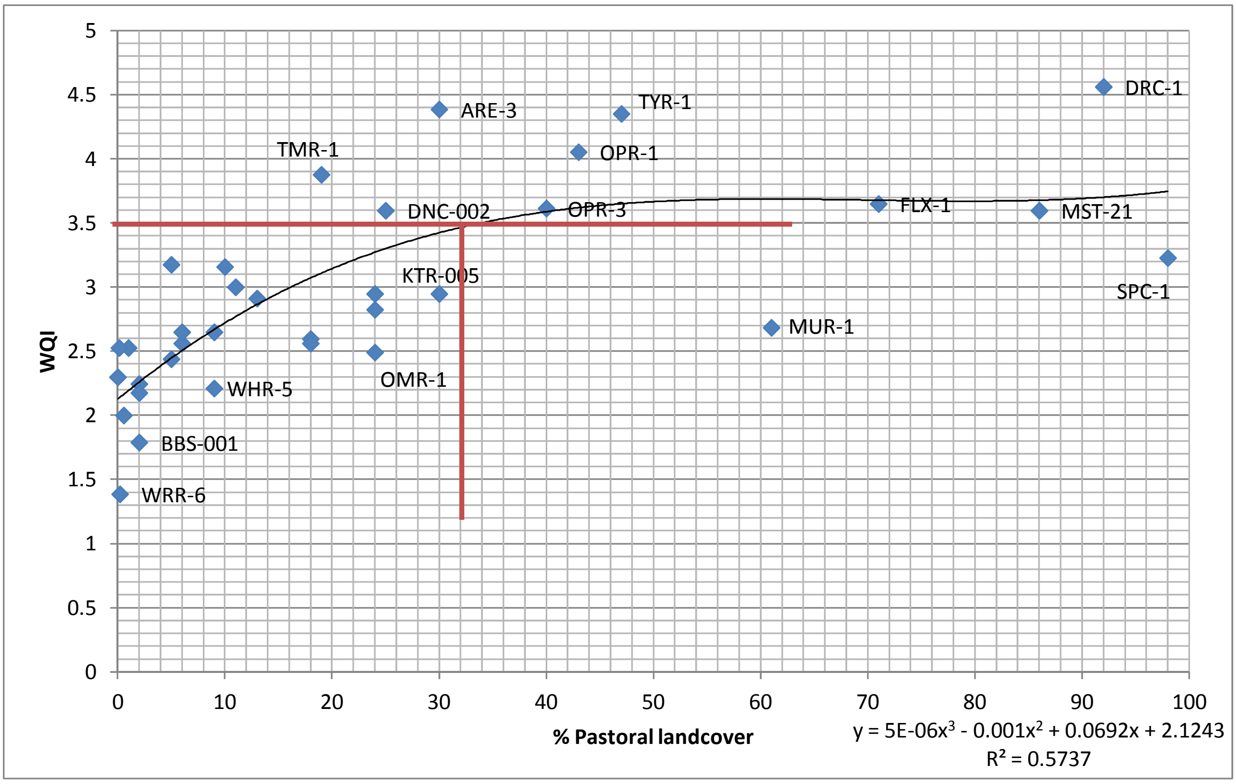


Figure 23: Scatter diagram showing the percentage of land in pastoral landcover versus the WQI score.

Cawthron have modelled MCI scores for the whole of the country (Joanne Clapcott pers comm.) based on a variety of different scenarios including current land use (Leathwick, 2010) and reference conditions (i.e. absence of current landuse). Figure 24 shows the results. Mostly there is a very good correlation between the modelled MCI score and the observed data (monitoring results) for current land use (Figure 24a), however the exception is the Awatere at Awapiri (AWR-3) which has a much lower score than what would be expected from the modelled data. Figure 24b shows the MCI scores expected in the absence of modern landuse. Very few observed results fit with the modelled results, with the exception of some areas of North Marlborough, indicating that land use change has had a huge impact on aquatic life.

(a) **(b)**

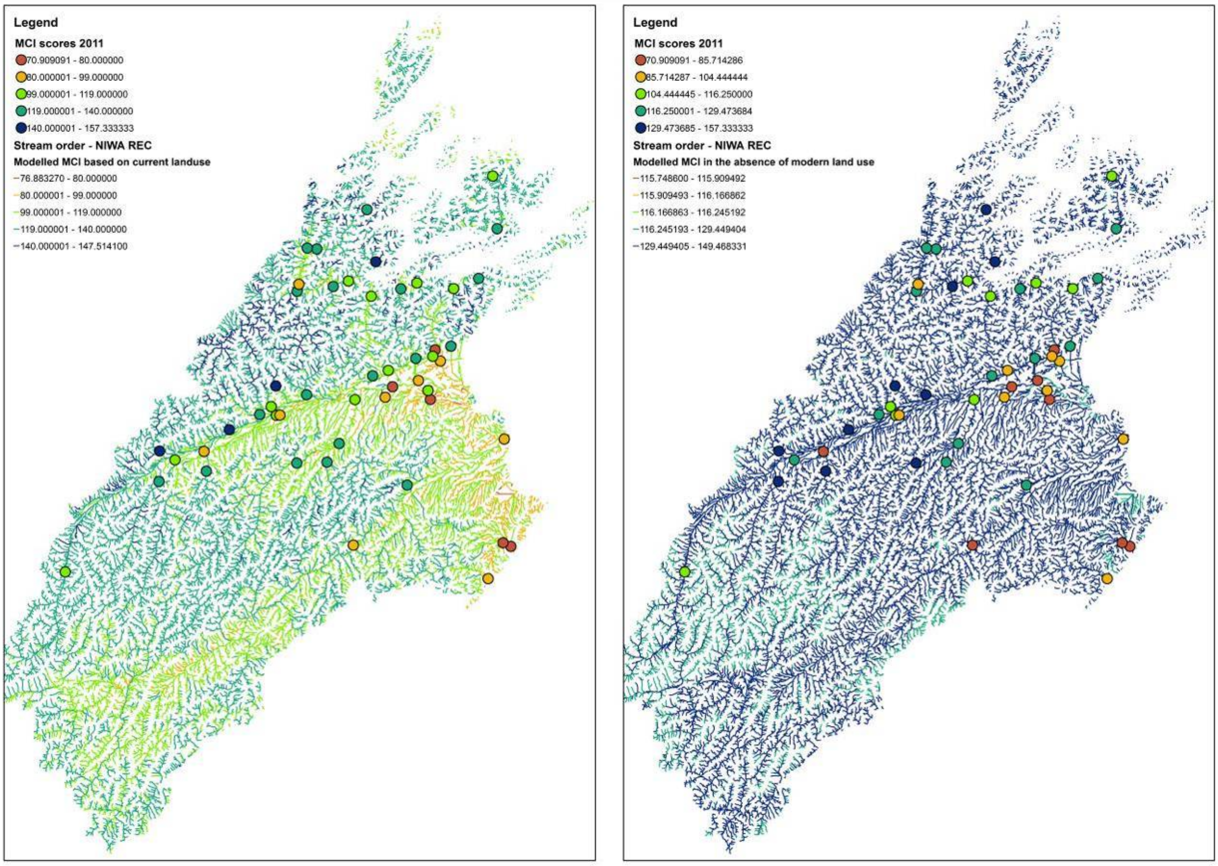


Figure 24: Modelled MCI scores compared with MCI scores from 2010-11 sampling for (a) current land use (b) absence of current landuse or 'reference' conditions

4. Trend Analysis

Trend analysis was carried out using NIWAs Timetrends software package, version 3.2, 2011. Many water quality parameters have seasonal trends. The seasonal Kendall test is a commonly used test in water quality trend analysis.

> The seasonal Kendall test is a non-parametric test that accounts for seasonality by calculating the Mann-Kendall test on each of the 'seasons' separately, and then combining the results. So for monthly "seasons", January data are compared only with January, February with February, etc. The Sen slope is the median annual slope of all possible pairs of values in each season. It is expressed in the units of the variable, standardised to a year. For example, if a parameter is measured in February 1998 and in February 2004, the slope is the difference between the 2 values divided by 6 (the number of years). Median annual slope is often compared to the median value of the variable as a measure of the magnitude of the change. For example, a statistically significant Kendall test with an annual trend of more than 1% of the median value is often considered meaningful. When the product of the number of seasons and number of years is greater than about 25, the distribution of Sk can be approximated by the normal distribution, with the expectation that Sk will be zero if there is no trend. Sk will be positive if there is an increasing trend and negative for a declining trend. (Timetrends, 2011).

The trend analysis carried out for this report follows the recommendations in the report '*Water quality trend analysis for the Land and Water New Zealand website (LAWNZ)*' (Ballantine, 2012).Trend analysis was carried out on sites with >45 samples over the period 2007 to 2011 (i.e. sites with a minimum of 5 years of data). A total of 24 sites have >45 samples for this time period. Flow adjusted analysis was carried out where flows were available (7 sites), non-flow adjusted data was used for the rest of the sites with five years of data (Table 6). The LOWESS method (smoothing with a 30% span) was used for flow adjusted data as recommended by Ballantine (2012).

Table 6: Sites for which trend analysis was carried out

Site	Flow adjusted
Awatere at Awapiri (AWR-3)	✓
Awatere at River Mouth (AWR-1)	
Flaxbourne at Quarry (FLX-1)	
Graham River (GRR-001)	
Kenepuru (KNR-1)	✓
Kaituna at Readers Road (KTR-005)	✓
Omaka River at Hawkesbury Road (OMR-1)	
Onamalutu River (ONR-1)	
Opawa River at Hammerichs Road (OPR-3)	
Opawa River at Swamp Road (OPR-1)	
Pelorus River at Fishermans Flat (PLR-4)	
Pelorus River at Kahikatea Flat (PLR-5)	
Rai at Rai Falls (RAR-1)	✓
Spring Creek (SPC-1)	
Tuamarina (TMR-1)	
Taylor River (TYR-1)	
Waima River (WaiM)	
Wairau Diversion at Neals Road Bridge (WDV-1)	
Waihopai at SH63 (WHR-1)	
Waihopai at Flow site (WHR-5)	✓
Wakamarina (WKR-1)	
Wairau at SH1 (WRR-2)	✓
Wairau at Dip Flat (WRR-6)	✓
Waitohi Stream (WTS-009)	

Most water quality parameters are correlated with flow. Some parameters will become more concentrated with flow and some will become more dilute, depending on the characteristics of the catchment. In catchments dominated with diffuse sources of pollution, contaminants (such as *E. coli*, nitrate, DRP) will become more concentrate with higher flows, whereas in catchments dominated with point sources of pollution contaminants will become more dilute with increasing flows.

Using flow adjusted data for trend analysis will give an indication of the relative loadings of pollutants in the catchment. Often it is required to be able to quantify effects on water quality from land use change, these effects can be obscured if there have been particularly wet or dry periods; therefore it is desirable to use flow adjusted data to assess trends. However because non-adjusted data uses the actual concentration this analysis will reflect more accurately what is happening in the catchment and as a consequence what the effects on aquatic life might be. Climate change will lead to some areas becoming wetter or dryer and thus looking at trends in non-adjusted data is important to assess changes over time due to climate change.

It is recommended that both flow adjusted and unadjusted analyses are used for state of the environment reporting. Only key parameters were chosen to look at trends, these include, nitrate, dissolved reactive phosphorus, *E. coli,* turbidity, conductivity and pH.

Seasonal kendall tests were performed for all 24 sites to assess trends in nitrate, DRP, *E. coli*, turbidity, conductivity and pH concentrations between 2007 and 2011. Trends were deemed statistically significant when $P< 0.05$. The Sen slope gives the magnitude of the trend. A meaningful increase/decrease was determined if the magnitude of the trend (seasonal kendall slope estimate, SKSE) was greater than one percent per annum of the raw data median (relative seasonal kendall estimate, RSKE). The one percent used to infer a meaningful increase/decrease is arbitrary but is what has been recommended by Ballantine (2012) and used in previous NIWA reports when reporting on trends in water quality nationally. Appendix 8 shows the results from the Timetrends analysis.

4.1. Nitrate Trend Analysis

Six sites showed a statistically significant trend in nitrate concentrations. Of these sites five showed an improvement in water quality with regard to nitrate concentrations i.e. nitrate concentrations decreased over the five year period from 2007 to 2011, whilst one remained stable for this time period.

The Flaxbourne River shows a statistically significant trend in nitrate concentrations, however the trend is stable (i.e. shows neither an increase or decrease concentrations) over time.

The Kaituna River shows a meaningful decrease in nitrate concentrations for both flow adjusted and non-adjusted data, although the decrease is slightly less for the flow adjusted data (15% Vs 12% per year).

The Rai River shows a decrease in nitrate concentrations for both flow adjusted and non-adjusted data. There was no difference between the magnitude of the decrease for the flow adjusted and non-adjusted data; both showed a decrease of 9% per year. The lower Pelorus shows a slightly larger decrease of 13% per year.

The Omaka River shows a decrease in nitrate concentrations of around 15% per year. The Taylor River also shows a decrease of approximately 9% per year. The is no flow data available for these sites to determine if the decrease is flow related or not, however the winter of 2008 was particularly wet, which may account for some of the decrease (as high nitrate concentrations recorded that year would have subsequently decreased in later years).

4.2. Dissolved Reactive Phosphorus Trend Analysis

Five sites showed a statistically significant trend in DRP concentration. Of these five sites all showed a deterioration in water quality i.e. DRP concentrations increased over the five year period from 2007 to 2011.

The Flaxbourne River shows an increase in DRP concentrations of approximately 10% per year. The Omaka River shows an increase of 16% per year. Unadjusted data for The Rai shows an increase of 12%, however there is no trend for the flow adjusted data. The Wakamarina shows an increase of approximately 8% per year. The Wairau at Tuamarina shows an increase of 16% for the non-adjusted data and 9% for the flow adjusted data.

4.3. *E. coli* Trend Analysis

Seven sites showed a statistically significant trend in *E. coli* numbers. Of these seven sites all showed a deterioration in water quality i.e. *E. coli* numbers increased over the five year period from 2007 to 2011.

The Wairau Diversion at Neals Road Bridge, the Awatere River at Awapiri and the Flaxbourne River show the largest increases in *E. coli* numbers. There is a 30% increase in *E. coli* for the Wairau Diversion and the Flaxbourne River, whilst *E. coli* has increased by 25% at the Awatere River at Awapiri relative to the median for the time period. The Flow adjusted data for the Awatere showed no significant trends in *E. coli* numbers, indicating that the increase is a result of increased flows/rainfall in the catchment.

Spring Creek, the Opawa River at Hammerichs Road, the Tuamarina River and the Taylor River showed increases of 12%, 15%, 16% and 22% respectively.

4.4. Turbidity Trend Analysis

Thirteen sites showed a statistically significant trend in turbidity. All of these sites showed a deterioration in water quality with regard to turbidity i.e. turbidity levels increased over the five year period from 2007 to 2011.

The Waihopai at Craiglochart shows a large increase in turbidity levels for the flow adjusted data (76% increase over the median), however this is not reflected in the non-adjusted data, where trends are only marginally significant (p=0.06). The Onamalutu River had the next highest increase in turbidity levels relative to its median, with a 43% increase.

The Waima River, Wakamarina River, Taylor River, Waihopai River at SH63 and the Pelorus River at Kahikatea Flat showed increases of 25%, 23%, 21%, 20% and 20% respectively.

The Flaxbourne River, the Kaituna River and the Rai River all showed increases in turbidity levels of 17% relative to their median over the time period. The Wairau Diversion, the Opawa River at Swamp Road and Spring Creek showed increases of 13%, 12% and 8% respectively.

4.5. Conductivity Trend Analysis

Ten sites showed a statistically significant trend in conductivity. All of these sites showed a decrease in conductivity over the five year period from 2007 to 2011. Most sites showed a decrease in conductivity between 2% and 5%. The largest decrease was observed for the Waima River (15%).

Flow adjusted data showed a decrease of 3.8% for the Kaituna, whilst unadjusted data showed a decrease of 2.4%. Flow adjusted data for the Rai River showed a decrease of 2.3%, whilst unadjusted data showed a decrease of 3.6%. The upper and lower Pelorus River sites showed a decrease of 4.8% and 4.3% respectively. The Wakamarina showed a decrease of 5%.

Decreases were also observed for the Omaka River, Onamalutu River, Tuamarina River and the Awatere at Awapiri (5%, 4.6%, 3.5% and 4.2%).

4.6. pH Trend Analysis

Ten sites showed a statistically significant trend in pH. Of these, three showed a decrease in pH whilst seven showed an increase.

The Kaituna River showed a similar increase in pH for both flow adjusted and non-adjusted data (1.1% and 1.4% respectively). The Wairau River at Tuamarina and at Dip Flat showed similar trends in pH. Flow adjusted and non-adjusted data were the same for the Wairau at Tuamarina (0.5% decrease) whilst non-adjusted data for Dip Flat showed a decrease of 0.4%; there was no significant trend for flow adjusted data for the Wairau at Dip Flat.

Decreases in pH were also observed at the Awatere at the River mouth (0.7%).

Increases in pH were observed for the Omaka River, Onamalutu River, Taylor River, Tuamarina River, the Waihopai at SH63 bridge and the Waima River (1.2%, 0.5%, 1.4%, 1%, 1.2% and 0.6% respectively).

5. Discussion

State of the Environment reporting requires that the state and trends of surface waters are assessed on a timely basis. Comprehensive State of the Environment reports are produced by Council at 5 year intervals. The frequency of monitoring and the longevity of monitoring need to be considered in order to satisfy the requirements of state of the environment reporting. Three years of monthly monitoring is considered a minimum to assess the state or baseline water quality. Five years of monthly monitoring is considered the minimum to detect trends in water quality. Taking a catchment management approach to water quality management allows for the ability to assess land use and land use change with water quality trends over time. There are very few point source discharges to surface waters in Marlborough and thus the biggest threat to surface water quality comes from diffuse pollution from land use, including urban development. The ability to track changes in water quality with changes in land use is essential in order to allow for the development of appropriate land management practices to prevent degradation of water bodies and to enhance and maintain water bodies where appropriate.

Water quality in Marlborough’s rivers and streams is generally good. Half of all monitored sites are classed as ‘Excellent’ or ‘Good’ while a further 23% are classed as ‘Fair’ using the water quality index. Macroinvertebrate monitoring shows that just over 70% of monitored sites are classed as ‘Excellent’ or ‘Good’. Water quality is seen to deteriorate in agricultural and urban areas, particularly where there has been little or no riparian management and/or where there are extensive pastoral areas.

Nitrate levels are of most concern in the spring fed streams (e.g. Doctors Creek, Mill Stream, Murphy’s Creek and the Taylor River) where levels often exceed the threshold for ecological toxicity (Hickey and Martin, 2009). The sensitivity of these waterways and their reliance on groundwater quality is an indication of the need to manage groundwater quality for the protection of aquatic life in spring fed streams. Trend analysis shows that nitrate concentrations are decreasing across the region, of the six sites which had a significant trend, 5 of these showed nitrate decreasing whilst one was stable.

Ammonia concentrations are generally very low or non-detectable in most sites sampled. This is predominately a reflection of the absence of point source discharges and the generally well oxygenated nature of the waters.

Median E. coli numbers are generally good with the exception of Are Are Creek, Cullens Creek, Duncan Stream (Linkwater) Doctors Creek and Mill Stream. Where trends in E. coli numbers have been detected, all showed increasing numbers over time. The greatest increase was observed for the Wairau Diversion at Neals Road Bridge.

Water clarity is generally very good as indicated by low turbidity levels. However trend analysis shows that turbidity is increasing at a number of sites across the region. Notable exceptions where water clarity is poor include: the Awatere, Duncan Stream (Linkwater) and Doctors Creek. The Awatere has naturally high turbidity levels but it is likely that the poor clarity for Duncan Stream and Doctors Creek is due to poor riparian management resulting in sediment input from eroding stream banks. It is also of note that trend analysis has shown an increase in turbidity for two sites with very good water clarity i.e. the Wakamarina and the Pelorus River at Kahikatea Flat.

Arsenic is not of concern for any of the waterways sampled; however copper and zinc frequently exceed the ANZECC guidelines at the sites sampled.

Land use (in particular pastoral land use) shows a significant correlation with water quality indicating that diffuse pollution is the main problem for Marlborough's rivers and streams. Improvements in land use practices such as fencing and riparian planting along with better management of farm effluent in rural pastoral areas amongst other measures (McKergow et al., 2007) and improved stormwater management in urban areas will go a long way to significantly improving water quality throughout Marlborough. Combining water quality, water flow, biological sampling and habitat assessments at the same site improves the analysis and interpretation of data that can be made. The ability to assess the effectiveness of land management practices and/or water quality management initiatives is essential in order to ensure that resources and funds are managed in a sustainable way.

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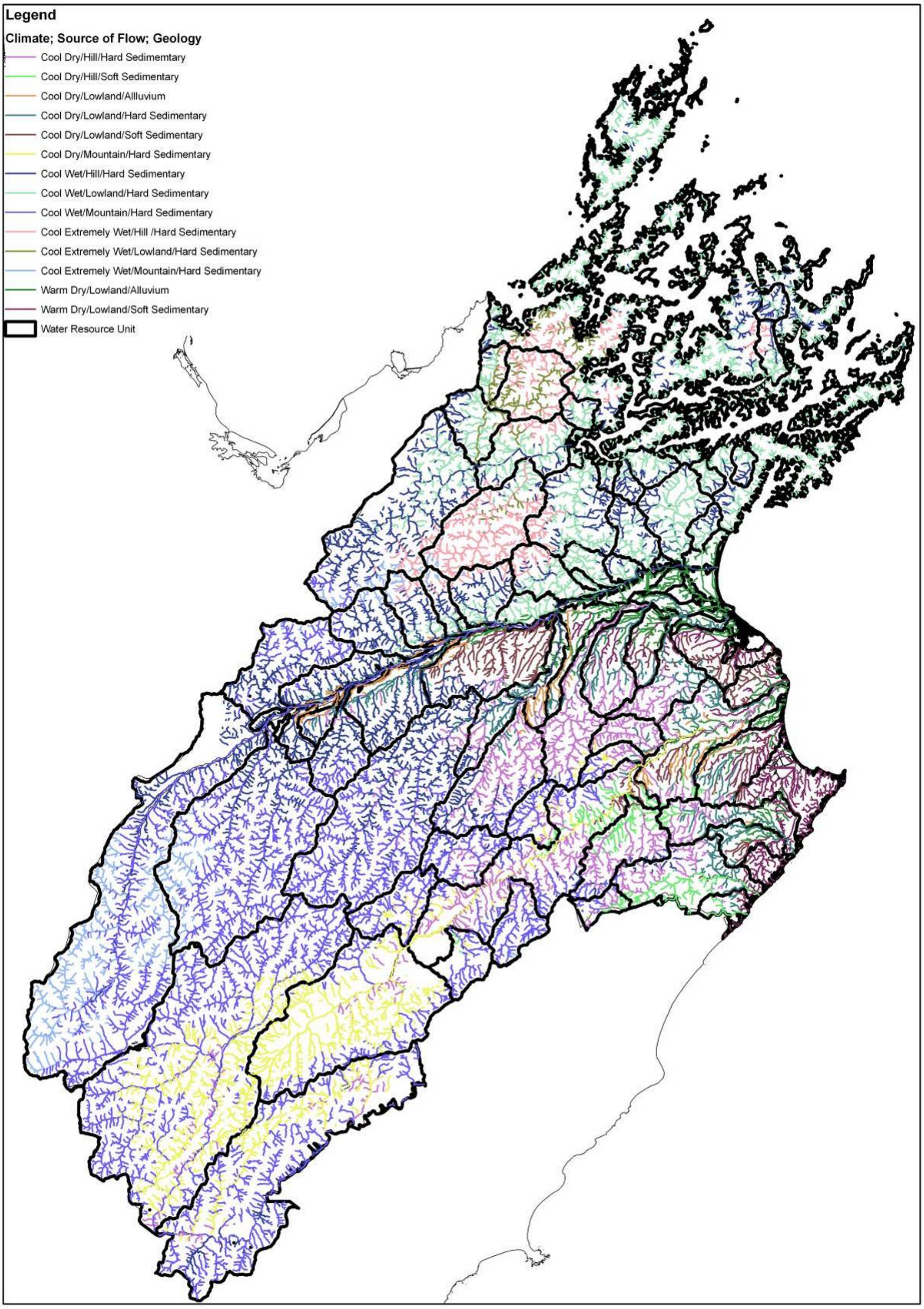
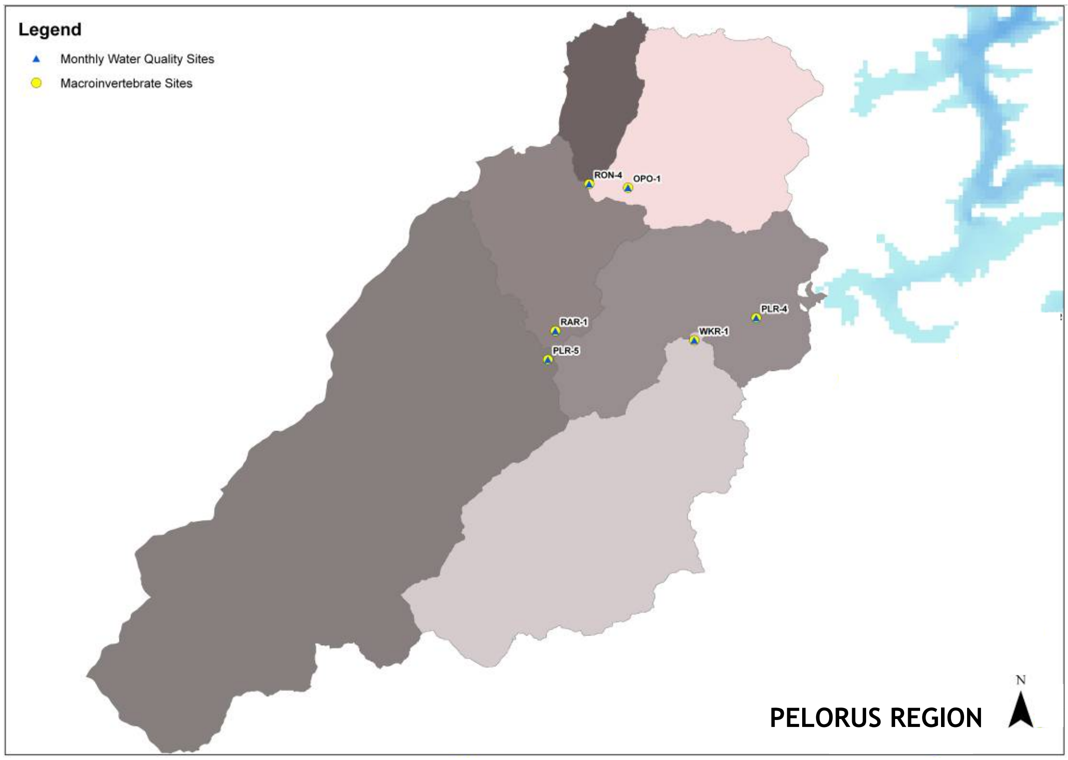
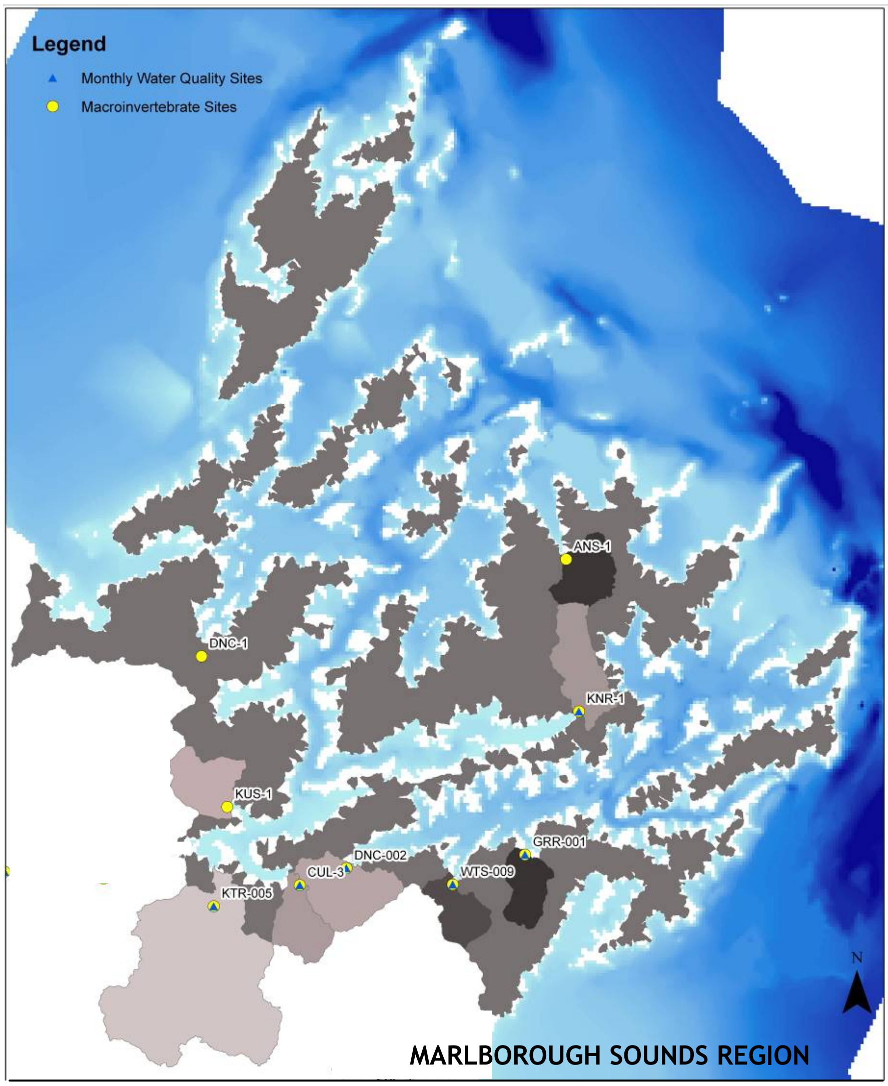
Appendix 1: River 'types' in Marlborough according to the River Environment Classification (Snelder *et al*,2004). Water Resource Units boundaries are shown in black and listed in the following table along with information on the catchment characteristics according to Leathwick *et al*. (2010).



Region	Water Resource Unit	Monitoring Site	River Name	NZ Reach Number	Catchment Area (km^2)	% Bare Land	% Exotic Forest	% Indigenous Forest	% Pastoral Land	% Scrub	% Tussock	% Urban	Low Flow (l/s)	Elevation (m)
Pelorus	Ronga	RON-4	Ronga River	11009511	32.98	0.2	7.0	62.0	24.0	4.0	0.4	0.1	140.64	48.555
Pelorus	Opouri	OPO-1	Opouri River	11009660	70.40	0.6	11.0	60.0	18.0	8.0	0.0	0.0	226.25	43.725
Pelorus	Rai	RAR-1	Rai River	11011511	209.03	0.5	12.0	54.0	24.0	8.0	0.1	0.0	947.45	35.485
Pelorus	Upper Pelorus	PLR-5	Pelorus River	11011819	378.96	0.6	2.0	93.0	0.6	2.0	0.9	0.0	2747.47	36.725
Pelorus	Wakamarina	WKR-1	Wakamarina	11011667	186.51	0.4	9.0	81.0	2.0	5.0	0.1	0.0	1016.4	3.645
Pelorus	Lower Pelorus	PLR-4	Pelorus River	11011349	863.60	0.6	7.0	79.0	6.0	5.0	0.5	0.0	5829.23	0
Marlborough Sounds	Small Sounds streams	DNC-1	Duncan Bay Stream	11007732	5.02	0.0	0.0	98.0	0.0	1.0	0.0	0.0	11.52	34.47
Marlborough Sounds	Anakoha	ANS-1	Anakoha Stream	11006296	20.72	0.0	0.0	80.0	3.0	16.0	0.0	0.0	21.81	6.68
Marlborough Sounds	Kenepuru	KNR-1	Kenepuru River	11008643	27.30	0.4	14.0	47.0	18.0	19.0	0.0	0.0	30.22	2.9
Marlborough Sounds	Kaiuma	KUS-1	Kaiuma Bay Stream	11010162	21.97	0.0	18.0	57.0	15.0	8.0	0.1	0.0	53.3	7.265
Marlborough Sounds	Kaituna	KTR-005	Kaituna River	11012276	135.54	0.3	19.0	32.0	30.0	17.0	0.0	0.0	356.24	0
Marlborough Sounds	Cullens Creek	CUL-3	Cullens Creek	11011611	20.25	0.0	37.0	43.0	10.0	8.0	0.0	0.0	36.67	7.89
Marlborough Sounds	Ada Creek 'complex'	DNC-002	Duncan Stream	11011436	8.38	0.0	39.0	16.0	25.0	18.0	0.0	0.0	15.54	6.94
Marlborough Sounds	Waitohi	WTS-009	Waitohi Stream	11011673	15.24	0.0	0.1	77.0	0.0	17.0	0.0	4.0	21.12	8.36
Marlborough Sounds	Graham River	GRR-001	Graham River	11011033	16.80	0.0	0.4	76.0	2.0	20.0	0.0	0.0	17.73	7.21
Wairau	Upper Wairau	WRR-6	Wairau River	11029639	518.04	48.0	0.0	19.0	0.2	5.0	26.0	0.0	6041.79	673.53
Wairau	Branch River	BNR-1	Branch River	11024066	551.62	32.0	0.3	24.0	0.1	28.0	14.0	0.0	4890.17	381.375
Wairau	Goulter	GLT-1	Goulter River	11022457	145.59	5.0	0.0	66.0	0.0	27.0	0.5	0.0	1155.35	340.575
Wairau	Patriarch 'complex'	ENS-1	Enchanted Stream	11021363	7.41	3.0	0.0	61.0	1.0	33.0	0.0	0.0	60.91	253.785
Wairau	Argyle Pond													
Wairau	Saltwater Stream	SWC-1	Saltwater Stream	11022769	23.77	0.0	30.0	0.0	46.0	1.0	21.0	0.0	208.82	323.29
Wairau	Cabbage Tree Gully Stream	CTG-1	Cabbage Tree Gully Stream	11022082	23.98	0.3	3.0	0.0	87.0	3.0	6.0	0.0	171.16	274.97
Wairau	Wye River	WYE-1	Wye River	11023508	66.37	10.0	2.0	18.0	3.0	36.0	27.0	0.0	497.37	352.015
Wairau	Top Valley Stream	TVR-1	Top Valley Stream	11020463	88.78	2.0	11.0	84.0	0.4	1.0	0.7	0.0	678.2	187.34
Wairau	Boundary Creek 'complex'	MST-21	Mill Stream	11019999	31.94	2.0	0.5	0.0	86.0	1.0	8.0	0.0	206.43	155.07
Wairau	Timms Creek	TMC-1	Timms Creek	11019990	67.58	2.0	8.0	78.0	3.0	1.0	6.0	0.0	480.49	165.57
Wairau	Centre Valley Stream 'complex'	WST-5	Walkers Stream	11020308	1.80	0.0	4.0	0.0	95.0	0.0	0.0	0.0	11.02	160.6
Wairau	Pine Valley Stream	PNV-01	Pine Valley Stream	11018517	20.60	6.0	0.0	93.0	0.0	0.0	0.0	0.0	143.58	236.81
Wairau	Bartletts Creek	BRC-1	Bartletts Creek	11019171	71.60	0.4	15.0	72.0	3.0	8.0	0.0	0.0	351.88	112.09
Wairau	North Bank 'complex'	SYC-1	Storeys Creek	11017194	7.83	0.0	64.0	0.0	6.0	29.0	0.0	0.0	12.02	26.46
Wairau	Onamalutu	ONR-1	Onamalutu River	11017762	71.70	0.0	39.0	46.0	6.0	7.0	0.0	0.0	235.24	45.16
Wairau	Are Are Creek	ARE-3	Are Are Creek	11017507	31.12	0.0	62.0	0.2	30.0	6.0	0.0	0.0	71.8	30.565
Wairau	Waikakaho	WKK-1	Waikakaho River	11016590	57.89	0.0	21.0	47.0	5.0	25.0	0.0	0.0	101.4	9.7
Wairau	Tuamarina	TMR-1	Tuamarina River	11016362	102.04	0.1	34.0	30.0	19.0	15.0	0.0	0.0	147.77	1.955
Wairau	Pukaka Stream	PUK-5	Pukaka Stream	11015643	22.43	0.8	27.0	60.0	0.3	8.0	1.0	0.0	26.4	11.155
Wairau	Spring Creek	SPC-1	Spring Creek	11016829	13.55	0.0	0.0	0.0	98.0	0.0	0.0	0.7	16.34	1.06
Wairau	Grovetown Lagoon													
Wairau	Coastal Wairau 'complex'	WDV-1	Wairau Diversion	11016737	3569.59	22.0	5.0	31.0	5.0	18.0	17.0	0.0	26159.7	0.365
Wairau	Wairau River	WRR-2	Wairau River	11016544	3518.43	22.0	5.0	31.0	5.0	18.0	17.0	0.0	26002.36	0.23
Wairau	Lower Wairau Trib 'complex'													
Waihopai	Upper Waihopai	WHR-2	Waihopai River	11023053	486.71	17.0	1.0	6.0	5.0	28.0	40.0	0.0	2795.06	261.435
Waihopai	Avon	AVR-1	Avon River	11022862	182.52	2.0	0.2	25.0	23.0	37.0	11.0	0.0	622.64	209.845
Waihopai	Mid Waihopai	WHR-5	Waihopai River	11022016	738.55	14.0	1.0	9.0	9.0	29.0	35.0	0.0	3709.35	173.465
Waihopai	Lower Waihopai	WHR-1	Waihopai River	11019403	782.31	14.0	1.0	9.0	9.0	29.0	35.0	0.0	3861.21	83.865
Omaka	Omaka River	OMR-1	Omaka River	11019336	120.44	0.2	0.0	9.0	24.0	49.0	15.0	0.0	235.49	69.25
Omaka	Gibsons Creek	GBC-1	Gibsons Creek	11018540	52.65	0.0	5.0	0.1	92.0	1.0	0.0	0.3	102.38	33.315
Omaka	Fairhall River													
Omaka	Doctors Creek	DRC-1	Doctors Creek	11019119	48.05	0.0	0.0	0.0	92.0	7.0	0.0	0.2	55.22	7.065
Omaka	Blenheim Springs	MUR-1	Murphys Creek	11018883	2.37	0.0	0.0	0.0	61.0	1.0	0.0	36.0	1.71	7.63
Omaka	Taylor River	TYR-1	Taylor River	11019007	145.63	0.1	6.0	0.0	47.0	34.0	9.0	1.0	139.23	3.14
Omaka	Opawa River	OPR-3	Opawa River	11018115	287.21	0.2	0.8	6.0	40.0	38.0	11.0	0.3	504.6	13.25
Omaka	Lower Opawa	OPR-1	Opawa River	11019373	460.18	0.2	2.0	5.0	43.0	36.0	11.0	0.9	600.26	1.845
Omaka	Seventeen Valley Stream 'complex'													
Omaka	Wairau Lagoon 'complex'													
Awatere	Upper Awatere													
Awatere	Castle River													
Awatere	Winterton River													
Awatere	Grey River													
Awatere	Mid Awatere	AWR-3	Awatere	11028051	984.33	41.0	0.0	1.0	1.0	13.0	43.0	0.0	3219.87	341.22
Awatere	Hodder River													
Awatere	Penk River													
Awatere	Medway River													
Awatere	Black Birch Stream	BBS-001	Black Birch Stream	11024343	29.93	2.0	0.0	0.8	2.0	55.0	39.0	0.0	39.51	223.7
Awatere	Blairich Stream													
Awatere	Lower Awatere	AWR-1	Awatere River	11021862	1571.69	31.0	0.5	1.0	11.0	17.0	38.0	0.0	3957.92	11.07
South Marlborough	Blind River													
South Marlborough	East Coast 'complex'													
South Marlborough	Flaxbourne	FLX-1	Flaxbourne River	11027969	150.52	0.0	0.3	0.0	71.0	23.0	4.0	0.0	70.87	7.875
South Marlborough	Needles/Tachalls	NED-3	Needles Creek	11027907	41.81	0.0	0.1	0.0	66.0	32.0	0.3	0.0	18.6	26.98
South Marlborough	Waima	WaiM	Waima River	11030093	152.46	4.0	0.0	12.0	13.0	39.0	29.0	0.0	97.4	4.74
Clarence	Acheron													
Clarence	Upper Clarence													


Legend
Monthly Water Quality Sites
Macroinvertebrate Sites
RON-4
OPO-1
RAR-1
PLR-5
WKR-1
PLR-4
N
PELORUS REGION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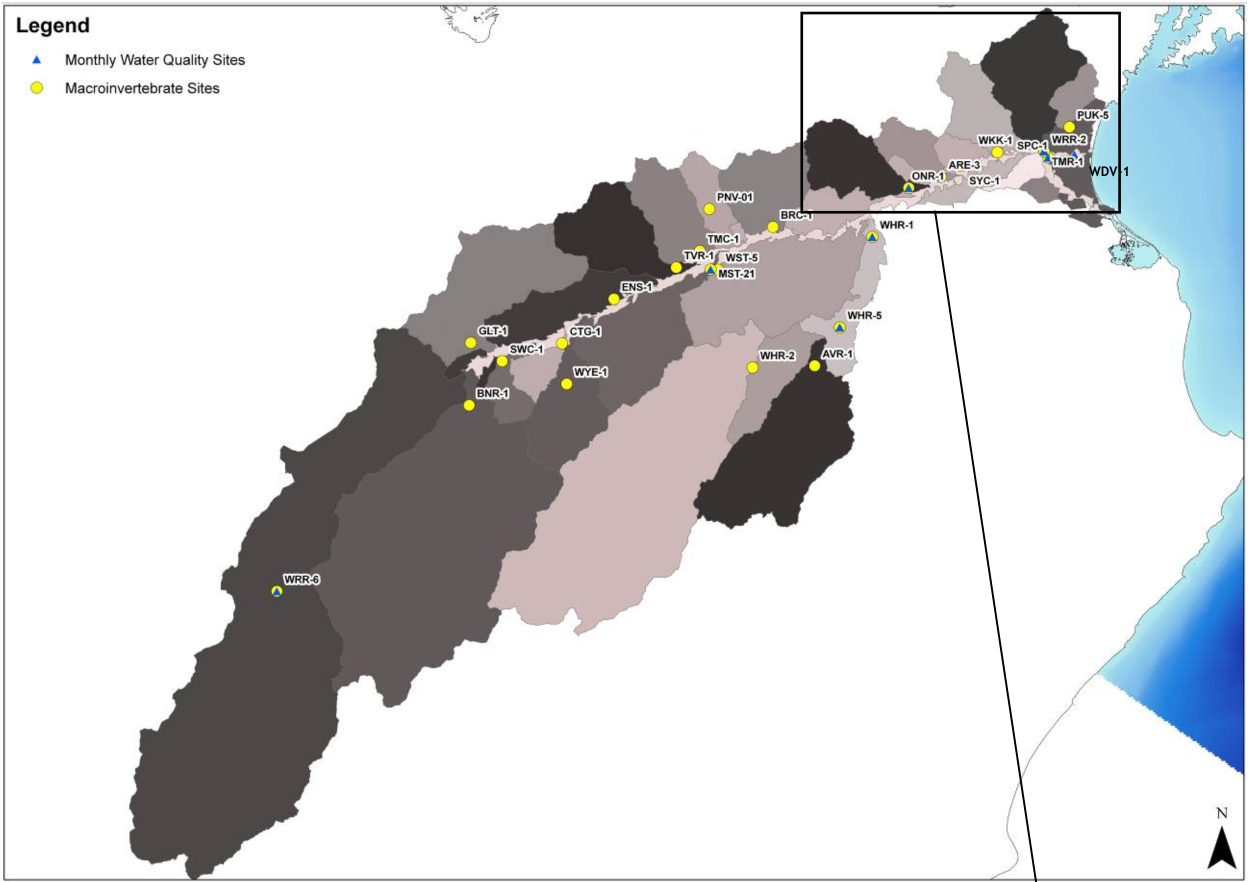
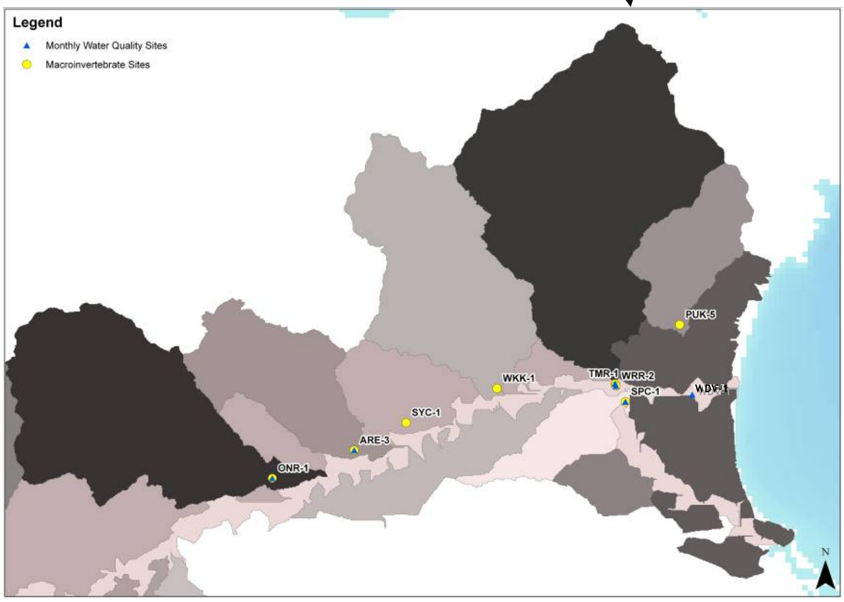
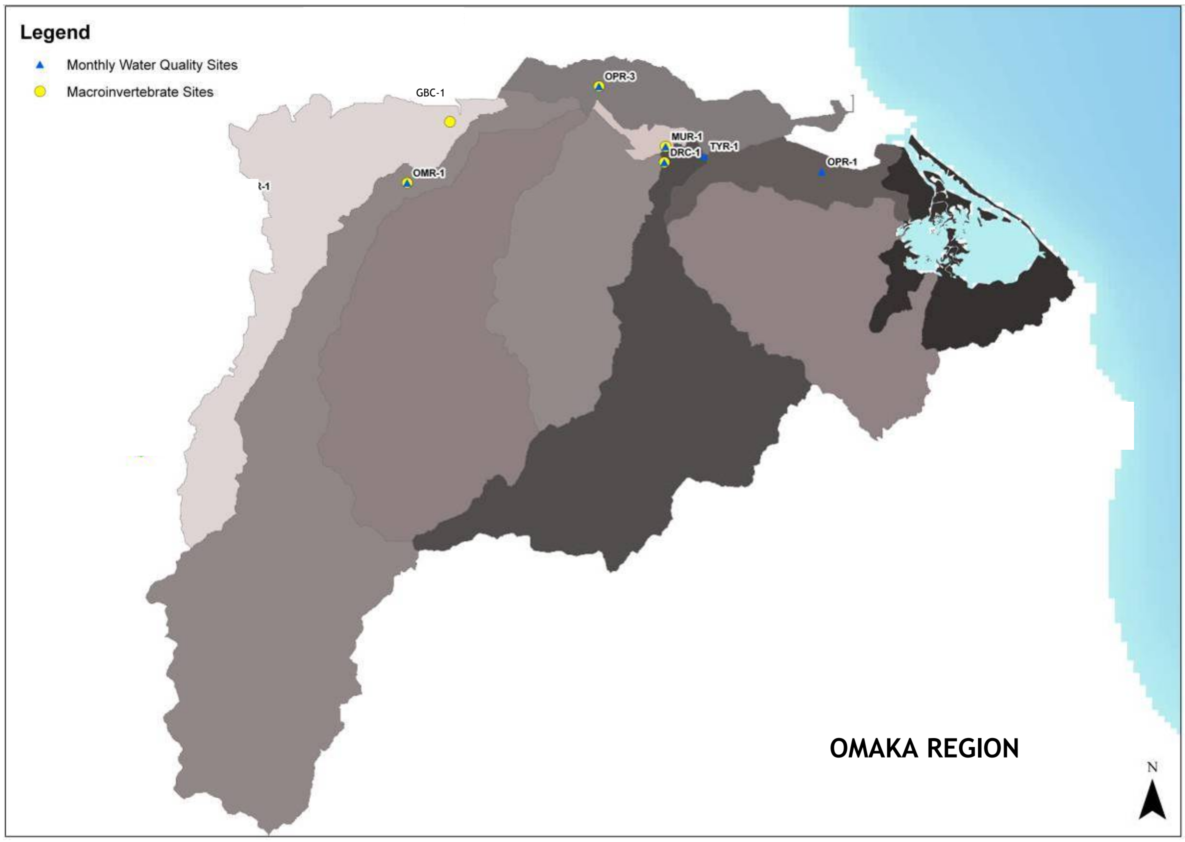
Monthly Water Quality Sites
Macroinvertebrate Sites
ANS-1
DNC-1
KNR-1
KUS-1
GRR-001
DNC-002
CUL-3
WTS-009
KTR-005
N
MARLBOROUGH SOUNDS REGION



WAIRAU AND WAIHOPAI REGIONS

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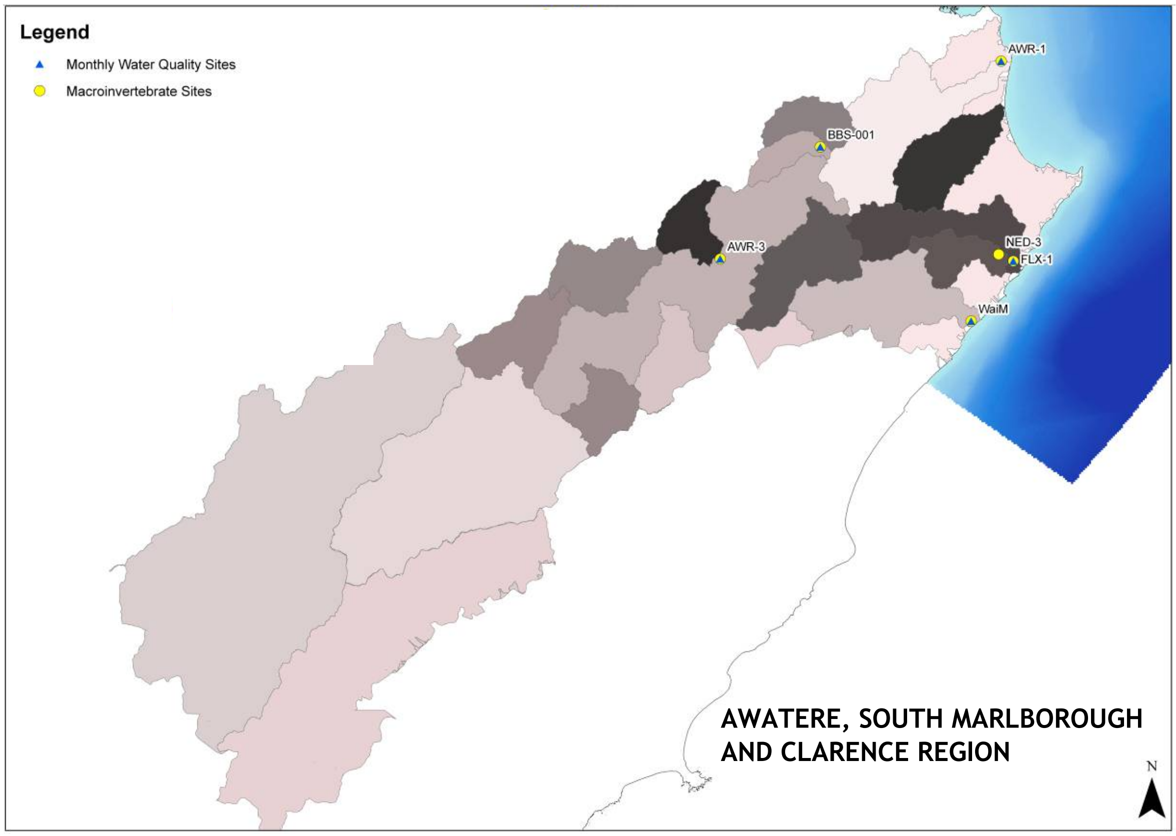
Monthly Water Quality Sites
Macroinvertebrate Sites
GBC-1
OPR-3
MUR-1
DRC-1
TYR-1
OPR-1
OMR-1
OMAKA REGION
N


Legend
Monthly Water Quality Sites
Macroinvertebrate Sites
AWR-1
BBS-001
AWR-3
NED-3
FLX-1
WaiM
AWATERE, SOUTH MARLBOROUGH
AND CLARENCE REGION
N

List of monthly SoE sites and catchment information

Site ID	Site Name	NZ Reach	Easting	Northing	Frequency	Flow	Site Type (REC)	Climate (REC)	Elevation (REC)	Geology (REC)	Pressures
ARE-3	Are Are Creek at Kaituna Tuamarina Road	11027449	2578900	5970850	Monthly since July 2009	Yes	Rural lowland	Cool wet	Lowland	Hard sedimentary	Viticulture, pasture, historic realignment of channel
AWR-1	Awatere at River Mouth	11021883	2605963	5954796	Monthly since February 2007	No	Rural lowland	Cool dry	Hill	Hard sedimentary	Viticulture, Seddon landfill, Seddon wastewater treatment plant
AWR-3	Awatere at Awapiri	11021883	2570719	5929995	Monthly since February 2007	Yes	Upland	Cool dry	Hill	Hard sedimentary	Hill country farming
BBS-001	Black Birch Stream at water intake	11021883	2583282	5944040	Monthly since February 2007	No	Upland	Cool dry	Hill	Hard sedimentary	Low
BNR-1	Branch River at flow site	11024749	2525306	5944887	Monthly since July 2009	Yes	Upland	Cool wet	Mountain	Hard sedimentary	Hydro power station
CUL-3	Cullens Creek upstream of bridge	11011585	2581811	5989883	Monthly since July 2009	No	Rural lowland	Cool wet	Hill	Hard sedimentary	Dairy farming
DNC-002	Duncan Stream	11011381	2585561	5991258	Monthly since July 2008	No	Rural lowland	Cool wet	Lowland	Hard sedimentary	Dairy farming
DRC-1	Doctors Creek at Taylor River Confluence	11018918	2588550	5965400	Monthly since July 2009	No	Rural lowland	Warm dry	Lowland	Alluvium	Viticulture, historic dairying
FLX-1	Flaxbourne at Quarry	11028279	2607501	5929727	Monthly since February 2007	No	Rural lowland	Cool dry	Lowland	Hard sedimentary	Hill country farming
GRR-001	Graham River at road bridge	11010999	2599962	5992336	Monthly since August 2007	No	Rural lowland	Cool wet	Hill	Hard sedimentary	Lowland farming
KNR-1	Kenepuru at NIWA flow site	11008448	2604300	6003929	Monthly since February 2007	Yes	Rural lowland	Cool wet	Lowland	Hard sedimentary	Pasture, farming
KTR-005	Kaituna at Readers Road	11011383	2574884	5988168	Monthly since February 2007	Yes	Rural lowland	Cool wet	Lowland	Hard sedimentary	Dairy farming, pasture, Havelock oxidation ponds
MST-21	Mill Stream at flow site	11019984	2552750	5960325	Monthly since September 2008	Yes	Rural lowland	Cool wet	Hill	Hard sedimentary	Pasture, beef, sheep and deer farming
MUR-1	Murphys Creek at Taylor River Confluence	11018918	2588597	5966040	Monthly since July 2009	No	Urban Spring	Warm dry	Lowland	Alluvium	Urban stormwater, low flows - water abstraction
OMR-1	Omaka at Hawkesbury Road	11018918	2578160	5964570	Monthly since February 2007	No	Rural lowland	Cool dry	Hill	Hard sedimentary	Low
ONR-1	Onamalutu Northbank Road	11015812	2575229	5969594	Monthly since February 2007	Yes	Rural lowland	Cool wet	Lowland	Hard sedimentary	Dairying, pasture
OPO-1	Lower Opouri	11010920	2562207	5999209	Monthly since September 2008	No	Rural lowland	Cool extremely wet	Lowland	Hard sedimentary	Dairying
OPR-1	Opawa River at Swamp Road	11018918	2594901	5965020	Monthly since February 2007	No	Rural lowland	Cool dry	Lowland	Hard sedimentary	Viticulture, urban stormwater
OPR-3	Opawa River at Hammerichs Road	11018918	2585909	5968470	Monthly since February 2007	Yes	Rural lowland	Warm dry	Lowland	Alluvium	Viticulture
PLR-4	Pelorus at Fishermans Flat	11010920	2569576	5991721	Monthly since August 2007	No	Rural lowland	Cool wet	Lowland	Hard sedimentary	Dairying, pasture
PLR-5	Pelorus at Kahikatea Flat	11010920	2557587	5989317	Monthly since February 2007	Yes	Rural lowland	Cool wet	Hill	Hard sedimentary	Dairying
RAR-1	Rai Falls	11010920	2558020	5990970	Monthly since February 2007	Yes	Rural lowland	Cool wet	Lowland	Hard sedimentary	Dairying
RON-4	Lower Ronga at gravel layby	11010920	2559969	5999418	Monthly since September 2008	No	Rural lowland	Cool wet	Mountain	Hard sedimentary	Dairying, shhep, beef cattle
SPC-1	Spring Creek at flood gates	11016643	2591064	5973037	Monthly since February 2007	No	Rural lowland	Warm dry	Lowland	Alluvium	Urban residential, viticulture

TMR-1	Tuamarina at Wairau confluence	11016362	2590600	5973846	Monthly since February 2007	No	Rural lowland	Cool wet	Lowland	Hard sedimentary	Viticulture, historic dairying
TYR-1	Taylor River at Rail Bridge	11018918	2590161	5965648	Monthly since February 2007	No	Rural lowland	Cool dry	Hill	Hard sedimentary	Urban stormwater, historic dairying, viticulture
WaiM	Waima at SH1 bridge	11030144	2602200	5922200	Monthly since August 2007	No	Rural lowland	Cool dry	Hill	Soft sedimentary	Hill country farming
WDV-1	Wairau Diversion at Neals Road	11016624	2594060	5973353	Monthly since August 2007	No	Rural lowland	Warm dry	Lowland	Alluvium	Dairying, viticulture, pasture
WHR-1	Waihopai at SH63 bridge	11018880	2571094	5964027	Monthly since February 2007	No	Rural lowland	Cool dry	Lowland	Alluvium	Viticulture, hill farming
WHR-5	Waihopai at flow station	11018880	2567405	5953749	Monthly since July 2007	Yes	Rural lowland	Cool dry	Hill	Hard sedimentary	Hill farming
WKR-1	Wakamarina at SH Bridge	11010920	2566016	5990425	Monthly since February 2007	No	Rural lowland	Cool extremely wet	Hill	Hard sedimentary	Low
WRR-2	Wairau at SH1 bridge	11016624	2590635	5973743	Monthly since January 1989	Yes	Rural lowland	Cool wet	Mountain	Hard sedimentary	Viticulture, hydropower stations, pasture
WRR-6	Wairau at Dip Flat	11023270	2503477	5923767	Monthly since January 1989	Yes	Upland	Cool wet	Mountain	Hard sedimentary	Low
WTS-009	Waitohi Stream at SH bridge	11011620	2594144	5989933	Monthly since August 2007	No	Rural lowland	Cool wet	Lowland	Hard sedimentary	Urban runoff

Appendix 2: Water quality parameters measured for state of the environment surface water monitoring; the test method used for analysis and the detection limit for each parameter. Analysis is carried out by Environmental Laboratories Services (ELS) Ltd to IANZ accredited standards (February 2007 to June 2011) and Hill Laboratories Ltd (July 2011 to present) at all but the two sites on the Wairau which are sampled and analysed by NIWA.

Environmental Laboratories Services (ELS) Ltd

Test Name	Test Method	Detection Limits
pH	Dedicated pH meter following APHA 21st Edition Method 4500 H. LAS official test 5.03.	<0.1
Suspended Solids - Total	APHA 21st Edition Method 2540 D	<3 g/m³
Conductivity at 25°C	APHA 21st Edition Method 2510 B. LAS official test 5.02.	<0.1 mS/m
Turbidity	Turbidity Meter following APHA 21st Edition Method 2130 B. LAS official test 5.04.	<0.01 NTU
Faecal Coliforms	Membrane Filtration following APHA 21st Edition Method 9222 D	<1 cfu/100mL
E. coli	APHA 21st Edition 9222 G.	<1 cfu/100mL
Inorganic Nitrogen	By Calculation - NNN plus Ammonia	<0.01 g/m³
Nitrite Nitrate Nitrogen	Flow Injection Autoanalyser following APHA 21st Edition Method 4500-NO3 I. LAS official tests 5.13 and 5.14.	<0.005 g/m³
Nitrate - Nitrogen	Ion Chromatography following USEPA 300.0 (modified). LAS official test 5.13.	<0.01 g/m³
Ammonia Nitrogen	Flow Injection Autoanalyser following APHA 21st Edition Method 4500 NH3 H. LAS official test 5.10.	<0.01 g/m³
Dissolved Reactive Phosphorus	Flow Injection Autoanalyser following APHA 21st Edition Method 4500-P G. Official LAS test 5.15.	<0.005 g/m³
Arsenic - Total	ICP-MS following APHA 21st edition method 3125 (modified)	<0.002 g/m³
Copper - Total	ICP-MS following APHA 21st edition method 3125 (modified)	<0.002 g/m³
Zinc - Total	ICP-MS following APHA 21st edition method 3125 (modified)	<0.005 g/m³
Arsenic - Dissolved	ICP-MS following APHA 21st edition method 3125 (modified). LAS official test 5.18	<0.001 g/m³
Copper - Dissolved	ICP-MS following APHA 21st edition method 3125 (modified). LAS official test 5.23	<0.0005 g/m³
Zinc - Dissolved	ICP-MS following APHA 21st edition method 3125 (modified). LAS official test 5.33	<0.002 g/m³
Aqueous Total Metal Digestion	Follows APHA 21st Edition Method 3030E (modified) using nitric acid.	
Sample Filtration	Sample filtered through 0.45 micron filter following APHA 21st Edition Method 3030B.	

'<' means that no analyte was found in the sample at the level of detection shown. Detection limits are based on a clean matrix and may vary according to individual sample.

g/m^3 is the equivalent to mg/L and ppm

Hill Laboratories Ltd

Test	Method Description	Default Detection Limit
Individual Tests		
Filtration, Unpreserved	Sample filtration through 0.45µm membrane filter. Performed at Hill Laboratories - Chemistry; 101c Waterloo Road, Christchurch.	-
Total Digestion	Boiling nitric acid digestion. APHA 3030 E 21st ed. 2005.	-
Total anions for anion/cation balance check	Calculation: sum of anions as mEquiv/L.	0.07 meq/L
Total cations for anion/cation balance check	Calculation: sum of cations as mEquiv/L.	0.05 meq/L
% Difference in Ion Balance	Calculation from Sum of Anions and Cations. Please note: The result reported for the '% Difference in Ion Balance' is an absolute difference between the 'Sum of Anions' and 'Sum of Cations' based on the formula taken from APHA. This does not indicate whether the 'Sum of Anions' or the 'Sum of Cations' produced a higher value. APHA 1030 E 21st ed. 2005.	0.10 %
Turbidity	Analysis using a Hach 2100 Turbidity meter. Analysed at Hill Laboratories - Chemistry; 101c Waterloo Road, Christchurch. APHA 2130 B 21st ed. 2005.	0.05 NTU
pH	pH meter. Analysed at Hill Laboratories - Chemistry; 101c Waterloo Road, Christchurch. APHA 4500-H^+ B 21st ed. 2005.	0.1 pH Units
Total Alkalinity	Titration to pH 4.5 (M-alkalinity), autotitrator. Analysed at Hill Laboratories - Chemistry; 101c Waterloo Road, Christchurch. APHA 2320 B (Modified for alk <20) 21st ed. 2005.	1.0 g/m^3 as $CaCO_3$
Total Hardness	Calculation from Calcium and Magnesium. APHA 2340 B 21st ed. 2005.	1.0 g/m^3 as $CaCO_3$
Electrical Conductivity (EC)	Conductivity meter, 25°C. Analysed at Hill Laboratories - Chemistry; 101c Waterloo Road, Christchurch. APHA 2510 B 21st ed. 2005.	0.1 mS/m
Total Suspended Solids	Filtration using Whatman 934 AH, Advantec GC-50 or equivalent filters (nominal pore size 1.2 - 1.5µm), gravimetric determination. Analysed at Hill Laboratories - Chemistry; 101c Waterloo Road, Christchurch. APHA 2540 D 21st ed. 2005.	3 g/m^3
Filtration for dissolved metals analysis	Sample filtration through 0.45µm membrane filter and preservation with nitric acid. APHA 3030 B 21st ed. 2005.	-
Dissolved Arsenic	Filtered sample, ICP-MS, trace level. APHA 3125 B 21st ed. 2005.	0.0010 g/m^3
Total Arsenic	Nitric acid digestion, ICP-MS, trace level. APHA 3125 B 21st ed. 2005 / US EPA 200.8.	0.0011 g/m^3
Dissolved Calcium	Filtered sample, ICP-MS, trace level. APHA 3125 B 21st ed. 2005.	0.05 g/m^3
Dissolved Copper	Filtered sample, ICP-MS, trace level. APHA 3125 B 21st ed. 2005.	0.0005 g/m^3
Total Copper	Nitric acid digestion, ICP-MS, trace level. APHA 3125 B 21st ed. 2005 / US EPA 200.8.	0.00053 g/m^3
Dissolved Magnesium	Filtered sample, ICP-MS, trace level. APHA 3125 B 21st ed. 2005.	0.02 g/m^3
Dissolved Potassium	Filtered sample, ICP-MS, trace level. APHA 3125 B 21st ed. 2005.	0.05 g/m^3
Dissolved Sodium	Filtered sample, ICP-MS, trace level. APHA 3125 B 21st ed. 2005.	0.02 g/m^3
Dissolved Zinc	Filtered sample, ICP-MS, trace level. APHA 3125 B 21st ed. 2005.	0.0010 g/m^3
Total Zinc	Nitric acid digestion, ICP-MS, trace level. APHA 3125 B 21st ed. 2005 / US EPA 200.8.	0.0011 g/m^3
Chloride	Filtered sample from Christchurch. Ferric thiocyanate colorimetry. Discrete Analyser. APHA 4500 Cl- E (modified from continuous flow analysis) 21st ed. 2005.	0.5 g/m^3
Total Inorganic Nitrogen	Calculation: NH_4-N + NO_3-N + NO_2-N.	0.010 g/m^3
Total Ammoniacal-N	Filtered sample from Christchurch. Phenol/hypochlorite colorimetry. Discrete Analyser. (NH4-N = NH4+-N + NH3-N). APHA 4500-NH3 F (modified from manual analysis) 21st ed. 2005.	0.010 g/m^3
Nitrite-N	Filtered sample from Christchurch. Automated Azo dye colorimetry, Flow injection analyser. APHA 4500-NO3- I (Modified) 21st ed. 2005.	0.002 g/m^3
Nitrate-N	Calculation: (Nitrate-N + Nitrite-N) - NO2N.	0.002 g/m^3
Nitrate-N + Nitrite-N	Filtered sample from Christchurch. Total oxidised nitrogen. Automated cadmium reduction, flow injection analyser. APHA 4500-NO3- I (Modified) 21st ed. 2005.	0.002 g/m^3
Dissolved Reactive Phosphorus	Filtered sample from Christchurch. Molybdenum blue colorimetry. Discrete Analyser. APHA 4500-P E (modified from manual analysis) 21st ed. 2005.	0.004 g/m^3
Reactive Silica	Filtered sample from Christchurch. Heteropoly blue colorimetry. Discrete analyser. APHA 4500-SiO2 F (modified from flow injection analysis) 21st ed. 2005.	0.10 g/m^3 as SiO_2
Sulphate	Filtered sample from Christchurch. Ion Chromatography. APHA 4110 B 21st ed. 2005.	0.5 g/m^3
Cation Profile		-
Faecal Coliforms and E. coli profile		
Faecal Coliforms	Membrane Filtration, Count on mFC agar, Incubated at 44.5°C for 22 hours, Confirmation Analysed at Hill Laboratories - Microbiology; 101c Waterloo Road, Hornby, Christchurch. APHA 9222 D, 21st ed. 2005.	1 cfu / 100mL
Escherichia coli	Membrane filtration, Count on mFC agar, Incubated at 44.5°C for 22 hours, MUG Confirmation Analysed at Hill Laboratories - Microbiology; 101c Waterloo Road, Hornby, Christchurch. APHA 9222 G, 21st ed. 2005.	1 cfu / 100mL

Appendix 3: Summary statistics for each water quality parameter for the 34 state of the environment (SoE) water quality monitoring sites.

Descriptive Statistics Ammonia (mg/L) 2007-2011										
	Valid Number	Mean	Median	Minimum	Maximum	Lower Quartile	Upper Quartile	10%ile	90%ile	Standard Deviation.
ARE-3	30	0.022267	0.010000	0.005000	0.160000	0.005000	0.024000	0.005000	0.049500	0.030809
AWR -1	58	0.010431	0.005000	0.005000	0.080000	0.005000	0.005000	0.005000	0.023000	0.015052
AWR-3	59	0.037712	0.005000	0.005000	0.724000	0.005000	0.005000	0.005000	0.017000	0.119000
BBS-001	18	0.003139	0.002500	0.002500	0.008000	0.002500	0.002500	0.002500	0.006000	0.001561
BNR-1	29	0.005552	0.005000	0.005000	0.011000	0.005000	0.005000	0.005000	0.010000	0.001660
CUL-3	27	0.008667	0.005000	0.005000	0.047000	0.005000	0.005000	0.005000	0.020000	0.009668
DNC-002	41	0.014146	0.010000	0.005000	0.060000	0.005000	0.020000	0.005000	0.030000	0.012228
DRC-1	31	0.015484	0.005000	0.005000	0.070000	0.005000	0.020000	0.005000	0.036000	0.018756
FLX-1	59	0.007424	0.005000	0.005000	0.050000	0.005000	0.005000	0.005000	0.013000	0.007035
GRR-001	53	0.006245	0.005000	0.005000	0.043000	0.005000	0.005000	0.005000	0.005000	0.005595
KNR-1	55	0.007709	0.005000	0.005000	0.055000	0.005000	0.005000	0.005000	0.016000	0.008335
KTR-005	59	0.007508	0.005000	0.005000	0.030000	0.005000	0.010000	0.005000	0.015000	0.004851
MST-21	38	0.006868	0.005000	0.005000	0.020000	0.005000	0.005000	0.005000	0.018000	0.004651
MUR-1	30	0.006100	0.005000	0.005000	0.023000	0.005000	0.005000	0.005000	0.007500	0.003772
OMR-1	57	0.005737	0.005000	0.005000	0.030000	0.005000	0.005000	0.005000	0.005000	0.003543
ONR-1	59	0.005780	0.005000	0.005000	0.030000	0.005000	0.005000	0.005000	0.005000	0.003582
OPO-1	49	0.005204	0.005000	0.005000	0.010000	0.005000	0.005000	0.005000	0.005000	0.001000
OPR-1	60	0.012617	0.010000	0.005000	0.044000	0.005000	0.018000	0.005000	0.025000	0.009510
OPR-3	60	0.008600	0.005000	0.005000	0.165000	0.005000	0.005000	0.005000	0.010000	0.020660
PLR-4	53	0.007151	0.005000	0.005000	0.054000	0.005000	0.005000	0.005000	0.011000	0.007705
PLR-5	59	0.006441	0.005000	0.005000	0.048000	0.005000	0.005000	0.005000	0.005000	0.006188
RAR-1	68	0.009088	0.005000	0.005000	0.236000	0.005000	0.005000	0.005000	0.010000	0.028010
RON-4	49	0.007000	0.005000	0.004000	0.080000	0.005000	0.005000	0.005000	0.006000	0.010826
SPC-1	59	0.006542	0.005000	0.005000	0.020000	0.005000	0.005000	0.005000	0.011000	0.003664
TMR-1	59	0.010000	0.005000	0.005000	0.071000	0.005000	0.013000	0.005000	0.020000	0.009847
TYR-1	60	0.012833	0.005000	0.005000	0.105000	0.005000	0.012000	0.005000	0.021500	0.017489
WaiM	51	0.005353	0.005000	0.002000	0.020000	0.005000	0.005000	0.005000	0.005000	0.002296
WDV-1	53	0.011057	0.005000	0.005000	0.030000	0.005000	0.019000	0.005000	0.024000	0.008179
WHR-1	59	0.016339	0.005000	0.005000	0.560000	0.005000	0.005000	0.005000	0.011000	0.072534
WHR-5	53	0.006264	0.005000	0.005000	0.038000	0.005000	0.005000	0.005000	0.005000	0.005035
WKR-1	59	0.005593	0.005000	0.005000	0.019000	0.005000	0.005000	0.005000	0.005000	0.002386
WRR-2	60	0.002775	0.003000	0.000500	0.010000	0.001500	0.004000	0.001000	0.005000	0.001745
WRR-6	60	0.001975	0.001500	0.000500	0.009000	0.001000	0.002000	0.000500	0.004000	0.001661
WTS-009	53	0.006189	0.005000	0.005000	0.033000	0.005000	0.005000	0.005000	0.005000	0.004715

Descriptive Statistics Dissolved Oxygen (% saturation) 2007-2011										
	Valid Number	Mean	Median	Minimum	Maximum	Lower Quartile	Upper Quartile	10%ile	90%ile	Standard Deviation.
ARE-3	30	102.5833	100.4500	59.50000	130.0000	91.9000	117.0000	85.10000	126.0000	16.30773
AWR -1	44	100.8545	100.5000	77.20000	116.0000	98.1000	104.0000	93.90000	109.0000	6.43835
AWR-3	44	96.9295	97.0000	88.70000	111.0000	93.5000	99.8500	92.00000	101.0000	4.53224
BNR-1	24	95.1000	94.8000	86.00000	103.0000	91.7500	97.7500	90.20000	102.0000	4.40010
CUL-3	27	96.3333	94.5000	81.60000	123.0000	93.3000	99.0000	88.60000	105.0000	7.75063
DNC-002	41	87.5098	88.2000	60.40000	98.9000	84.3000	93.4000	77.90000	95.9000	8.02994
DRC-1	30	101.2433	99.5500	72.20000	138.0000	87.2000	110.0000	79.15000	128.5000	17.32868
FLX-1	46	108.4739	105.0000	83.60000	150.0000	96.2000	115.0000	92.10000	136.0000	16.09941
GRR-001	50	97.9800	98.1000	80.30000	140.0000	93.8000	102.0000	86.50000	104.5000	9.49257
KNR-1	49	94.0531	97.3000	39.90000	119.0000	93.7000	101.0000	69.50000	104.0000	14.01817
KTR-005	50	95.4940	93.9500	79.10000	123.0000	91.1000	97.2000	88.40000	104.0000	7.70206
MST-21	34	92.3912	91.7500	56.60000	109.0000	89.1000	99.8000	82.30000	105.0000	10.20723
MUR-1	29	80.3345	79.8000	70.70000	91.7000	75.2000	84.9000	73.10000	88.1000	5.66078
OMR-1	50	90.7060	92.9500	51.90000	126.0000	87.9000	96.5000	72.45000	103.5000	13.43081
ONR-1	51	95.5020	94.9000	83.90000	112.0000	92.1000	97.8000	88.60000	103.0000	5.61161
OPO-1	49	94.3041	93.3000	85.20000	110.0000	91.3000	96.6000	89.40000	99.9000	5.26790
OPR-1	53	98.8151	100.0000	32.50000	137.0000	88.2000	106.0000	81.10000	121.0000	17.56555
OPR-3	52	107.5846	105.5000	75.40000	125.0000	101.5000	117.0000	99.30000	120.0000	9.60291
PLR-4	50	99.3100	97.4000	87.60000	120.0000	95.4000	102.0000	91.65000	112.5000	7.23733
PLR-5	52	99.1769	97.6000	91.10000	130.0000	95.5500	100.0000	92.50000	109.0000	7.03692
RAR-1	61	100.9246	101.0000	86.50000	120.0000	96.6000	104.0000	93.10000	111.0000	6.68348
RON-4	49	83.9082	83.2000	69.80000	106.0000	78.6000	88.2000	74.50000	93.1000	7.82413
SPC-1	51	85.4510	84.9000	65.40000	110.0000	76.2000	93.3000	72.00000	98.4000	10.79295
TMR-1	51	72.5980	72.5000	25.90000	120.0000	54.4000	87.4000	47.50000	96.4000	20.83514

TYR-1	51	104.0980	102.0000	68.90000	143.0000	92.7000	114.0000	87.10000	126.0000	16.06552
WaiM	42	92.1024	91.7000	63.50000	134.0000	84.5000	95.5000	78.20000	107.0000	12.62505
WDV-1	51	93.8137	93.8000	80.80000	130.0000	88.9000	97.6000	85.80000	102.0000	7.92237
WHR-1	50	98.8860	98.8500	77.40000	113.0000	96.2000	101.0000	93.90000	107.0000	5.68435
WHR-5	49	98.3612	98.7000	80.90000	106.0000	96.8000	100.0000	94.60000	104.0000	4.39027
WKR-1	51	97.2706	96.6000	85.60000	115.0000	93.9000	99.2000	91.60000	104.0000	5.96357
WRR-2	60	103.9400	103.1500	96.10000	117.5000	99.7500	106.6500	98.00000	111.6500	5.24948
WRR-6	60	100.5033	100.5500	97.50000	102.3000	100.2000	100.9000	99.50000	101.2000	0.78481
WTS-009	52	107.4019	106.5000	86.70000	134.0000	101.5000	112.0000	96.70000	118.0000	9.36812

Descriptive Statistics Dissolved Reactive Phosphorus (mg/L) 2007-2011										
	Valid Number	**Mean**	**Median**	**Minimum**	**Maximum**	**Lower Quartile**	**Upper Quartile**	**10%ile**	**90%ile**	**Standard Deviation.**
ARE-3	30	0.018533	0.017500	0.001000	0.069000	0.011000	0.024000	0.004000	0.033000	0.013871
AWR -1	57	0.013474	0.010000	0.002000	0.067000	0.006000	0.016000	0.005000	0.026000	0.011720
AWR-3	59	0.017627	0.013000	0.002000	0.089000	0.010000	0.016000	0.006000	0.030000	0.018987
BBS-001	18	0.015333	0.014500	0.012000	0.034000	0.013000	0.015000	0.012000	0.018000	0.004899
BNR-1	29	0.009000	0.009000	0.002000	0.023000	0.008000	0.010000	0.005000	0.012000	0.003694
CUL-3	27	0.019852	0.019000	0.002000	0.047000	0.016000	0.024000	0.012000	0.032000	0.009214
DNC-002	41	0.017610	0.016000	0.006000	0.055000	0.013000	0.019000	0.010000	0.026000	0.008902
DRC-1	31	0.025548	0.025000	0.001000	0.048000	0.021000	0.032000	0.019000	0.035000	0.010148
FLX-1	59	0.011254	0.010000	0.002000	0.034000	0.006000	0.014000	0.002000	0.023000	0.007820
GRR-001	52	0.013442	0.013000	0.006000	0.023000	0.011000	0.016000	0.009000	0.019000	0.003707
KNR-1	55	0.009400	0.010000	0.002000	0.033000	0.007000	0.011000	0.002000	0.013000	0.005377
KTR-005	59	0.011203	0.012000	0.002000	0.020000	0.009000	0.014000	0.005000	0.016000	0.003995
MST-21	38	0.016368	0.017000	0.002000	0.026000	0.014000	0.020000	0.010000	0.023000	0.005053
MUR-1	30	0.014933	0.014000	0.001000	0.060000	0.011000	0.017000	0.005000	0.019000	0.010184
OMR-1	57	0.008070	0.008000	0.002000	0.020000	0.005000	0.010000	0.002000	0.014000	0.004391
ONR-1	59	0.008763	0.009000	0.002000	0.014000	0.007000	0.012000	0.002000	0.013000	0.003505
OPO-1	48	0.012792	0.013500	0.002000	0.017000	0.012000	0.015000	0.010000	0.016000	0.003445
OPR-1	60	0.016533	0.015000	0.001000	0.033000	0.012500	0.021000	0.009000	0.024500	0.007191
OPR-3	60	0.008117	0.007000	0.001000	0.038000	0.005000	0.010000	0.002000	0.014500	0.006333
PLR-4	53	0.009660	0.009000	0.002000	0.017000	0.007000	0.013000	0.005000	0.014000	0.003828
PLR-5	59	0.010237	0.010000	0.002000	0.017000	0.008000	0.013000	0.006000	0.014000	0.003617
RAR-1	68	0.011632	0.012000	0.002000	0.020000	0.010000	0.014000	0.006000	0.016000	0.003955
RON-4	49	0.013469	0.013000	0.002000	0.043000	0.012000	0.015000	0.005000	0.018000	0.005916
SPC-1	59	0.013237	0.013000	0.006000	0.019000	0.012000	0.015000	0.010000	0.017000	0.002648
TMR-1	59	0.014831	0.014000	0.006000	0.036000	0.011000	0.018000	0.008000	0.022000	0.005347
TYR-1	60	0.018450	0.017000	0.001000	0.064000	0.015000	0.020500	0.011000	0.026000	0.008730
WaiM	51	0.006333	0.006000	0.002000	0.023000	0.002000	0.008000	0.002000	0.011000	0.003928
WDV-1	53	0.013094	0.012000	0.002000	0.024000	0.010000	0.017000	0.007000	0.018000	0.004579
WHR-1	59	0.012678	0.010000	0.002000	0.154000	0.006000	0.013000	0.005000	0.015000	0.020443
WHR-5	53	0.012226	0.012000	0.002000	0.043000	0.009000	0.014000	0.006000	0.017000	0.005902
WKR-1	59	0.011610	0.012000	0.002000	0.019000	0.011000	0.014000	0.006000	0.015000	0.003494
WRR-2	60	0.004225	0.004000	0.000500	0.010000	0.002000	0.006000	0.002000	0.007000	0.002203
WRR-6	60	0.003467	0.003000	0.002000	0.006000	0.003000	0.004000	0.002000	0.005000	0.001033
WTS-009	53	0.014623	0.015000	0.001000	0.033000	0.013000	0.017000	0.008000	0.019000	0.005630

Descriptive Statistics *E. coli* (cfu/100mL) 2007-2011										
	Valid Number	**Mean**	**Median**	**Minimum**	**Maximum**	**Lower Quartile**	**Upper Quartile**	**10%ile**	**90%ile**	**Standard Deviation.**
ARE-3	30	738.9667	160.0000	14.00000	5100.00	61.0000	800.0000	18.00000	2300.000	1277.683
AWR -1	58	100.7586	26.0000	1.00000	2900.00	8.0000	72.0000	3.00000	140.000	379.824
AWR-3	59	45.1186	13.0000	1.00000	770.00	6.0000	30.0000	2.00000	100.000	115.426
BBS-001	18	2.5556	1.0000	1.00000	5.00	1.0000	5.0000	1.00000	5.000	1.917
BNR-1	29	72.2069	5.0000	1.00000	1600.00	1.0000	16.0000	1.00000	70.000	296.030
CUL-3	27	723.8889	210.0000	48.00000	5900.00	100.0000	380.0000	60.00000	2000.000	1416.059
DNC-002	41	524.8293	180.0000	6.00000	3900.00	140.0000	500.0000	70.00000	1200.000	762.185
DRC-1	31	339.6774	170.0000	42.00000	1400.00	120.0000	310.0000	57.00000	1100.000	404.266
FLX-1	59	680.4746	64.0000	2.00000	28000.00	33.0000	170.0000	10.00000	400.000	3650.487
GRR-001	53	199.3019	51.0000	1.00000	2600.00	22.0000	130.0000	12.00000	300.000	482.061
KNR-1	54	253.4074	120.0000	2.00000	3500.00	92.0000	180.0000	59.00000	290.000	559.170
KTR-005	59	359.9492	88.0000	10.00000	7000.00	49.0000	160.0000	25.00000	500.000	1089.106
MST-21	38	858.9737	130.0000	1.00000	20000.00	76.0000	300.0000	36.00000	1200.000	3234.023
MUR-1	30	138.3667	51.0000	8.00000	1900.00	20.0000	100.0000	11.50000	295.000	346.686
OMR-1	57	18.3684	8.0000	1.00000	190.00	4.0000	22.0000	2.00000	32.000	29.578
ONR-1	59	163.9661	56.0000	1.00000	3900.00	26.0000	110.0000	9.00000	170.000	546.967
OPO-1	49	69.6939	54.0000	9.00000	400.00	32.0000	86.0000	15.00000	140.000	66.364

OPR-1	59	105.2373	24.0000	1.00000	3600.00	14.0000	54.0000	8.00000	140.000	466.170
OPR-3	59	81.1864	51.0000	1.00000	750.00	27.0000	89.0000	9.00000	160.000	114.198
PLR-4	53	92.3019	24.0000	1.00000	2000.00	12.0000	70.0000	3.00000	140.000	280.026
PLR-5	57	34.0702	14.0000	1.00000	250.00	8.0000	29.0000	5.00000	80.000	51.201
RAR-1	68	185.4412	53.5000	6.00000	6200.00	31.5000	96.0000	20.00000	270.000	752.069
RON-4	49	329.5714	57.0000	1.00000	5300.00	32.0000	180.0000	11.00000	250.000	957.831
SPC-1	59	56.0000	48.0000	1.00000	190.00	33.0000	68.0000	24.00000	110.000	35.683
TMR-1	59	184.2542	48.0000	3.00000	6700.00	29.0000	70.0000	13.00000	150.000	871.138
TYR-1	59	341.5763	60.0000	6.00000	9400.00	39.0000	140.0000	18.00000	310.000	1340.761
WaiM	51	92.2353	27.0000	1.00000	1000.00	14.0000	89.0000	3.00000	240.000	169.777
WDV-1	53	203.2264	46.0000	2.00000	4600.00	15.0000	83.0000	7.00000	220.000	669.823
WHR-1	59	90.3898	12.0000	1.00000	880.00	4.0000	73.0000	1.00000	190.000	192.199
WHR-5	53	78.0566	30.0000	1.00000	831.00	9.0000	61.0000	4.00000	150.000	155.565
WKR-1	58	69.3103	22.0000	1.00000	1600.00	11.0000	41.0000	7.00000	69.000	221.439
WRR-2	59	49.9746	10.7000	1.00000	1203.30	3.0000	31.4000	1.00000	101.000	163.298
WRR-6	57	23.3649	7.4000	1.00000	101.00	2.0000	20.1000	1.00000	101.000	36.628
WTS-009	53	164.1132	81.0000	13.00000	1500.00	42.0000	150.0000	24.00000	230.000	298.749

Descriptive Statistics Nitrate (mg/L) 2007-2011										
	Valid Number	**Mean**	**Median**	**Minimum**	**Maximum**	**Lower Quartile**	**Upper Quartile**	**10%ile**	**90%ile**	**Standard Deviation.**
ARE-3	30	0.684533	0.690000	0.030000	1.041000	0.500000	0.900000	0.420000	0.956500	0.233792
AWR -1	58	0.085552	0.020000	0.005000	0.876000	0.005000	0.096000	0.005000	0.247000	0.159249
AWR-3	59	0.022797	0.005000	0.004000	0.140000	0.005000	0.040000	0.005000	0.060000	0.029268
BBS-001	18	0.022944	0.014500	0.008000	0.079000	0.012000	0.021000	0.010000	0.067000	0.020107
BNR-1	29	0.013345	0.005000	0.001000	0.070000	0.005000	0.012000	0.005000	0.040000	0.016290
CUL-3	27	0.333259	0.310000	0.005000	0.910000	0.230000	0.410000	0.131000	0.460000	0.185422
DNC-002	41	0.378195	0.351000	0.005000	0.804000	0.260000	0.520000	0.060000	0.620000	0.201677
DRC-1	31	1.545742	1.590000	0.005000	2.790000	1.240000	1.910000	1.070000	2.290000	0.604656
FLX-1	59	0.116780	0.005000	0.001000	0.940000	0.005000	0.050000	0.005000	0.568000	0.258111
GRR-001	53	0.029660	0.020000	0.001000	0.089000	0.005000	0.049000	0.005000	0.070000	0.024691
KNR-1	55	0.155473	0.161000	0.005000	0.370000	0.070000	0.235000	0.020000	0.270000	0.095549
KTR-005	59	0.887424	0.820000	0.005000	2.360000	0.660000	1.090000	0.400000	1.516000	0.442342
MST-21	38	1.993211	1.935000	0.840000	3.147000	1.660000	2.426000	1.200000	2.797000	0.548720
MUR-1	30	1.330533	1.296500	0.180000	1.970000	1.170000	1.510000	1.060000	1.715000	0.333030
OMR-1	57	0.293596	0.236000	0.005000	1.081000	0.080000	0.388000	0.035000	0.705000	0.264879
ONR-1	59	0.201847	0.200000	0.005000	0.416000	0.150000	0.240000	0.099000	0.340000	0.084816
OPO-1	49	0.409408	0.415000	0.240000	0.720000	0.326000	0.470000	0.270000	0.535000	0.105060
OPR-1	60	1.079167	0.973000	0.005000	3.188000	0.790000	1.214500	0.575000	1.817000	0.589895
OPR-3	60	0.439583	0.170000	0.003000	3.612000	0.020000	0.570500	0.005000	1.390000	0.670083
PLR-4	53	0.250226	0.255000	0.005000	0.450000	0.190000	0.321000	0.140000	0.376000	0.104347
PLR-5	59	0.027441	0.020000	0.001000	0.078000	0.005000	0.050000	0.005000	0.060000	0.022998
RAR-1	68	0.650324	0.644500	0.270000	1.060000	0.506000	0.770500	0.440000	0.915000	0.179059
RON-4	49	0.767714	0.743000	0.340000	1.080000	0.660000	0.886000	0.560000	0.973000	0.165250
SPC-1	59	0.318203	0.250000	0.130000	0.962000	0.195000	0.429000	0.160000	0.520000	0.172426
TMR-1	59	0.345780	0.346000	0.005000	1.034000	0.060000	0.540000	0.013000	0.777000	0.293286
TYR-1	60	1.494217	1.356500	0.010000	3.744000	1.095000	1.622000	0.950000	2.218500	0.685781
WaiM	51	0.110490	0.090000	0.001000	0.382000	0.020000	0.180000	0.005000	0.270000	0.099569
WDV-1	53	0.214038	0.160000	0.005000	1.051000	0.080000	0.271000	0.030000	0.440000	0.212884
WHR-1	59	0.152492	0.073000	0.001000	0.989000	0.024000	0.228000	0.005000	0.402000	0.194260
WHR-5	53	0.044170	0.005000	0.001000	0.280000	0.005000	0.051000	0.005000	0.160000	0.065195
WKR-1	59	0.021661	0.017000	0.001000	0.066000	0.005000	0.035000	0.005000	0.050000	0.017899
WRR-2	60	0.140983	0.119000	0.012000	0.483000	0.069000	0.189500	0.035500	0.283000	0.100410
WRR-6	60	0.015733	0.011500	0.001000	0.048000	0.005000	0.025500	0.003000	0.033000	0.012539
WTS-009	53	0.022019	0.018000	0.001000	0.060000	0.005000	0.034000	0.005000	0.048000	0.017778

Descriptive Statistics pH 2007-2011										
	Valid Number	**Mean**	**Median**	**Minimum**	**Maximum**	**Lower Quartile**	**Upper Quartile**	**10%ile**	**90%ile**	**Standard Deviation.**
ARE-3	30	7.260000	7.250000	6.900000	7.800000	7.000000	7.400000	6.900000	7.600000	0.256770
AWR -1	57	8.247368	8.200000	7.800000	8.800000	8.000000	8.500000	8.000000	8.600000	0.252208
AWR-3	58	7.951724	7.950000	7.500000	8.400000	7.800000	8.100000	7.700000	8.200000	0.183763
BBS-001	15	7.600000	7.600000	7.300000	8.000000	7.400000	7.700000	7.300000	8.000000	0.217124
BNR-1	29	7.589655	7.600000	7.200000	7.900000	7.500000	7.700000	7.400000	7.800000	0.144778
CUL-3	27	7.074074	7.000000	6.800000	7.500000	7.000000	7.100000	6.900000	7.400000	0.163125
DNC-002	41	6.712195	6.700000	6.100000	7.400000	6.600000	6.800000	6.300000	7.000000	0.271289
DRC-1	31	7.209677	7.200000	6.900000	7.800000	7.100000	7.300000	7.000000	7.400000	0.200591
FLX-1	59	8.038983	8.000000	7.400000	8.900000	7.800000	8.200000	7.600000	8.400000	0.331671

GRR-001	53	7.275472	7.300000	6.100000	8.200000	7.100000	7.500000	6.900000	7.700000	0.344130
KNR-1	55	7.170909	7.100000	6.300000	8.300000	7.000000	7.400000	6.700000	7.600000	0.377454
KTR-005	59	6.998305	7.100000	6.400000	7.500000	6.800000	7.100000	6.600000	7.300000	0.238885
MST-21	38	7.165789	7.200000	6.700000	7.600000	7.100000	7.300000	6.800000	7.400000	0.200373
MUR-1	29	6.775862	6.700000	6.600000	7.300000	6.700000	6.800000	6.600000	7.200000	0.192085
OMR-1	57	7.407018	7.500000	6.700000	8.000000	7.200000	7.600000	6.800000	7.900000	0.346853
ONR-1	59	7.205085	7.200000	6.600000	7.900000	7.000000	7.400000	6.800000	7.600000	0.280039
OPO-1	49	6.959184	7.000000	6.300000	7.700000	6.900000	7.100000	6.600000	7.200000	0.255700
OPR-1	60	7.405000	7.350000	6.900000	8.500000	7.200000	7.500000	7.100000	7.850000	0.329573
OPR-3	60	8.188333	8.150000	7.100000	9.600000	7.700000	8.700000	7.450000	9.000000	0.588619
PLR-4	53	7.377358	7.400000	6.500000	8.700000	7.100000	7.500000	7.000000	7.700000	0.352814
PLR-5	59	7.550847	7.600000	6.800000	8.200000	7.400000	7.800000	7.100000	7.900000	0.288500
RAR-1	68	7.108824	7.200000	6.500000	7.500000	6.900000	7.300000	6.700000	7.400000	0.243565
RON-4	49	6.695918	6.700000	5.800000	7.200000	6.500000	7.000000	6.300000	7.100000	0.314880
SPC-1	59	7.144068	7.100000	6.600000	7.900000	7.000000	7.300000	6.800000	7.500000	0.262134
TMR-1	59	7.050847	7.000000	6.500000	7.800000	6.800000	7.300000	6.600000	7.400000	0.317519
TYR-1	60	7.101667	7.100000	6.500000	8.000000	6.950000	7.300000	6.800000	7.400000	0.290232
WaiM	51	8.100000	8.100000	7.600000	9.100000	7.900000	8.300000	7.800000	8.400000	0.274955
WDV-1	53	7.373585	7.400000	6.500000	9.300000	7.200000	7.500000	7.000000	7.700000	0.380360
WHR-1	59	7.586441	7.600000	6.900000	9.100000	7.400000	7.800000	7.200000	7.900000	0.342636
WHR-5	53	7.735849	7.700000	7.100000	9.100000	7.500000	7.900000	7.400000	8.100000	0.355773
WKR-1	59	7.254237	7.300000	6.400000	7.700000	7.100000	7.400000	6.800000	7.600000	0.286671
WRR-2	60	7.698667	7.650000	7.320000	8.570000	7.500000	7.820000	7.400000	8.080000	0.274785
WRR-6	60	7.655333	7.640000	7.330000	7.930000	7.555000	7.740000	7.510000	7.840000	0.128201
WTS-009	53	7.960377	7.900000	6.900000	9.400000	7.500000	8.300000	7.200000	8.700000	0.587805

Descriptive Statistics Suspended Solids (mg/L) 2007-2011

	Valid Number	Mean	Median	Minimum	Maximum	Lower Quartile	Upper Quartile	10%ile	90%ile	Standard Deviation.
ARE-3	30	11.3000	3.00000	1.500000	185.000	1.500000	6.0000	1.500000	18.5000	33.4462
AWR -1	57	124.7719	23.00000	1.500000	2270.000	4.000000	116.0000	1.500000	291.0000	328.1204
AWR-3	59	106.3305	18.00000	1.500000	1630.000	4.000000	76.0000	1.500000	328.0000	246.8693
BBS-001	0									
BNR-1	29	37.7241	1.50000	1.500000	415.000	1.500000	1.5000	1.500000	231.0000	110.1483
CUL-3	27	4.0556	1.50000	1.500000	41.000	1.500000	3.5000	1.500000	6.0000	7.6703
DNC-002	41	16.5854	8.00000	3.000000	84.000	5.000000	15.0000	5.000000	42.0000	19.6799
DRC-1	31	13.3226	8.00000	1.500000	54.000	5.000000	17.0000	1.500000	31.0000	13.6989
FLX-1	59	4.6441	1.50000	1.500000	33.000	1.500000	6.0000	1.500000	11.0000	6.1111
GRR-001	53	4.7642	1.50000	1.500000	141.000	1.500000	1.5000	1.500000	5.0000	19.1381
KNR-1	55	1.8727	1.50000	1.500000	6.000	1.500000	1.5000	1.500000	3.0000	0.9870
KTR-005	58	5.0690	1.50000	1.500000	98.000	1.500000	3.0000	1.500000	6.0000	13.8749
MST-21	38	7.9079	6.00000	1.500000	52.000	3.000000	7.0000	1.500000	18.0000	9.3742
MUR-1	30	1.7833	1.50000	1.000000	6.000	1.500000	1.5000	1.500000	2.7500	0.9798
OMR-1	57	2.9298	1.50000	1.500000	38.000	1.500000	1.5000	1.500000	7.0000	5.1378
ONR-1	58	8.6897	1.50000	1.500000	228.000	1.500000	1.5000	1.500000	11.0000	31.7057
OPO-1	49	1.9694	1.50000	1.500000	12.000	1.500000	1.5000	1.500000	1.5000	2.0218
OPR-1	60	2.7417	1.50000	1.500000	18.000	1.500000	3.0000	1.500000	4.5000	2.8796
OPR-3	59	5.8898	3.00000	1.500000	42.000	1.500000	7.0000	1.500000	12.0000	7.6390
PLR-4	53	2.4057	1.50000	1.500000	13.000	1.500000	1.5000	1.500000	5.0000	2.5383
PLR-5	59	3.9661	1.50000	1.500000	94.000	1.500000	1.5000	1.500000	5.0000	12.4273
RAR-1	68	2.9191	1.50000	1.500000	50.000	1.500000	1.5000	1.500000	4.0000	6.4221
RON-4	49	2.2755	1.50000	1.500000	14.000	1.500000	1.5000	1.500000	4.0000	2.4089
SPC-1	59	1.6017	1.50000	1.000000	6.000	1.500000	1.5000	1.500000	1.5000	0.6001
TMR-1	59	3.5847	1.50000	1.000000	20.000	1.500000	4.0000	1.500000	11.0000	4.4268
TYR-1	60	5.6500	1.50000	1.000000	68.000	1.500000	5.0000	1.500000	10.0000	9.8996
WaiM	51	13.0490	1.50000	1.500000	309.000	1.500000	2.5000	1.500000	8.0000	45.9918
WDV-1	53	19.8302	5.00000	1.500000	317.000	1.500000	10.0000	1.500000	36.0000	49.4467
WHR-1	59	38.8644	1.50000	1.500000	1140.000	1.500000	9.0000	1.500000	95.0000	154.7997
WHR-5	53	50.0472	1.50000	1.000000	1380.000	1.500000	8.0000	1.500000	63.0000	198.1272
WKR-1	58	2.5000	1.50000	1.500000	34.000	1.500000	1.5000	1.500000	2.0000	4.6632
WRR-2	53	1.8491	1.50000	1.500000	8.000	1.500000	1.5000	1.500000	1.5000	1.1832
WRR-6	30	11.3000	3.00000	1.500000	185.000	1.500000	6.0000	1.500000	18.5000	33.4462
WTS-009	57	124.7719	23.00000	1.500000	2270.000	4.000000	116.0000	1.500000	291.0000	328.1204

Descriptive Statistics Temperature (^{o}C) 2007-2011

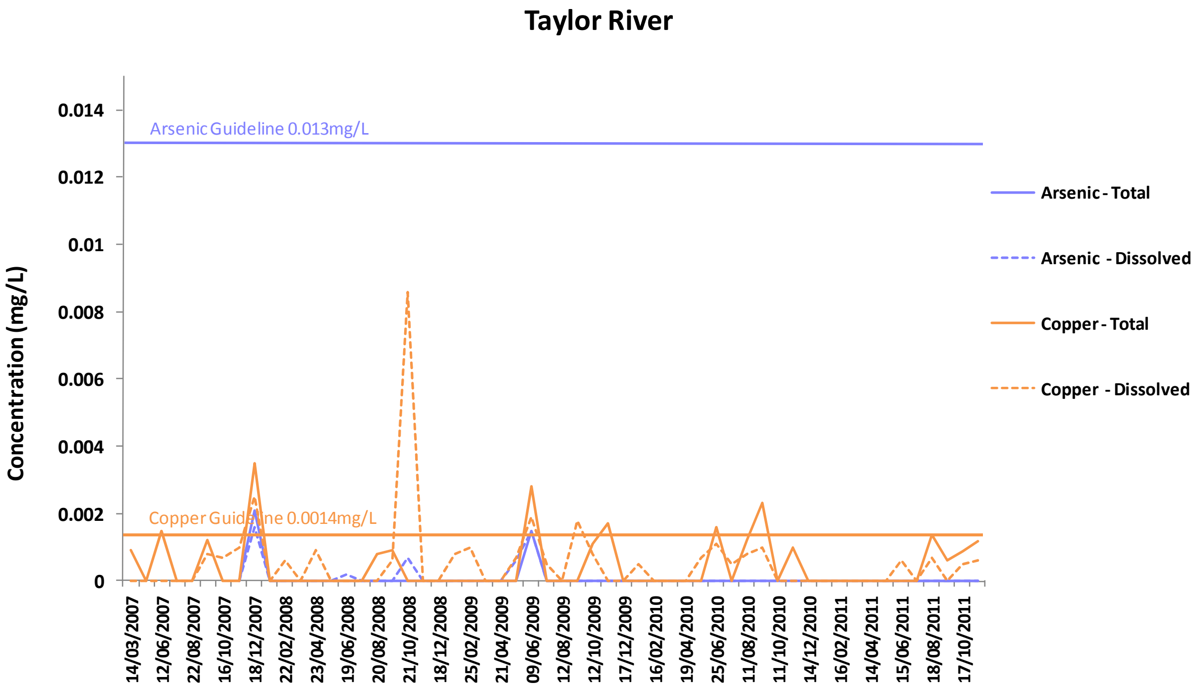
	Valid Number	Mean	Median	Minimum	Maximum	Lower Quartile	Upper Quartile	10%ile	90%ile	Standard Deviation.
ARE-3	30	13.62000	13.45000	7.40000	21.70000	11.00000	15.20000	9.70000	17.85000	3.386729

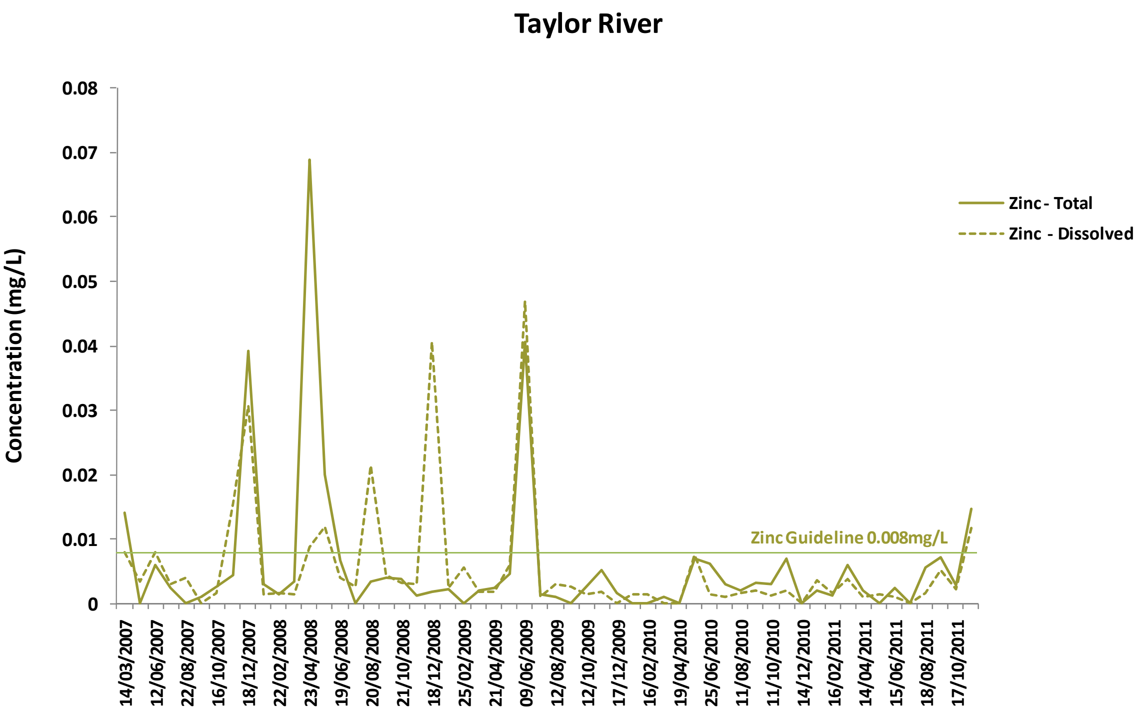
AWR -1	55	13.27455	12.70000	3.90000	22.90000	9.10000	17.20000	7.00000	19.70000	4.980600
AWR-3	56	9.90714	9.50000	0.40000	19.80000	5.95000	14.15000	3.60000	17.20000	5.198177
BNR-1	28	10.00357	10.65000	3.60000	16.70000	6.20000	13.10000	5.20000	16.10000	4.064798
CUL-3	27	12.09259	12.70000	8.20000	15.50000	9.50000	14.70000	9.00000	15.30000	2.520672
DNC-002	41	12.37073	12.50000	8.10000	17.20000	9.70000	14.70000	8.70000	15.90000	2.706866
DRC-1	31	13.76129	13.80000	10.00000	18.90000	11.90000	15.00000	11.10000	16.10000	2.155718
FLX-1	55	14.58545	14.60000	4.80000	24.40000	10.00000	18.50000	7.90000	21.80000	5.138757
GRR-001	52	13.75192	13.90000	6.90000	21.30000	10.60000	16.20000	9.50000	17.90000	3.328810
KNR-1	52	11.82885	11.35000	8.10000	16.50000	9.80000	14.00000	9.10000	14.90000	2.351748
KTR-005	54	12.85926	12.90000	6.80000	18.90000	10.80000	15.30000	8.30000	16.80000	3.146458
MST-21	37	13.48108	13.70000	9.80000	17.50000	11.60000	15.10000	10.80000	15.80000	1.976506
MUR-1	30	13.98000	13.85000	13.00000	15.60000	13.50000	14.40000	13.40000	14.80000	0.582148
OMR-1	54	13.86296	14.35000	5.70000	22.00000	10.00000	17.70000	7.40000	19.20000	4.448926
ONR-1	55	11.77273	11.70000	6.30000	17.60000	9.40000	13.70000	8.10000	16.10000	2.957881
OPO-1	49	12.67551	12.60000	8.80000	16.10000	11.40000	14.20000	10.40000	14.80000	1.772655
OPR-1	56	14.27143	14.00000	8.80000	19.90000	12.10000	17.00000	9.80000	18.70000	3.194297
OPR-3	56	12.75536	12.15000	3.70000	22.20000	8.70000	17.75000	5.50000	20.20000	5.134090
PLR-4	51	13.27843	12.50000	5.40000	21.90000	10.00000	17.20000	7.30000	19.60000	4.489156
PLR-5	57	11.71930	11.50000	3.10000	21.20000	8.30000	15.40000	5.70000	17.90000	4.579669
RAR-1	66	13.65606	13.95000	7.60000	18.60000	11.10000	15.90000	10.00000	17.50000	2.877666
RON-4	49	13.37551	14.10000	10.10000	17.30000	11.70000	15.00000	10.50000	15.50000	1.929327
SPC-1	55	13.34545	13.20000	11.70000	15.40000	12.60000	14.10000	12.30000	14.70000	0.918093
TMR-1	55	12.95091	13.10000	6.30000	21.20000	9.60000	16.10000	8.10000	18.10000	3.848803
TYR-1	56	14.34464	14.40000	10.50000	18.50000	12.95000	15.70000	11.70000	17.00000	1.956985
WaiM	49	13.48367	13.50000	8.30000	20.60000	11.20000	15.30000	9.70000	17.00000	2.729343
WDV-1	52	13.26154	12.90000	6.80000	21.00000	8.95000	17.60000	7.80000	19.40000	4.406820
WHR-1	53	13.55472	14.10000	4.90000	25.90000	9.80000	17.60000	6.20000	20.60000	5.462198
WHR-5	50	11.90000	12.45000	2.30000	23.00000	7.80000	15.50000	4.05000	18.55000	5.256095
WKR-1	55	11.41818	11.40000	3.40000	23.10000	8.50000	14.80000	6.30000	17.40000	4.309210
WRR-2	60	14.36500	13.50000	6.50000	23.90000	10.55000	18.25000	8.40000	20.25000	4.636913
WRR-6	60	7.34000	7.15000	2.60000	12.80000	4.55000	9.70000	3.50000	11.55000	2.998768
WTS-009	52	13.42500	13.85000	5.70000	21.20000	10.05000	16.30000	8.30000	18.80000	4.126285

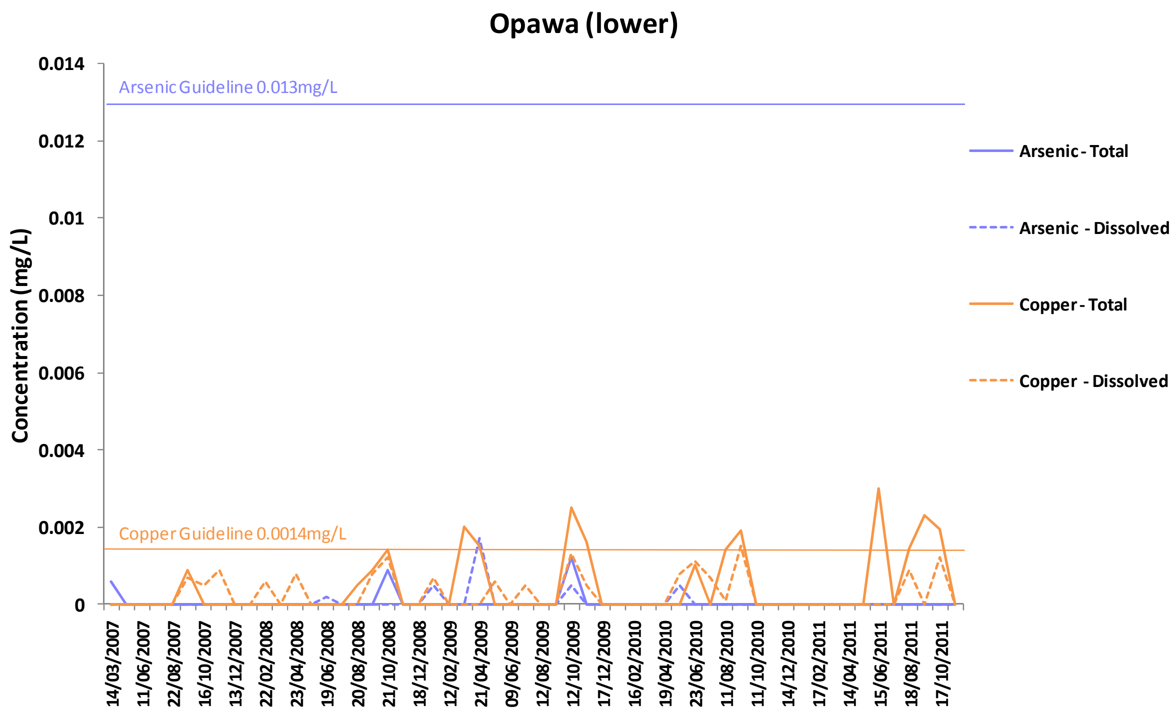
Descriptive Statistics Turbidity (NTU) 2007-2011										
	Valid Number	Mean	Median	Minimum	Maximum	Lower Quartile	Upper Quartile	10%ile	90%ile	Standard Deviation.
ARE-3	30	8.8667	2.65000	0.400000	123.000	1.300000	5.50000	1.050000	15.0000	22.7420
AWR -1	57	114.1807	16.00000	1.000000	2600.000	3.800000	90.60000	1.700000	188.0000	361.9048
AWR-3	58	80.9362	14.00000	0.500000	1320.000	5.100000	62.30000	1.100000	220.0000	196.0277
BBS-001	16	0.5563	0.30000	0.200000	2.700	0.200000	0.55000	0.200000	1.5000	0.6693
BNR-1	29	12.6655	1.30000	0.300000	174.000	0.800000	2.70000	0.400000	18.7000	39.6549
CUL-3	27	3.4963	1.60000	0.600000	42.600	1.300000	2.70000	0.800000	4.6000	7.9169
DNC-002	41	8.9390	5.30000	1.400000	42.400	3.300000	11.10000	2.000000	20.8000	9.1135
DRC-1	31	8.2355	5.20000	1.400000	27.000	3.700000	9.80000	2.100000	16.7000	6.7307
FLX-1	59	2.4983	0.90000	0.200000	19.500	0.500000	2.00000	0.300000	6.8000	4.2335
GRR-001	53	1.3453	0.50000	0.100000	35.900	0.300000	0.80000	0.200000	1.9000	4.8811
KNR-1	55	0.8673	0.70000	0.300000	2.900	0.500000	1.00000	0.400000	1.7000	0.5575
KTR-005	59	2.7542	0.60000	0.300000	51.300	0.400000	2.00000	0.300000	6.1000	7.3468
MST-21	38	3.2289	2.60000	0.800000	17.700	1.800000	3.50000	1.300000	4.9000	2.8917
MUR-1	30	0.7567	0.55000	0.200000	4.500	0.300000	0.90000	0.200000	1.5000	0.8316
OMR-1	57	1.4561	0.40000	0.200000	27.800	0.300000	1.00000	0.200000	2.3000	3.9149
ONR-1	59	5.0627	0.70000	0.200000	166.000	0.400000	2.40000	0.300000	6.5000	21.7546
OPO-1	49	1.0510	0.60000	0.200000	12.400	0.400000	1.00000	0.400000	1.9000	1.7707
OPR-1	60	3.3167	1.60000	0.500000	26.500	1.100000	3.15000	0.800000	8.0000	4.8357
OPR-3	60	6.5583	3.80000	1.000000	52.900	2.350000	5.75000	1.800000	11.4500	9.8801
PLR-4	53	1.4264	0.70000	0.200000	15.000	0.400000	1.20000	0.300000	2.2000	2.3962
PLR-5	59	2.0508	0.50000	0.200000	46.000	0.300000	1.00000	0.200000	5.9000	6.4019
RAR-1	68	2.2397	0.90000	0.300000	45.000	0.600000	1.50000	0.400000	3.1000	5.7910
RON-4	49	1.7551	0.70000	0.100000	17.800	0.300000	1.80000	0.200000	3.1000	3.1211
SPC-1	59	0.7492	0.60000	0.300000	3.100	0.500000	0.80000	0.400000	1.5000	0.4768
TMR-1	59	4.0814	2.20000	0.800000	23.700	1.700000	3.20000	1.300000	12.7000	5.1848
TYR-1	60	3.8150	1.70000	0.400000	26.000	1.050000	3.80000	0.650000	8.7000	5.3384
WaiM	51	10.8510	0.40000	0.100000	210.000	0.200000	0.90000	0.200000	3.6000	41.8177
WDV-1	53	10.7943	3.20000	0.800000	155.000	1.800000	5.50000	1.200000	19.6000	25.5634
WHR-1	59	28.1525	1.90000	0.200000	599.000	0.900000	8.00000	0.700000	64.2000	89.3181
WHR-5	53	29.1925	2.10000	0.300000	640.000	1.000000	7.80000	0.700000	58.1000	96.4945
WKR-1	59	1.1356	0.30000	0.100000	23.000	0.200000	0.90000	0.200000	2.0000	3.1071
WRR-2	60	7.9385	1.75000	0.400000	174.000	0.780000	4.75000	0.600000	14.5000	23.7573
WRR-6	60	3.2180	0.91000	0.250000	62.000	0.545000	2.49500	0.385000	6.5500	8.4096
WTS-009	53	1.6019	1.10000	0.300000	6.700	0.800000	1.90000	0.600000	3.0000	1.4359

Descriptive Statistics Specific Conductivity (µS/cm) 2007-2011										
	Valid Number	Mean	Median	Minimum	Maximum	Lower Quartile	Upper Quartile	10%ile	90%ile	Standard Deviation.
ARE-3	30	91.8667	89.0000	68.0000	124.0000	86.0000	97.4000	81.5000	108.7000	11.8412
AWR -1	56	149.0071	149.5000	103.0000	233.0000	137.0000	160.5000	119.4000	168.0000	21.4717
AWR-3	57	111.0246	109.0000	79.2000	139.6000	97.0000	123.6000	88.0000	133.0000	16.3057
BBS-001	18	113.1111	110.0000	90.0000	130.0000	110.0000	120.0000	97.0000	130.0000	11.6714
BNR-1	29	47.7241	48.0000	36.0000	61.0000	43.5000	52.0000	38.0000	55.0000	6.0789
CUL-3	27	67.9593	68.1000	58.0000	79.0000	64.0000	73.0000	61.0000	74.0000	5.1761
DNC-002	41	72.1659	72.4000	64.0000	78.0000	69.2000	75.0000	67.2000	77.0000	3.6625
DRC-1	31	187.7710	191.0000	129.0000	236.0000	165.0000	196.0000	154.0000	224.0000	25.5312
FLX-1	59	443.8305	427.0000	241.0000	699.0000	380.0000	533.0000	329.0000	582.0000	101.0925
GRR-001	53	97.8208	92.0000	70.4000	195.0000	89.6000	98.3000	83.0000	125.0000	20.1143
KNR-1	55	57.8091	55.6000	48.9000	87.6000	52.5000	61.0000	50.0000	73.0000	8.3992
KTR-005	59	64.2475	64.4000	36.0000	86.4000	57.3000	71.7000	50.4000	75.9000	10.0207
MST-21	38	145.6658	146.0000	128.0000	165.8000	139.0000	152.1000	131.0000	157.6000	9.9553
MUR-1	30	124.6967	125.6000	101.0000	141.0000	115.0000	134.0000	110.0000	140.0000	11.1440
OMR-1	56	125.6393	124.9500	92.0000	170.2000	115.6000	135.5000	105.2000	147.0000	15.9151
ONR-1	59	57.9000	58.0000	40.8000	72.4000	50.7000	64.9000	46.0000	69.0000	8.2536
OPO-1	49	53.1184	54.0000	41.0000	59.6000	51.0000	56.0000	48.0000	57.0000	3.7150
OPR-1	55	166.4309	151.0000	75.3000	440.0000	125.4000	174.0000	118.0000	225.0000	70.7597
OPR-3	60	86.8433	75.0000	52.0000	182.8000	66.5000	105.1500	63.2500	126.0000	28.5482
PLR-4	53	64.9415	65.0000	46.1000	129.0000	55.0000	72.2000	50.0000	79.3000	13.8741
PLR-5	59	64.1373	66.0000	29.0000	87.3000	53.3000	73.9000	47.6000	80.5000	12.4695
RAR-1	68	70.7309	71.9500	36.0000	88.0000	66.6500	76.5000	60.0000	79.0000	8.3740
RON-4	48	82.0938	81.9500	61.0000	98.0000	78.0000	86.1000	74.4000	90.8000	6.9174
SPC-1	59	72.1559	70.4000	63.0000	89.0000	67.9000	76.0000	65.0000	82.4000	6.2086
TMR-1	59	111.5000	114.0000	55.0000	136.0000	103.0000	124.4000	88.0000	128.8000	16.2997
TYR-1	59	142.9186	139.0000	78.2000	192.6000	132.4000	153.5000	123.0000	166.3000	18.9085
WaiM	51	343.5098	335.0000	283.0000	401.0000	323.0000	370.0000	312.0000	379.0000	29.3110
WDV-1	46	97.0348	93.4000	51.0000	181.6000	78.0000	112.0000	70.9000	128.0000	26.2195
WHR-1	59	70.3915	70.4000	54.9000	82.7000	65.0000	75.6000	62.0000	79.6000	6.8363
WHR-5	53	68.5491	69.1000	51.0000	80.6000	64.6000	74.0000	58.0000	76.8000	7.1981
WKR-1	59	44.0102	44.0000	28.0000	65.4000	38.2000	49.1000	34.1000	54.2000	7.6739
WRR-2	60	63.0183	63.1500	45.1000	81.8000	58.5500	67.6000	55.3000	71.2000	6.5535
WRR-6	60	47.0633	47.4000	34.7000	64.3000	43.6500	50.0500	41.6500	52.0500	4.6941
WTS-009	53	104.3038	103.0000	73.3000	140.0000	91.8000	114.4000	82.0000	129.0000	16.4026

Appendix 4: Arsenic, copper and zinc concentrations for selected rivers. Both total and dissolved concentrations are measured. The guidelines refer to the ANZECC trigger values for slightly to moderately disturbed systems for the protection of 95% of species in freshwater. The ANZECC guidelines do not differentiate between total and dissolved concentrations.






Opawa (lower)
Arsenic Guideline 0.013mg/L
Copper Guideline 0.0014mg/L
Concentration (mg/L)
0.014
0.012
0.01
0.008
0.006
0.004
0.002
0
Arsenic - Total
Arsenic - Dissolved
Copper - Total
Copper - Dissolved
14/03/2007
11/06/2007
22/08/2007
16/10/2007
13/12/2007
22/02/2008
23/04/2008
19/06/2008
20/08/2008
21/10/2008
18/12/2008
12/02/2009
21/04/2009
09/06/2009
12/08/2009
12/10/2009
17/12/2009
16/02/2010
19/04/2010
23/06/2010
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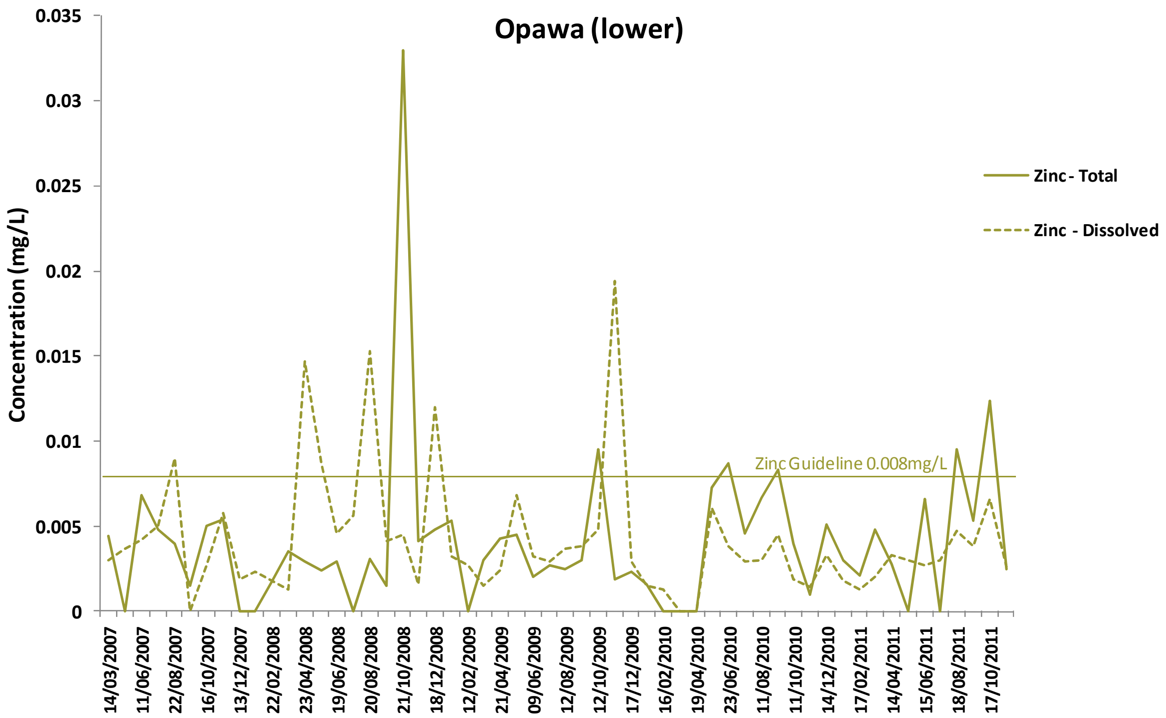
18/08/2011
17/10/2011


Opawa (lower)
Zinc Guideline 0.008mg/L
Concentration (mg/L)
0.035
0.03
0.025
0.02
0.015
0.01
0.005
0
Zinc - Total
Zinc - Dissolved
14/03/2007
11/06/2007
22/08/2007
16/10/2007
13/12/2007
22/02/2008
23/04/2008
19/06/2008
20/08/2008
21/10/2008
18/12/2008
12/02/2009
21/04/2009
09/06/2009
12/08/2009
12/10/2009
17/12/2009
16/02/2010
19/04/2010
23/06/2010
11/08/2010
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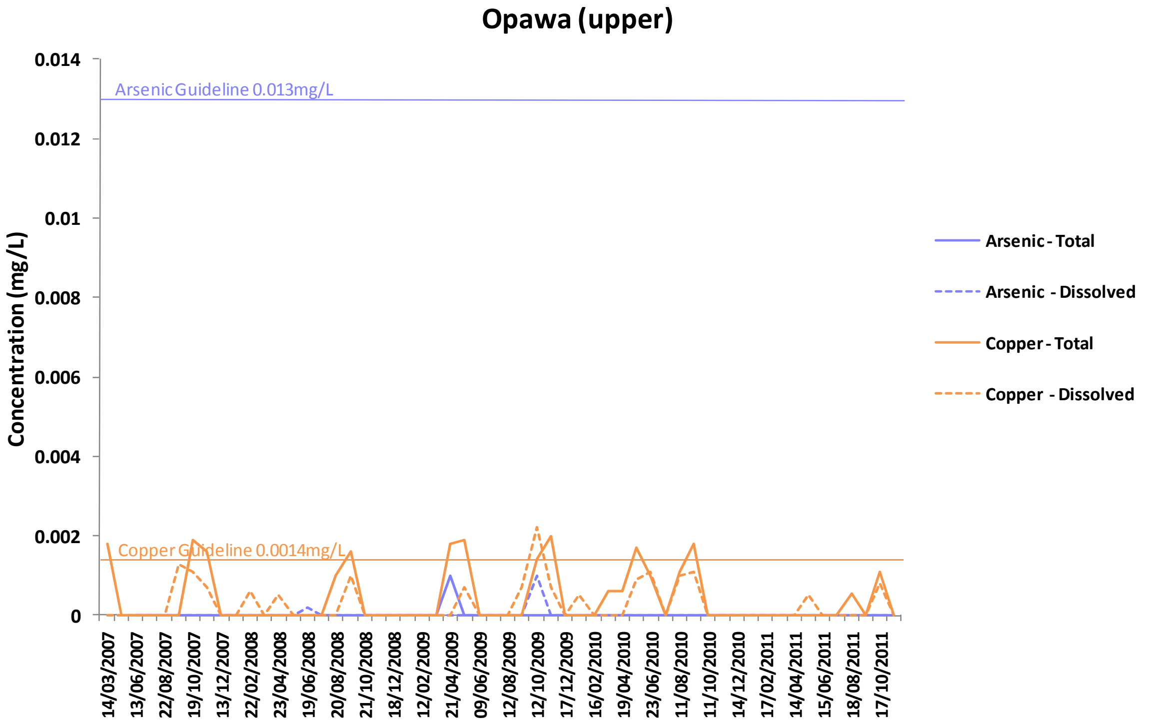
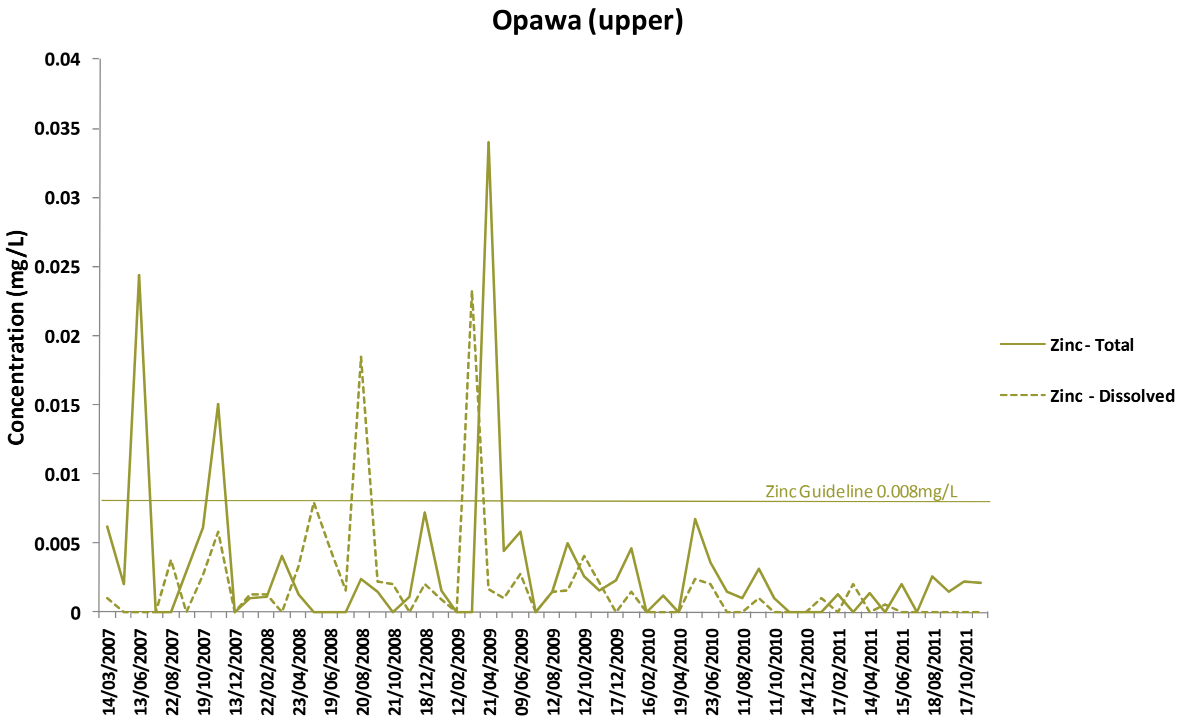
17/02/2011
14/04/2011
15/06/2011
18/08/2011
17/10/2011


Opawa (upper)
Concentration (mg/L)
0.014
0.012
0.01
0.008
0.006
0.004
0.002
0
Arsenic Guideline 0.013mg/L
Copper Guideline 0.0014mg/L
Arsenic - Total
Arsenic - Dissolved
Copper - Total
Copper - Dissolved
14/03/2007
13/06/2007
22/08/2007
19/10/2007
13/12/2007
22/02/2008
23/04/2008
19/06/2008
20/08/2008
21/10/2008
18/12/2008
12/02/2009
21/04/2009
09/06/2009
12/08/2009
12/10/2009
17/12/2009
16/02/2010
19/04/2010
23/06/2010
11/08/2010
11/10/2010
14/12/2010
17/02/2011
14/04/2011
15/06/2011
18/08/2011
17/10/2011


Opawa (upper)
Concentration (mg/L)
0.04
0.035
0.03
0.025
0.02
0.015
0.01
0.005
0
Zinc Guideline 0.008mg/L
Zinc - Total
Zinc - Dissolved
14/03/2007
13/06/2007
22/08/2007
19/10/2007
13/12/2007
22/02/2008
23/04/2008
19/06/2008
20/08/2008
21/10/2008
18/12/2008
12/02/2009
21/04/2009
09/06/2009
12/08/2009
12/10/2009
17/12/2009
16/02/2010
19/04/2010
23/06/2010
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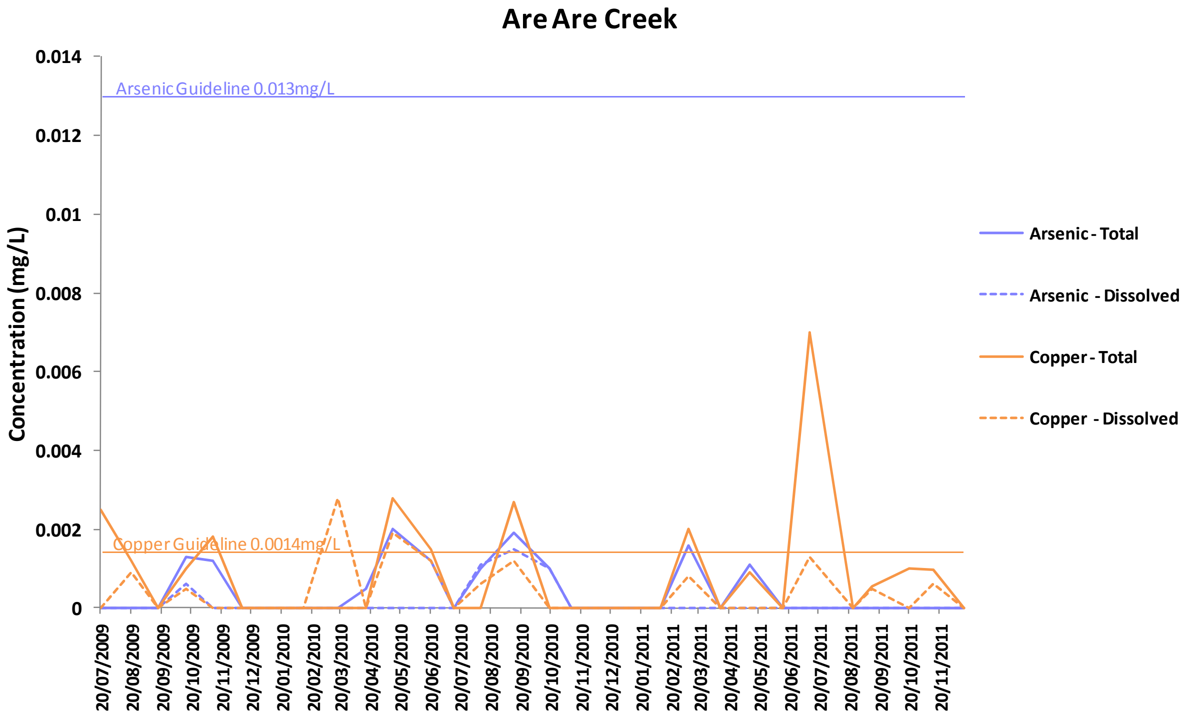
11/10/2010
14/12/2010
17/02/2011
14/04/2011
15/06/2011
18/08/2011
17/10/2011


Are Are Creek
Concentration (mg/L)
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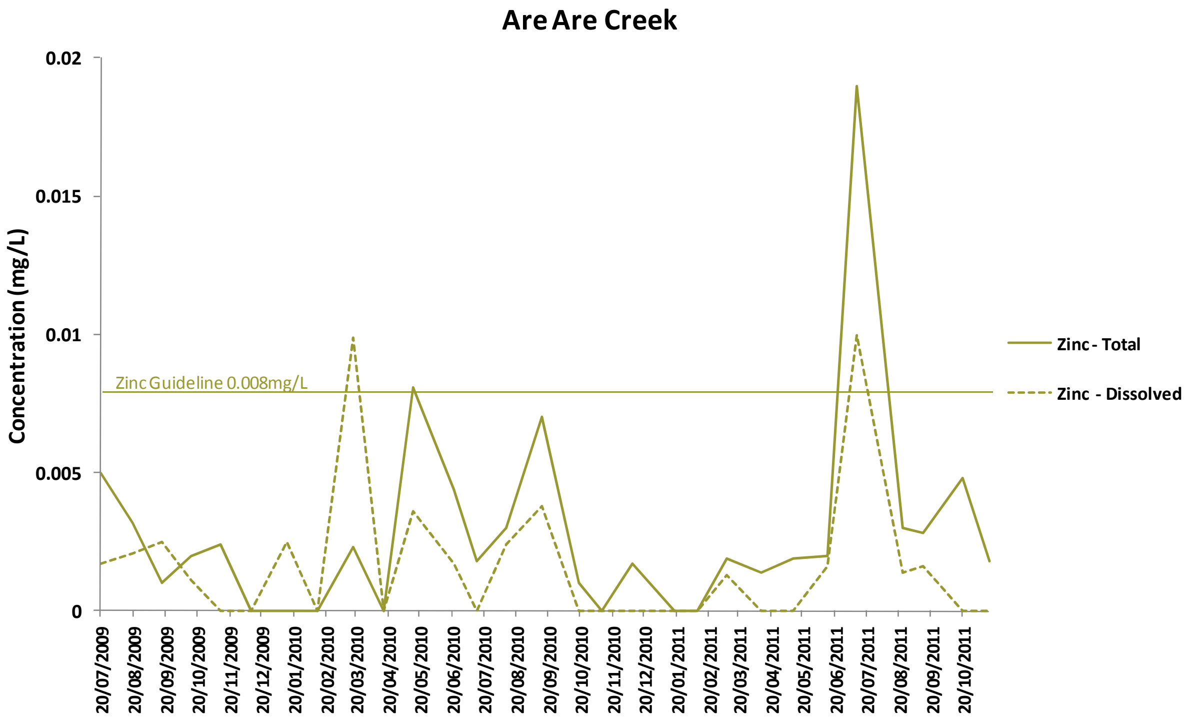
0.012
0.01
0.008
0.006
0.004
0.002
0
Arsenic Guideline 0.013mg/L
Copper Guideline 0.0014mg/L
Arsenic - Total
Arsenic - Dissolved
Copper - Total
Copper - Dissolved
20/07/2009
20/08/2009
20/09/2009
20/10/2009
20/11/2009
20/12/2009
20/01/2010
20/02/2010
20/03/2010
20/04/2010
20/05/2010
20/06/2010
20/07/2010
20/08/2010
20/09/2010
20/10/2010
20/11/2010
20/12/2010
20/01/2011
20/02/2011
20/03/2011
20/04/2011
20/05/2011
20/06/2011
20/07/2011
20/08/2011
20/09/2011
20/10/2011
20/11/2011


Are Are Creek
Concentration (mg/L)
0.02
0.015
0.01
0.005
0
Zinc Guideline 0.008mg/L
Zinc - Total
Zinc - Dissolved
20/07/2009
20/08/2009
20/09/2009
20/10/2009
20/11/2009
20/12/2009
20/01/2010
20/02/2010
20/03/2010
20/04/2010
20/05/2010
20/06/2010
20/07/2010
20/08/2010
20/09/2010
20/10/2010
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20/12/2010
20/01/2011
20/02/2011
20/03/2011
20/04/2011
20/05/2011
20/06/2011
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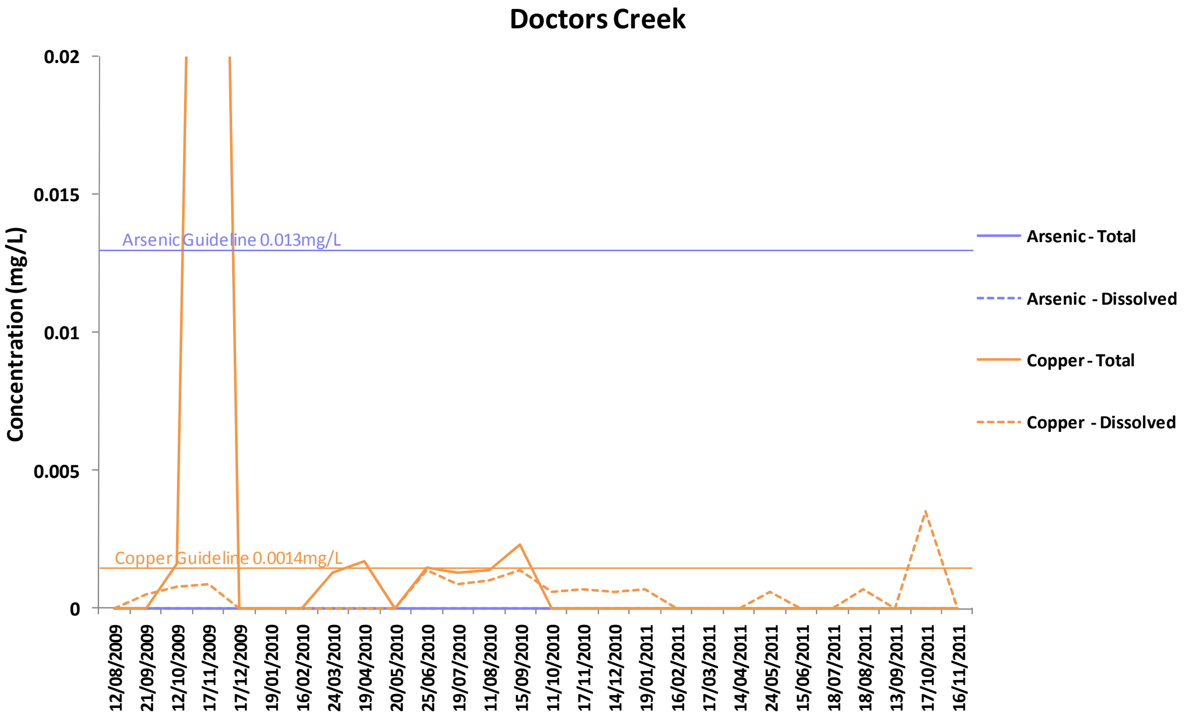
20/08/2011
20/09/2011
20/10/2011


Doctors Creek
Concentration (mg/L)
0.02
0.015
0.01
0.005
0
Arsenic Guideline 0.013mg/L
Copper Guideline 0.0014mg/L
Arsenic - Total
Arsenic - Dissolved
Copper - Total
Copper - Dissolved
12/08/2009
21/09/2009
12/10/2009
17/11/2009
17/12/2009
19/01/2010
16/02/2010
24/03/2010
19/04/2010
20/05/2010
25/06/2010
19/07/2010
11/08/2010
15/09/2010
11/10/2010
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16/02/2011
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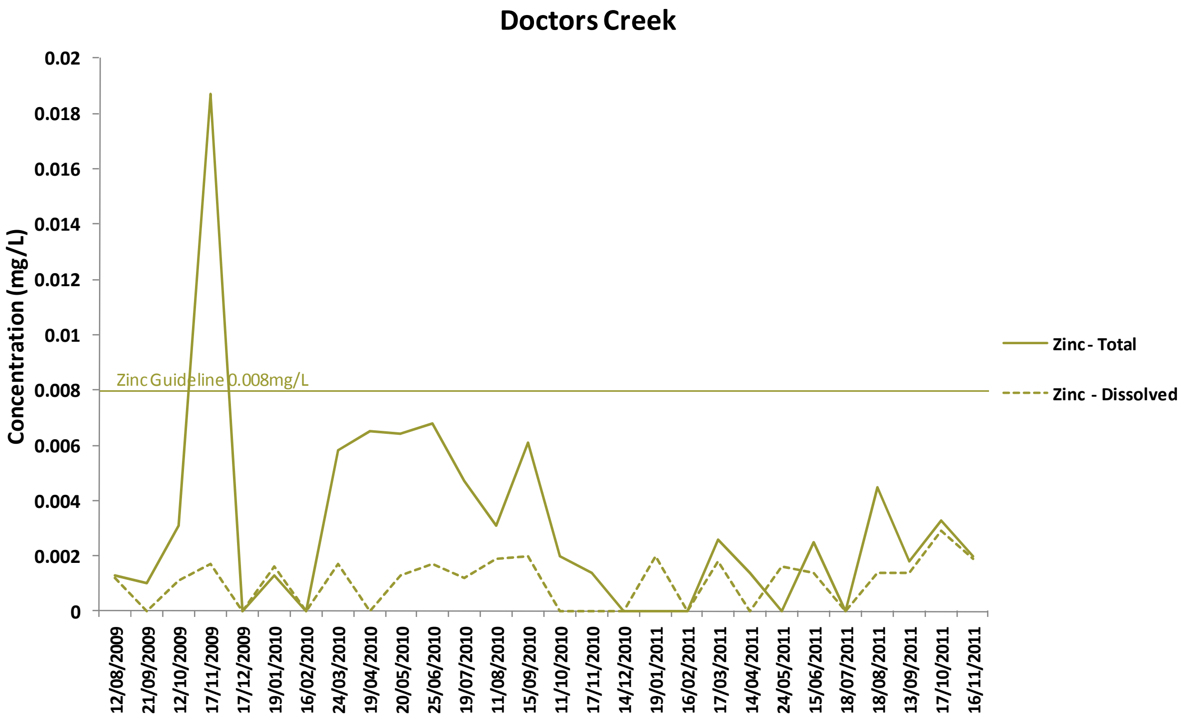
13/09/2011
17/10/2011
16/11/2011


Doctors Creek
Concentration (mg/L)
0.02
0.018
0.016
0.014
0.012
0.01
0.008
0.006
0.004
0.002
0
Zinc Guideline 0.008mg/L
Zinc - Total
Zinc - Dissolved
12/08/2009
21/09/2009
12/10/2009
17/11/2009
17/12/2009
19/01/2010
16/02/2010
24/03/2010
19/04/2010
20/05/2010
25/06/2010
19/07/2010
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14/12/2010
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16/02/2011
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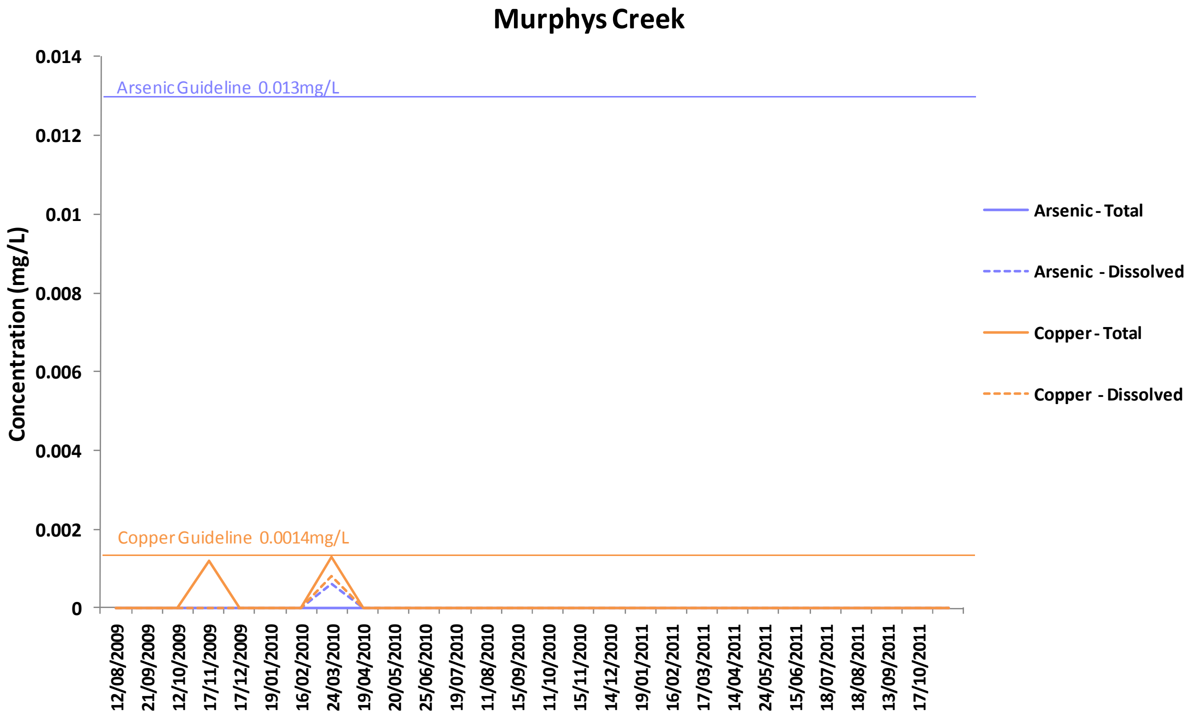
17/10/2011
16/11/2011


Murphys Creek
Concentration (mg/L)
0.014
0.012
0.01
0.008
0.006
0.004
0.002
0
Arsenic Guideline 0.013mg/L
Copper Guideline 0.0014mg/L
Arsenic - Total
Arsenic - Dissolved
Copper - Total
Copper - Dissolved
12/08/2009
21/09/2009
12/10/2009
17/11/2009
17/12/2009
19/01/2010
16/02/2010
24/03/2010
19/04/2010
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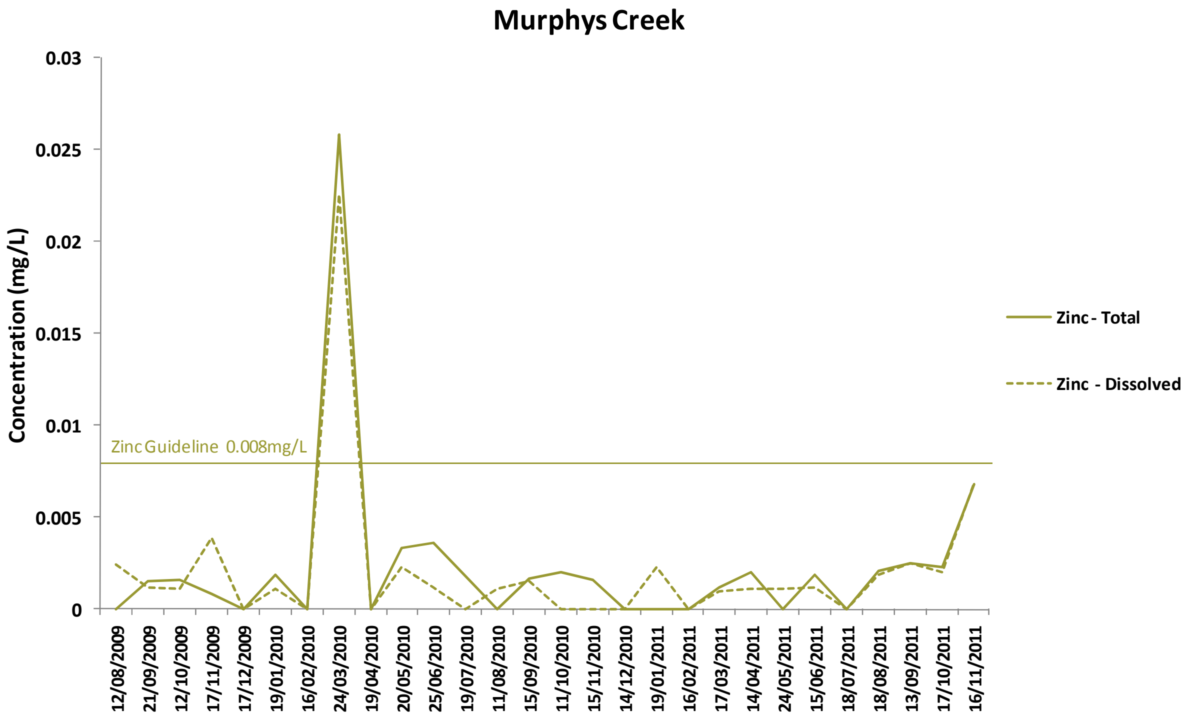
15/11/2010
14/12/2010
19/01/2011
16/02/2011
17/03/2011
14/04/2011
24/05/2011
15/06/2011
18/07/2011
18/08/2011
13/09/2011
17/10/2011


Murphys Creek
Concentration (mg/L)
0.03
0.025
0.02
0.015
0.01
0.005
0
Zinc Guideline 0.008mg/L
Zinc - Total
Zinc - Dissolved
12/08/2009
21/09/2009
12/10/2009
17/11/2009
17/12/2009
19/01/2010
16/02/2010
24/03/2010
19/04/2010
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25/06/2010
19/07/2010
11/08/2010
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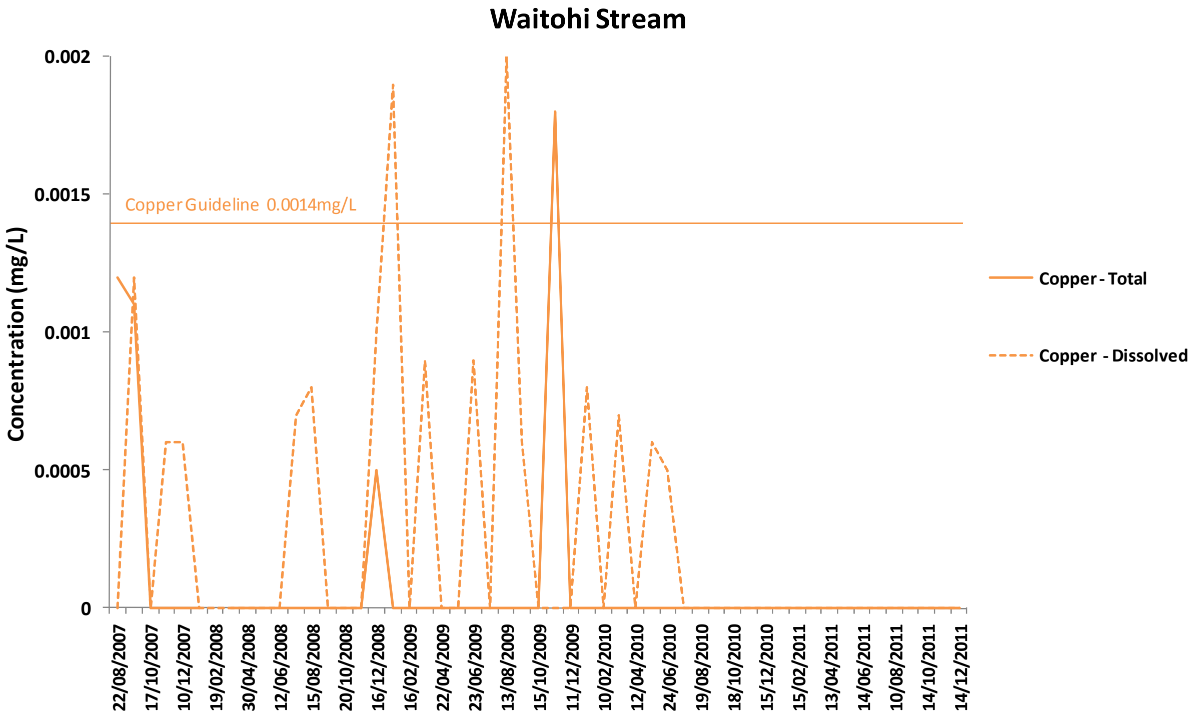
17/10/2011
16/11/2011


Waitohi Stream
Concentration (mg/L)
0.002
0.0015
0.001
0.0005
0
Copper Guideline 0.0014mg/L
Copper - Total
Copper - Dissolved
22/08/2007
17/10/2007
10/12/2007
19/02/2008
30/04/2008
12/06/2008
15/08/2008
20/10/2008
16/12/2008
16/02/2009
22/04/2009
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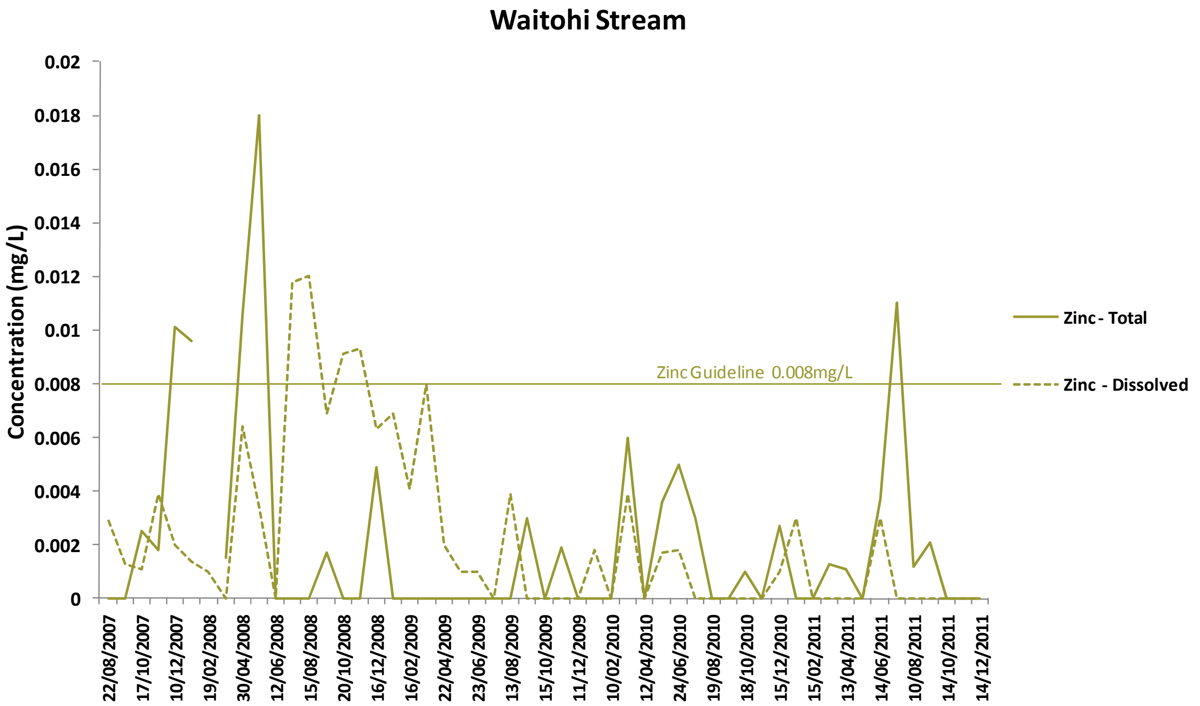
14/12/2011


Waitohi Stream
Concentration (mg/L)
0.02
0.018
0.016
0.014
0.012
0.01
0.008
0.006
0.004
0.002
0
Zinc Guideline 0.008mg/L
Zinc - Total
Zinc - Dissolved
22/08/2007
17/10/2007
10/12/2007
19/02/2008
30/04/2008
12/06/2008
15/08/2008
20/10/2008
16/12/2008
16/02/2009
22/04/2009
23/06/2009
13/08/2009
15/10/2009
11/12/2009
10/02/2010
12/04/2010
24/06/2010
19/08/2010
18/10/2010
15/12/2010
15/02/2011
13/04/2011
14/06/2011
10/08/2011
14/10/2011
14/12/2011

Appendix 5: Derivation of the water quality index scores and assessment of water quality grades.

Water Quality Weighting

Ammonia	DO	Nitrate	DRP	Turbidity	E. coli
1.5	1.5	1	1	0.5	0.2

Water Quality Guidelines

WQ Class	*Ammonia*	*DO*	*Nitrate*	*DRP*	*Turbidity*	*E. coli*	*SCORE*
Very Poor	0.9	20	1.7	0.05	5.6	550	5
Poor	0.021	15	0.444	0.021	4.1	260	4
Fair	0.01	10	0.167	0.01	2	126	3
Good	0.005	5	0.05	0.005	1	50	2
Excellent	<.005	<5	<0.05	<.005	<1	<50	1

Water Quality Grades

5.7	The lowest possible score if all parameters scored '1' according to their water quality assessed against the guidelines
28.5	The highest possible score if all parameters scored '5' according to their water quality assessed against the guidelines

The difference between 28.5 and 5.7 is **22.8**

22.8 divided by 5 WQ classes is 4.56
The lowest score (5.7) plus the difference between classes (4.56) gives the width band for the excellent class and so forth for the 5 classes

All scores are subsequently divided by 5.7 to give a band width from 1 to 5.

A	Excellent	1 - 1.8
B	Good	1.9 - 2.6
C	Fair	2.7 - 3.4
D	Poor	3.5 - 4.2
E	Very Poor	4.3 - 5

Appendix 6: Summary statistics for the water quality parameters used to calculate the water quality score and assess the water quality grade.

Water Quality Grade Calculations (2007-11)

Site ID	Ammonia (90%ile)	DO (Quartile Range)	Nitrate (90%ile)	DRP (90%ile)	E. coli (90%ile)	Turbidity (mean)	Number of Samples	WQ Score	WQ Grade	Grade Status
ARE-3	0.05	25.10	0.96	0.03	2300.00	8.87	30	4.4	Very Poor	Complete
AWR-1	0.02	5.90	0.25	0.03	140.00	114.18	58	3.0	Fair	Complete
AWR-3	0.02	6.35	0.06	0.03	100.00	80.94	59	2.5	Good	Complete
BBS-001	0.01	0.00	0.07	0.02	5.00	0.56	18	1.8	Excellent	Interim
BNR-1	0.01	6.00	0.04	0.01	70.00	12.67	29	2.5	Good	Interim
CUL-3	0.02	5.70	0.46	0.03	2000.00	3.50	27	3.2	Fair	Interim
DNC-002	0.03	9.10	0.62	0.03	1200.00	8.94	41	3.6	Poor	Complete
DRC-1	0.04	22.80	2.29	0.04	1100.00	8.24	31	4.6	Very Poor	Complete
FLX-1	0.01	18.80	0.57	0.02	400.00	2.50	59	3.6	Poor	Complete
GRR-001	0.01	8.20	0.07	0.02	300.00	1.35	53	2.2	Good	Complete
KNR-1	0.02	7.30	0.27	0.01	290.00	0.87	55	2.6	Good	Complete
KTR-005	0.02	6.10	1.52	0.02	500.00	2.75	59	2.9	Fair	Complete
MST-21	0.02	10.70	2.80	0.02	1200.00	3.23	38	3.6	Poor	Complete
MUR-1	0.01	9.70	1.72	0.02	295.00	0.76	30	2.7	Good	Complete
OMR-1	0.01	8.60	0.71	0.01	32.00	1.46	57	2.5	Good	Complete
ONR-1	0.01	5.70	0.34	0.01	170.00	5.06	59	2.6	Good	Complete
OPO-1	0.01	5.30	0.54	0.02	140.00	1.05	49	2.6	Good	Complete
OPR-1	0.03	17.80	1.82	0.02	140.00	3.32	60	4.1	Poor	Complete
OPR-3	0.01	15.50	1.39	0.01	160.00	6.56	60	3.6	Poor	Complete
PLR-4	0.01	6.60	0.38	0.01	140.00	1.43	53	2.6	Good	Complete
PLR-5	0.01	4.45	0.06	0.01	80.00	2.05	59	2.0	Good	Complete
RAR-1	0.01	7.40	0.92	0.02	270.00	2.24	68	2.9	Fair	Complete
RON-4	0.01	11.00	0.97	0.02	250.00	1.76	49	2.8	Fair	Complete
SPC-1	0.01	17.10	0.52	0.02	110.00	0.75	59	3.2	Fair	Complete
TMR-1	0.02	33.00	0.78	0.02	150.00	4.08	59	3.9	Poor	Complete
TYR-1	0.02	21.30	2.22	0.03	310.00	3.82	60	4.4	Very Poor	Complete
WaiM	0.01	11.00	0.27	0.01	240.00	10.85	51	2.9	Fair	Complete
WDV-1	0.02	8.70	0.44	0.02	220.00	10.79	53	3.2	Fair	Complete
WHR-1	0.01	4.80	0.40	0.02	190.00	28.15	59	2.6	Good	Complete
WHR-5	0.01	3.20	0.16	0.02	150.00	29.19	53	2.2	Good	Complete
WKR-1	0.01	5.30	0.05	0.02	69.00	1.14	59	2.2	Good	Complete
WRR-2	0.01	6.90	0.28	0.01	101.00	7.94	60	2.4	Good	Complete
WRR-6	0.00	0.70	0.03	0.01	101.00	3.22	60	1.4	Excellent	Complete
WTS-009	0.01	10.50	0.05	0.02	230.00	1.60	53	2.3	Good	Complete

Number of complete grades = 31

*** Turbidity results for AWR-1 and AWR-3 excluded from calculations**

¥ No DO results for BBS-001

≏ Quartile range for RON-4 = 9.6 which ranks as good, however DO is lower than expected for a healthy stream and therefore a score of 11 is used instead

Appendix 7

Results of the 2010-11 Macroinvertebrate Analysis

Site ID	MCI Score	RON-4	OPO-1	RAR-1	PLR-5	PLR-4	WKR-1	KTR-005	KNR-1	ANS-1	WTS-009	GRR-001	DNC-1	KUS-1	CUL-3	DNC-002	OMR-1	DRC-1	MUR-1	OPR-3	AWR-3	AWR-1	FLX-1	WaiM	NED-3	AVR-1
Sample ID		20104769	20104770	20104771	20104772	20104773	20104774	20104775	20104776	20104777	20104778	20104779	20104780	20104781	20104782	20104783	20104810	20104811	20104812	20104813	20104814	20104815	20104816	20104817	20104818	20104806
Date		25-Nov-10	25-Nov-10	26-Nov-10	26-Nov-10	26-Nov-10	3-Dec-10	3-Dec-10	30-Nov-10	30-Nov-10	2-Dec-10	2-Dec-10	25-Nov-10	26-Nov-10	30-Nov-10	2-Dec-10	1-Dec-10	23-Nov-10	23-Nov-10	23-Nov-10	1-Dec-10	1-Dec-10	24-Nov-10	24-Nov-10	24-Nov-10	10-Dec-10
Easting		1649966	1652204	1648018	1647585	1659571	1656011	1664877	1694287	1693260	1684133	1689949	1663894	1657595	1671802	1675552	1668150	1678538	1678585	1675898	1660707	1695945	1697479	1692178	1695638	1654552
Northing		5437711	5437502	5429266	5427613	5430016	5428720	5426463	5442220	5454525	5428227	5430629	5446691	5438293	5428178	5429552	5402871	5403700	5404340	5406769	5368307	5393096	5368033	5360509	5368880	5387697
Mayflies																										
Austroclima sepia	9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	R	A	-	-	-	-	-	-
Coloburiscus	9	R	A	R	-	-	C	R	A	A	C	R	C	R	C	-	-	-	-	-	-	-	-	-	-	A
Deleatidium sp.	8	A	VA	A	A	VA	VA	A	A	VA	R	C	VA	A	VA	A	A	-	-	C	A	A	A	A	C	VA
Ichthybotus bicolor	6	-	-	-	-	-	-	-	R	R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Neozephlebia scita	7	-	-	-	-	-	-	-	-	-	-	R	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nesameletus sp.	9	R	-	-	-	-	-	-	R	-	-	-	-	-	C	-	R	-	-	-	-	-	-	-	-	R
Rallidens macfarlanei	9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Zephlebia versicolor	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Stoneflies																										
Austroperla cyrene	9	-	R	-	R	-	R	-	-	-	-	-	R	-	-	-	-	-	-	-	-	-	-	-	-	-
Stenoperla prasina	10	R	C	-	-	-	C	R	-	-	-	-	C	R	-	-	-	-	-	-	-	-	-	C	-	-
Stenoperla spp.	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Zelandobius sp.	5	-	-	-	-	-	-	-	R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Zelandoperla	10	-	-	-	-	-	-	-	R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Zelandoperla fenestrata	10	-	-	-	-	-	-	-	-	-	-	R	-	-	R	-	-	-	-	-	-	-	-	-	-	-
Zelandoperla sp.	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Odonata																										
Xanthocnemis zealandica	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Water Bugs																										
Sigara sp.	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dobsonflies																										
Archichauliodes diversus	7	-	C	C	R	R	C	R	C	R	R	R	R	R	R	-	-	-	-	R	-	-	-	-	-	R
Beetles																										
Elmidae type A	6	C	VA	R	-	C	R	-	-	-	R	-	-	R	R	-	R	-	-	C	-	-	-	R	-	C
Hydraenidae	8	-	-	-	-	-	R	-	R	-	-	R	-	R	R	-	-	-	-	-	-	-	-	-	-	-
True Flies																										
Anthomyiidae	3	-	-	R	-	-	-	-	-	-	R	-	-	-	-	-	R	R	-	-	-	-	-	R	-	-
Aphrophila neozelandica	5	R	C	-	R	-	C	R	R	R	C	R	C	-	R	R	R	R	-	-	-	R	-	R	-	A
Austrosimulium spp.	3	R	R	C	R	R	R	-	-	R	-	R	R	-	C	-	A	A	-	R	R	-	R	R	R	-
Ceratopogonidae	3	-	-	-	-	-	-	-	-	-	-	-	-	R	-	-	-	-	-	-	-	-	-	-	-	-
Chironomus sp. A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Chironomus	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	R	C	-	R	-
Eriopterini	9	-	R	-	R	-	-	R	R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hexatomini	5	-	-	-	-	-	-	R	-	-	-	-	-	R	-	-	-	-	-	-	-	-	-	-	-	-
Maoridiamesa spp.	3	C	-	C	-	-	-	R	-	A	C	R	-	-	-	-	R	-	-	-	-	R	R	A	-	-
Molophilus sp.	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Neocurupira hudsoni	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Orthocladiinae	2	C	-	C	R	R	R	R	C	C	C	R	C	-	C	C	C	A	-	A	R	A	A	A	C	R
Paradixa sp.	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Paralimnophila skusei	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	R	-	-	-	-	-	-	-	-
Polypedilum spp.	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Tabanidae	3	C	R	-	-	-	-	R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Tanypodinae	5	-	-	R	-	-	-	R	R	-	-	-	-	-	-	R	-	-	-	-	-	-	R	-	-	R
Tanytarsus spp.	3	R	-	C	R	-	-	-	-	-	-	-	-	-	-	-	C	-	-	R	R	R	-	R	-	R
Caddisflies																										
Aoteapsyche spp.	4	R	C	R	C	-	A	C	R	A	C	C	C	-	R	R	A	-	-	A	R	C	R	R	-	C
Beraeoptera roria	8	-	-	-	-	-	-	-	-	-	-	-	-	-	C	-	-	-	-	-	-	-	-	-	-	-
Costachorema xanthopterum	7	-	R	R	C	-	R	R	-	-	-	-	-	R	-	-	R	-	-	-	-	-	-	-	-	R
Costachorema spp.	7	-	R	R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Helicopsyche sp.	10	C	A	-	-	-	C	-	-	-	-	-	R	A	-	-	-	-	-	-	-	-	-	-	-	R
Hudsonema alienum	6	-	-	-	-	-	-	-	R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hudsonema amabile	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	R	-	-	-	-	-	-	-	-	-	-
Hydrobiosella stenocerca	9	-	-	-	-	-	-	-	-	R	R	-	C	-	-	R	-	-	-	-	-	-	-	-	-	-
Hydrobiosis clavigera	5	R	R	R	R	C	R	R	R	R	-	-	-	-	R	-	-	-	-	-	R	R	-	-	-	-
Hydrobiosis copis	5	R	-	C	-	R	-	-	R	-	C	C	-	-	R	C	C	C	-	R	R	-	-	-	-	-
Hydrobiosis gollanis	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hydrobiosis parumbripennis	5	R	R	-	-	-	-	R	R	R	R	R	-	R	R	C	R	R	R	R	R	-	R	-	-	-
Hydrobiosis umbripennis	5	-	-	-	-	-	-	R	-	-	-	-	-	-	-	R	A	C	-	R	R	R	A	A	C	R
Hydrobiosis silvicola	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hydrobiosis spp.	5	R	R	C	C	R	R	C	R	R	-	-	R	C	C	C	-	R	R	R	C	R	A	R	C	C
Neurochorema confusum	6	-	-	C	-	-	R	R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Olinga spp.	9	A	R	-	A	R	A	A	-	-	C	R	A	C	R	R	-	-	-	-	-	-	-	-	-	A
Oxyethira albiceps	2	-	-	R	-	-	-	-	-	-	-	-	-	-	-	-	-	A	-	C	-	-	-	-	-	-
Paroxyethira eatoni	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	R	-	-	-	-	-	-
Philorheithrus sp.	8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Plectrocnemia sp.	8	-	-	-	-	-	-	-	-	-	-	R	R	-	-	-	-	-	-	-	-	-	-	-	-	-
Polyplectropus	8	-	-	-	-	-	-	-	-	-	-	R	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Psilochorema bidens	8	-	-	-	-	-	-	R	-	-	R	R	-	C	-	R	-	-	-	-	-	R	R	-	-	-
Psilochorema leptoharpax	8	-	-	-	R	-	R	-	R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Psilochorema macroharpax	8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Psilochorema spp.	8	R	-	-	-	R	-	C	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pycnocentria evecta	7	R	R	-	-	-	-	R	-	-	-	C	-	-	R	R	-	-	A	R	-	R	-	-	-	A
Pycnocentrodes sp.	5	R	R	R	C	C	A	A	-	-	C	R	-	A	C	C	-	-	C	A	-	-	-	-	-	A
Triplectides obsoletus	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Crustacea																										
Ostracoda	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	C	-	-	-	-	-	-
Paracalliope sp.	5	-	-	-	-	-	-	-	-	-	-	R	R	-	-	R	-	A	C	-	-	-	-	-	C	C
Paranephrops planifrons	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	R	-	-	-	-	-	-
Paratya curvirostris	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Talitridae	5	-	-	-	-	-	-	-	-	-	R	-	-	-	-	-	-	-	-	-	-	-	-	-	C	-
Worms	1	-	-	-	-	-	-	C	-	-	-	R	-	-	R	R	-	-	R	C	-	-	R	A	R	-
Flatworms	3	-	C	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Leeches	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	R	-	-	-	-	-	-	-	-
Springtails	6	-	-	-	-	-	-	-	-	-	-	-	-	-	R	-	-	-	-	-	-	-	-	-	-	-
Snails																										
Austropeplea tomentosa	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ferrissia dohrnianus	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	R	-	-	-	-	-	-
Ferrissia neozelanica	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Gyraulus sp.	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	C	-	-	R	-	-	-
Pseudosuccinaea columella	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Physa acuta	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	A	-	-	R	-	R	-
Potamopyrgus antipodarum	4	C	A	C	-	C	-	C	C	-	R	C	R	-	C	R	-	A	A	A	-	-	C	-	A	-
Sphaeriidae	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Number of taxa		22	22	20	15	12	19	25	20	13	17	22	16	15	22	18	14	13	8	23	10	12	15	13	11	18
MCI		122	129	96	120	114	134	116	129	111	115	120	134	143	122	111	97	76	103	85	83	92	77	88	74	125
SQMCI		6.70	7.00	5.37	7.19	7.39	7.30	6.38	7.14	6.79	5.41	5.79	7.76	7.50	7.21	5.93	4.78	3.42	5.37	4.38	6.58	4.85	4.65	4.10	4.41	7.23
EPT_{taxa} (excluding *Oxyethira*)		63.64	63.64	50.00	60.00	58.33	68.42	60.00	65.00	61.54	52.94	59.09	62.50	66.67	59.09	66.67	50.00	30.77	62.50	39.13	70.00	58.33	40.00	38.46	27.27	61.11

Site ID	MCI Score	WHR-2	WHR-5	WHR-1	ARE-3	WRR-6	BNR-1	SWC-1	GLT-1	ENS-1	TVR-1	TMC-1	PNV-1	BRC-1	ONR-1	WKK-1	GBC-1	MST-21	WRR-2	WYE-1	CTG-1	WST-5	TMR-1	PUK-5	SPC-1	BBS-001
Sample ID		20104807	20104808	20104809	20104798	20104784	20104785	20104786	20104791	20104792	20104793	20104794	20104795	20104796	20104797	20104800	20104805	20104789	20104803	20104787	20104788	20104790	20104801	20104802	20104804	20112943
Date		7-Dec-10	7-Dec-10	7-Dec-10	6-Jan-11	14-Jan-11	14-Jan-11	14-Jan-11	17-Jan-11	17-Jan-11	17-Jan-11	28-Jan-11	28-Jan-11	28-Jan-11	28-Jan-11	11-Feb-11	11-Feb-11	18-Feb-11	1-Mar-11	1-Mar-11	1-Mar-11	1-Mar-11	16-Mar-11	16-Mar-11	16-Mar-11	24-Mar-11
Easting		1647510	1657397	1661086	1668891	1593486	1615310	1619068	1615505	1631755	1638848	1641504	1642598	1649816	1665221	1675301	1669880	1642747	1680623	1626403	1625856	1643573	1680588	1683488	1681052	1673268
Northing		5387498	5392054	5402329	5409150	5362089	5383200	5388223	5390310	5395282	5398855	5400735	5405503	5403453	5407894	5411934	5405340	5398630	5412041	5385627	5390229	5398609	5412144	5414797	5411335	5382346
Mayflies																										
Austroclima sepia	9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	A	-	-	-	-	-	A	A	-
Coloburiscus	9	-	C	C	-	-	-	-	R	C	R	-	-	R	C	R	-	R	-	R	-	-	-	-	-	-
Deleatidium sp.	8	VA	A	VA	C	A	A	A	A	R	A	A	A	A	A	A	-	C	A	VA	A	-	-	-	-	VA
Ichthybotus bicolor	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Neozephlebia scita	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	A	-	-	-	R	-	-	-	-
Nesameletus sp.	9	A	C	-	-	-	-	R	R	-	-	R	-	-	R	A	-	-	-	R	-	-	-	-	-	C
Rallidens macfarlanei	9	R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Zephlebia versicolor	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	R	-	R	-	-
Stoneflies																										
Austroperla cyrene	9	-	-	-	-	-	-	-	-	A	-	-	R	R	-	R	-	-	-	-	-	-	-	-	-	-
Stenoperla prasina	10	-	-	-	-	-	R	-	-	C	-	R	C	C	-	-	-	-	-	A	-	-	-	-	-	C
Stenoperla spp.	10	-	-	-	-	-	-	-	-	-	-	-	C	-	-	-	-	-	-	R	-	-	-	-	-	C
Zelandobius sp.	5	-	-	-	-	-	-	-	-	-	-	-	C	-	-	-	-	-	-	-	-	-	-	-	-	-
Zelandoperla	10	-	-	-	-	-	-	-	-	-	-	-	R	-	-	-	-	-	-	C	-	-	-	-	-	-
Zelandoperla fenestrata	10	-	-	-	-	-	-	-	-	R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Zelandoperla sp.	10	-	-	-	-	-	-	-	C	-	-	-	-	-	-	-	-	-	-	R	-	-	-	-	-	-
Odonata																										
Xanthocnemis zealandica	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	R	-	C	-	R	-
Water Bugs																										
Sigara sp.	5	-	-	-	R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dobsonflies																										
Archichauliodes diversus	7	R	R	R	R	-	R	C	R	R	R	R	C	R	C	R	-	-	-	C	-	-	-	R	-	C
Beetles																										
Elmidae type A	6	-	R	R	C	-	C	-	C	-	C	A	A	-	C	R	C	-	R	A	-	-	-	-	-	A
Hydraenidae	8	-	-	-	-	-	-	-	R	R	C	R	-	C	-	-	-	-	-	C	-	-	-	C	-	-
True Flies																										
Anthomyiidae	3	-	-	-	-	R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	R	-	-	-	-
Aphrophila neozelandica	5	C	C	A	-	C	R	R	R	R	C	R	R	R	R	R	-	-	-	-	-	-	-	-	-	A
Austrosimulium spp.	3	C	A	VA	R	-	-	C	R	-	C	R	R	R	-	R	R	C	-	C	C	A	R	R	A	C
Ceratopogonidae	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Chironomus sp. A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	R	-	-	-	-	-	R	-
Chironomus	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Eriopterini	9	C	R	-	-	-	R	-	-	-	-	-	-	R	-	R	R	R	R	R	-	-	-	-	-	-
Hexatomini	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Maoridiamesa spp.	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	C
Molophilus sp.	5	R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Neocurupira hudsoni	7	-	-	-	-	R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Orthocladiinae	2	-	R	C	-	-	-	C	-	-	R	R	-	R	-	R	A	R	C	R	R	R	R	-	C	R
Paradixa sp.	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	R	-	-	-	-
Paralimnophila skusei	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	R	-	-	-	-
Polypedilum spp.	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	R	-	-	-	-	R	-	-	-	R
Tabanidae	3	-	-	-	-	-	-	-	-	-	-	-	-	-	R	-	-	-	-	R	-	-	-	-	-	-
Tanypodinae	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	A	R	-	R	-	-	R	-
Tanytarsus spp.	3	-	C	R	-	-	-	R	-	-	-	-	-	-	-	R	R	-	A	R	-	-	-	-	R	-
Caddisflies																										
Aoteapsyche spp.	4	C	R	VA	-	-	R	A	A	A	A	C	C	A	C	R	A	A	-	C	R	-	-	-	-	VA
Beraeoptera roria	8	-	-	-	-	-	-	-	-	R	-	-	R	-	-	-	-	-	-	-	-	-	-	-	-	-
Costachorema xanthopterum	7	R	C	C	-	R	-	-	-	-	-	-	-	R	-	-	-	-	-	-	-	-	-	-	-	R
Costachorema spp.	7	-	-	-	-	-	-	-	-	-	R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Helicopsyche sp.	10	-	-	-	-	-	-	R	C	C	-	-	-	R	R	-	-	R	-	R	-	-	-	-	-	-
Hudsonema alienum	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	C	-	-
Hudsonema amabile	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	R	-	-	-	-	-
Hydrobiosella stenocerca	9	-	-	-	-	-	-	-	R	A	-	-	R	R	-	-	-	-	-	-	-	-	-	-	-	R
Hydrobiosis clavigera	5	R	-	C	-	-	-	-	R	-	C	R	-	R	R	C	-	-	-	R	-	-	-	-	-	-
Hydrobiosis copis	5	R	C	C	C	R	-	R	-	-	C	-	-	-	R	R	-	-	-	-	C	-	-	-	R	-
Hydrobiosis gollanis	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	C	-	-
Hydrobiosis parumbripennis	5	-	-	-	-	R	R	R	-	R	-	-	-	-	-	R	-	-	-	-	-	-	-	-	-	-
Hydrobiosis umbripennis	5	C	C	C	R	-	-	R	-	-	-	-	-	-	-	-	-	-	-	-	R	-	-	-	-	-
Hydrobiosis silvicola	5	-	-	-	-	-	-	-	-	-	-	-	R	-	-	-	-	-	-	-	-	-	-	-	-	-
Hydrobiosis spp.	5	C	C	A	R	R	-	-	-	-	R	R	-	C	C	R	-	-	-	R	-	-	-	-	R	C
Neurochorema confusum	6	-	-	R	-	-	-	C	-	-	-	-	-	-	R	R	-	-	-	-	R	R	-	-	-	R
Olinga spp.	9	A	C	-	-	R	-	R	A	R	C	-	-	A	C	-	-	R	-	VA	-	-	-	-	-	A
Oxyethira albiceps	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	A	-
Paroxyethira eatoni	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Philorheithrus sp.	8	-	-	-	-	-	-	-	-	-	-	-	R	-	-	-	-	-	-	-	-	-	-	-	-	-
Plectrocnemia sp.	8	-	-	R	-	-	-	-	R	-	-	-	R	-	-	-	-	-	-	-	-	-	-	-	-	-
Polyplectropus	8	-	-	-	-	-	-	-	-	-	-	R	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Psilochorema bidens	8	-	R	-	R	-	-	-	-	-	-	-	-	R	R	-	-	-	-	-	C	-	-	-	-	-
Psilochorema leptoharpax	8	R	-	R	-	-	R	R	R	-	R	-	-	-	-	-	-	-	R	R	-	-	-	-	-	R
Psilochorema macroharpax	8	-	-	-	-	-	-	-	R	-	-	-	C	-	-	-	-	-	-	-	R	-	-	-	-	R
Psilochorema spp.	8	-	-	-	-	-	-	-	R	-	-	-	-	-	-	R	-	-	-	R	R	-	-	-	R	R
Pycnocentria evecta	7	-	-	-	-	-	-	R	-	R	R	R	-	-	C	-	-	R	-	-	-	C	-	A	C	-
Pycnocentrodes sp.	5	-	A	R	R	-	-	R	C	-	C	C	-	R	C	R	R	-	R	-	-	R	-	-	-	-
Triplectides obsoletus	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	C	-
Crustacea																										
Ostracoda	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	R	R	-	-	-	C	R	-	-	-
Paracalliope sp.	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	A	-	-	-	VVA	A	C	VVA	-
Paranephrops planifrons	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	R	-	R	-
Paratya curvirostris	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	A	-
Talitridae	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	R	-	-
Worms	1	-	-	-	C	R	-	-	-	-	-	R	-	C	R	-	R	R	-	-	C	-	-	-	-	-
Flatworms	3	-	-	-	-	-	-	-	-	-	-	R	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Leeches	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Springtails	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	R	-	-	-	-
Snails																										
Austropeplea tomentosa	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	C	-	R	-	-	-
Ferrissia dohrnianus	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ferrissia neozelanica	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	R	-	-	-	-	-	-	-	-
Gyraulus sp.	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	A	-	A	-	-	-
Pseudosuccinaea columella	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	A	-	-	-	-	-
Physa acuta	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	C	-	-	-	VVA	-	R	-	R	-
Potamopyrgus antipodarum	4	-	-	-	A	-	-	C	R	-	-	R	-	-	C	C	C	A	-	-	-	VVA	VA	A	R	R
Sphaeriidae	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	R	R	-	-	-
Number of taxa		16	18	18	12	10	9	18	20	15	17	18	17	20	19	20	12	16	9	23	17	17	11	11	18	21
MCI		135	124	115	104	113	138	119	141	157	124	112	141	135	125	120	77	116	104	135	86	93	71	122	89	120
SQMCI		7.69	5.77	5.06	4.64	6.88	7.44	5.54	7.16	7.76	5.92	6.28	7.15	6.75	6.65	7.21	3.42	5.78	5.13	8.16	3.24	4.48	3.99	6.45	4.95	6.22
EPT_{taxa} (excluding *Oxyethira*)		68.75	61.11	66.67	50.00	60.00	55.56	66.67	70.00	80.00	64.71	50.00	76.47	65.00	68.42	60.00	16.67	50.00	33.33	60.87	52.94	29.41	0.00	45.45	33.33	61.90

Added to reference collection

Samples processed by Yvonne Stark & Anne Biggs (Stark Environmental Ltd)

Data entry and index calculation by John Stark (Stark Environmental Ltd)

Appendix 8: Results from Timetrends analysis. Statistically significant trends marked in red bold.

Site name	Site ID	Parameter	Flow Adjustment?	Median value	Kendall statistic	Variance	Z	P	Median annual Sen slope	5% confidence limit	95% confidence limit	RSSE	%RSKSE	Significant	Meaningful
Awatere at River Mouth	AWR-1	Conductivity	No	149.5	-24	168	-1.77	0.08	-3.11	-8.15	-0.26	-0.020802676	-2.080267559	No	n/a
Awatere at River Mouth	AWR-1	DRP	No	10	6	168	0.39	0.7	0	-0.98	1.99	0	0	No	n/a
Awatere at River Mouth	AWR-1	E. coli	No	26	10	182	0.67	0.5	1.41	-3.98	6.18	0.054230769	5.423076923	No	n/a
Awatere at River Mouth	AWR-1	Nitrate	No	20	12	140.67	0.93	0.35	0	0	2.89	0	0	No	n/a
Awatere at River Mouth	AWR-1	pH	No	8.2	-35	169	-2.62	**0.01**	-0.06	-0.1	-0.03	-0.007317073	-0.731707317	Yes	No
Awatere at River Mouth	AWR-1	Turbidity	No	16	15	175	1.06	0.29	0.94	-2.06	8.85	0.05875	5.875	No	n/a
Awatere at Awapiri	AWR-3	Conductivity	No	109	-38	176	-2.79	**0.01**	-4.64	-7.54	-2.26	-0.042568807	-4.256880734	Yes	Yes
Awatere at Awapiri	AWR-3	Conductivity	Yes	109.62	-4	176	-0.23	0.82	-0.32	-2.32	1.16	-0.002919175	-0.291917533	No	n/a
Awatere at Awapiri	AWR-3	DRP	Yes	12.44	8	192	0.51	0.61	0.32	-0.72	1.36	0.025723473	2.572347267	No	n/a
Awatere at Awapiri	AWR-3	DRP	No	13	14	188	0.95	0.34	0.58	-0.98	1.5	0.044615385	4.461538462	No	n/a
Awatere at Awapiri	AWR-3	E. coli	Yes	9.52	20	192	1.37	0.17	2.26	-0.51	5.69	0.237394958	23.7394958	No	n/a
Awatere at Awapiri	AWR-3	E. coli	No	13	30	190	2.1	**0.04**	3.3	1	5.11	0.253846154	25.38461538	Yes	Yes
Awatere at Awapiri	AWR-3	Nitrate	Yes	1.11	-24	192	-1.66	0.1	-1.31	-3.26	-0.17	-1.18018018	-118.018018	No	n/a
Awatere at Awapiri	AWR-3	Nitrate	No	5	-1	140.33	0	1	0	0	0	0	0	No	n/a
Awatere at Awapiri	AWR-3	pH	No	7.95	-21	162.33	-1.57	0.12	-0.03	-0.05	0	-0.003773585	-0.377358491	No	n/a
Awatere at Awapiri	AWR-3	pH	Yes	7.95	0	184	0	1	0	-0.03	0.02	0	0	No	n/a
Awatere at Awapiri	AWR-3	Turbidity	Yes	11.25	-6	184	-0.37	0.71	-0.79	-3.4	1.38	-0.070222222	-7.022222222	No	n/a
Awatere at Awapiri	AWR-3	Turbidity	No	14	14	184	0.96	0.34	1.72	-1.91	7.17	0.122857143	12.28571429	No	n/a
Flaxbourne at Quarry	FLX-1	Conductivity	No	427	12	192	0.79	0.43	12.26	-5.59	25.27	0.028711944	2.871194379	No	n/a
Flaxbourne at Quarry	FLX-1	DRP	No	10	29	182.33	2.07	**0.04**	1.02	0	2.01	0.102	10.2	Yes	Yes
Flaxbourne at Quarry	FLX-1	E. coli	No	64	48	192	3.39	**0**	18.89	13.2	41.74	0.29515625	29.515625	Yes	Yes
Flaxbourne at Quarry	FLX-1	Nitrate	No	5	23	123	1.98	**0.05**	0	0	0	0	0	Yes	No
Flaxbourne at Quarry	FLX-1	pH	No	8	15	181	1.04	0.3	0.04	0	0.1	0.005	0.5	No	n/a
Flaxbourne at Quarry	FLX-1	Turbidity	No	0.9	35	188.33	2.48	**0.01**	0.15	0.1	0.26	0.166666667	16.66666667	Yes	Yes
Graham River at road bridge	GRR-001	Conductivity	No	92	11	143	0.84	0.4	1	-1.19	3.38	0.010869565	1.086956522	No	n/a
Graham River at road bridge	GRR-001	DRP	No	13	15	133	1.21	0.22	1	-0.59	1.51	0.076923077	7.692307692	No	n/a
Graham River at road bridge	GRR-001	E. coli	No	51	18	144	1.42	0.16	5.85	-0.62	20.36	0.114705882	11.47058824	No	n/a
Graham River at road bridge	GRR-001	Nitrate	No	20	-3	141	-0.17	0.87	-0.67	-4.05	4.75	-0.0335	-3.35	No	n/a
Graham River at road bridge	GRR-001	pH	No	7.3	21	129	1.76	0.08	0.06	0	0.15	0.008219178	0.821917808	No	n/a
Graham River at road bridge	GRR-001	Turbidity	No	0.5	16	140	1.27	0.2	0.05	-0.02	0.1	0.1	10	No	n/a
Kenepuru at NIWA flow site	KNR-1	Conductivity	No	55.6	-3	163	-0.16	0.88	-0.15	-1.01	1.35	-0.002697842	-0.269784173	No	n/a
Kenepuru at NIWA flow site	KNR-1	Conductivity	Yes	55.57	11	163	0.78	0.43	0.74	-0.63	1.51	0.013316538	1.33165377	No	n/a
Kenepuru at NIWA flow site	KNR-1	DRP	No	10	7	154.33	0.48	0.63	0	-0.51	0.99	0	0	No	n/a
Kenepuru at NIWA flow site	KNR-1	DRP	Yes	10.02	0	162	0	1	0	-0.56	0.55	0	0	No	n/a
Kenepuru at NIWA flow site	KNR-1	E. coli	No	120	-20	154	-1.53	0.13	-11.33	-24.88	3.53	-0.094416667	-9.441666667	No	n/a
Kenepuru at NIWA flow site	KNR-1	E. coli	Yes	93.42	-3	155	-0.16	0.87	-3.17	-14.88	22.86	-0.033932777	-3.393277671	No	n/a
Kenepuru at NIWA flow site	KNR-1	Nitrate	No	161	-13	163	-0.94	0.35	-4.05	-21.9	6.62	-0.02515528	-2.51552795	No	n/a
Kenepuru at NIWA flow site	KNR-1	Nitrate	Yes	157.81	-7	163	-0.47	0.64	-2.66	-16.57	4.21	-0.016855713	-1.685571257	No	n/a
Kenepuru at NIWA flow site	KNR-1	pH	No	7.1	13	148.33	0.99	0.32	0	0	0.1	0	0	No	n/a
Kenepuru at NIWA flow site	KNR-1	pH	Yes	7.11	6	162	0.39	0.69	0.01	-0.04	0.06	0.00140647	0.140646976	No	n/a
Kenepuru at NIWA flow site	KNR-1	Turbidity	Yes	0.7	17	163	1.25	0.21	0.03	-0.01	0.08	0.042857143	4.285714286	No	n/a
Kenepuru at NIWA flow site	KNR-1	Turbidity	No	0.7	19	157	1.44	0.15	0.05	0	0.1	0.071428571	7.142857143	No	n/a
Kaituna at Readers Road	KTR-005	Conductivity	No	64.4	-42	192	-2.96	**0**	-2.5	-4.63	-1.11	-0.038819876	-3.881987578	Yes	Yes
Kaituna at Readers Road	KTR-005	Conductivity	Yes	64.24	-42	192	-2.96	**0**	-1.56	-2.04	-1.06	-0.024283935	-2.428393524	Yes	Yes
Kaituna at Readers Road	KTR-005	DRP	Yes	12.7	-4	192	-0.22	0.83	-0.06	-0.7	0.41	-0.004724409	-0.472440945	No	n/a
Kaituna at Readers Road	KTR-005	DRP	No	12	-2	182.67	-0.07	0.94	0	-1	0.7	0	0	No	n/a
Kaituna at Readers Road	KTR-005	E. coli	No	88	-23	191	-1.59	0.11	-8.5	-23.55	0.12	-0.096590909	-9.659090909	No	n/a
Kaituna at Readers Road	KTR-005	E. coli	Yes	74.16	-12	192	-0.79	0.43	-5.17	-20.8	5.27	-0.069714132	-6.971413161	No	n/a
Kaituna at Readers Road	KTR-005	Nitrate	No	820	-46	192	-3.25	**0**	-120.96	-173.86	-58.11	-0.147512195	-14.75121951	Yes	Yes
Kaituna at Readers Road	KTR-005	Nitrate	Yes	843.8	-38	192	-2.67	**0.01**	-100.95	-140.66	-24.4	-0.119637355	-11.96373548	Yes	Yes

Kaituna at Readers Road	KTR-005	pH	Yes	7.13	46	192	3.25	**0**	0.08	0.04	0.1	0.011220196	1.122019635	Yes	Yes
Kaituna at Readers Road	KTR-005	pH	No	7.1	47	173	3.5	**0**	0.1	0.03	0.13	0.014084507	1.408450704	Yes	Yes
Kaituna at Readers Road	KTR-005	Turbidity	Yes	0.58	22	192	1.52	0.13	0.04	0	0.11	0.068965517	6.896551724	No	n/a
Kaituna at Readers Road	KTR-005	Turbidity	No	0.6	31	175.67	2.26	**0.02**	0.1	0	0.3	0.166666667	16.66666667	Yes	Yes
Omaka at Hawkesbury Road	OMR-1	Conductivity	No	124.95	-40	168	-3.01	**0**	-6.26	-8.77	-2.1	-0.05010004	-5.010004002	Yes	Yes
Omaka at Hawkesbury Road	OMR-1	DRP	No	8	30	163.33	2.27	**0.02**	1.29	0	2	0.16125	16.125	Yes	Yes
Omaka at Hawkesbury Road	OMR-1	E. coli	No	8	20	172	1.45	0.15	1.67	0	3.02	0.20875	20.875	No	n/a
Omaka at Hawkesbury Road	OMR-1	Nitrate	No	236	-32	176	-2.34	**0.02**	-36.43	-81.42	-16.07	-0.154364407	-15.43644068	Yes	Yes
Omaka at Hawkesbury Road	OMR-1	pH	No	7.5	32	163.33	2.43	**0.02**	0.09	0.01	0.12	0.012	1.2	Yes	Yes
Omaka at Hawkesbury Road	OMR-1	Turbidity	No	0.4	10	163.33	0.7	0.48	0	-0.02	0.05	0	0	No	n/a
Onamalutu Northbank Road	ONR-1	Conductivity	No	58	-42	190	-2.97	**0**	-2.71	-3.76	-1.81	-0.046724138	-4.672413793	Yes	Yes
Onamalutu Northbank Road	ONR-1	DRP	No	9	4	177.33	0.23	0.82	0	-0.66	0.98	0	0	No	n/a
Onamalutu Northbank Road	ONR-1	E. coli	No	56	-2	190	-0.07	0.94	-0.49	-7.05	9.3	-0.00875	-0.875	No	n/a
Onamalutu Northbank Road	ONR-1	Nitrate	No	200	3	191	0.14	0.88	3.54	-14.59	12.68	0.0177	1.77	No	n/a
Onamalutu Northbank Road	ONR-1	pH	No	7.2	28	178.67	2.02	**0.04**	0.04	0	0.1	0.005555556	0.555555556	Yes	No
Onamalutu Northbank Road	ONR-1	Turbidity	No	0.7	53	189	3.78	**0**	0.3	0.13	0.61	0.428571429	42.85714286	Yes	Yes
Opawa River at Swamp Road	OPR-1	Conductivity	No	151.2	7	159.33	0.48	0.63	0.87	-3.41	4.51	0.005753968	0.575396825	No	n/a
Opawa River at Swamp Road	OPR-1	DRP	No	15	24	186	1.69	0.09	1	0	2.37	0.066666667	6.666666667	No	n/a
Opawa River at Swamp Road	OPR-1	E. coli	No	24	22	182	1.56	0.12	5.93	-0.03	9.93	0.247083333	24.70833333	No	n/a
Opawa River at Swamp Road	OPR-1	Nitrate	No	980	-23	191	-1.59	0.11	-67.08	-136.98	0.91	-0.06844898	-6.844897959	No	n/a
Opawa River at Swamp Road	OPR-1	pH	No	7.4	16	174	1.14	0.26	0.01	0	0.06	0.001351351	0.135135135	No	n/a
Opawa River at Swamp Road	OPR-1	Turbidity	No	1.7	40	188	2.84	**0**	0.2	0.13	0.47	0.117647059	11.76470588	Yes	Yes
Opawa River at Hammerichs Road	OPR-3	Conductivity	No	75.1	6	192	0.36	0.72	0.45	-1.68	5.22	0.005992011	0.599201065	No	n/a
Opawa River at Hammerichs Road	OPR-3	DRP	No	7	3	187	0.15	0.88	0	-0.81	0.99	0	0	No	n/a
Opawa River at Hammerichs Road	OPR-3	E. coli	No	50.5	34	182	2.45	**0.01**	7.75	2.96	18.91	0.153465347	15.34653465	Yes	Yes
Opawa River at Hammerichs Road	OPR-3	Nitrate	No	180	-23	163	-1.72	0.08	-6.65	-34.21	0	-0.036944444	-3.694444444	No	n/a
Opawa River at Hammerichs Road	OPR-3	pH	No	8.1	0	186	0	1	0	-0.11	0.1	0	0	No	n/a
Opawa River at Hammerichs Road	OPR-3	Turbidity	No	3.8	14	192	0.94	0.35	0.27	-0.1	0.5	0.071052632	7.105263158	No	n/a
Pelorus at Fishermans Flat	PLR-4	Conductivity	No	65	-26	142	-2.1	**0.04**	-2.82	-4.44	-0.72	-0.043384615	-4.338461538	Yes	Yes
Pelorus at Fishermans Flat	PLR-4	DRP	No	9	3	135	0.17	0.86	0	-0.99	0.99	0	0	No	n/a
Pelorus at Fishermans Flat	PLR-4	E. coli	No	24	0	142	0	1	0	-6.21	3.96	0	0	No	n/a
Pelorus at Fishermans Flat	PLR-4	Nitrate	No	255	-37	143	-3.01	**0**	-32.76	-43.01	-16.81	-0.128470588	-12.84705882	Yes	Yes
Pelorus at Fishermans Flat	PLR-4	pH	No	7.4	13	135	1.03	0.3	0.03	0	0.1	0.004054054	0.405405405	No	n/a
Pelorus at Fishermans Flat	PLR-4	Turbidity	No	0.7	22	140	1.77	0.08	0.1	0	0.2	0.142857143	14.28571429	No	n/a
Pelorus at Kahikatea Flat	PLR-5	Conductivity	No	66	-30	192	-2.09	**0.04**	-3.16	-5.75	-0.79	-0.047878788	-4.787878788	Yes	Yes
Pelorus at Kahikatea Flat	PLR-5	DRP	No	10	19	185	1.32	0.19	0.99	0	1.06	0.099	9.9	No	n/a
Pelorus at Kahikatea Flat	PLR-5	E. coli	No	14	4	168	0.23	0.82	0	-1.5	1.62	0	0	No	n/a
Pelorus at Kahikatea Flat	PLR-5	Nitrate	No	20	-12	158	-0.88	0.38	0	-2.78	0	0	0	No	n/a
Pelorus at Kahikatea Flat	PLR-5	pH	No	7.6	16	179.33	1.12	0.26	0.03	0	0.1	0.003947368	0.394736842	No	n/a
Pelorus at Kahikatea Flat	PLR-5	Turbidity	No	0.5	27	181.67	1.93	**0.05**	0.1	0	0.2	0.2	20	Yes	Yes
Rai Falls	RAR-1	Conductivity	No	71.9	-47	183	-3.4	**0**	-2.6	-3.9	-1.49	-0.036161335	-3.616133519	Yes	Yes
Rai Falls	RAR-1	Conductivity	Yes	71.31	-48	184	-3.46	**0**	-1.64	-2.28	-0.94	-0.022998177	-2.299817697	Yes	Yes
Rai Falls	RAR-1	DRP	Yes	12.08	12	184	0.81	0.42	0.47	-0.19	1.14	0.038907285	3.890728477	No	n/a
Rai Falls	RAR-1	DRP	No	12	29	177	2.1	**0.04**	1.42	0.01	1.97	0.118333333	11.83333333	Yes	Yes
Rai Falls	RAR-1	E. coli	Yes	-7.28	2	184	0.07	0.94	0.81	-11.33	7.21	-0.111263736	-11.12637363	No	n/a
Rai Falls	RAR-1	E. coli	No	53	6	184	0.37	0.71	1.66	-12.1	7.92	0.031320755	3.132075472	No	n/a
Rai Falls	RAR-1	Nitrate	Yes	637.6	-42	184	-3.02	**0**	-56.7	-79.53	-26.62	-0.088927227	-8.89272271	Yes	Yes
Rai Falls	RAR-1	Nitrate	No	650	-56	182	-4.08	**0**	-57.45	-88.7	-39.74	-0.088384615	-8.838461538	Yes	Yes
Rai Falls	RAR-1	pH	No	7.2	13	164.67	0.94	0.35	0	0	0.05	0	0	No	n/a
Rai Falls	RAR-1	pH	Yes	7.27	14	184	0.96	0.34	0.02	-0.01	0.07	0.002751032	0.275103164	No	n/a
Rai Falls	RAR-1	Turbidity	Yes	0.78	24	184	1.7	0.09	0.05	0.01	0.18	0.064102564	6.41025641	No	n/a
Rai Falls	RAR-1	Turbidity	No	0.95	31	181	2.23	**0.03**	0.16	0.03	0.3	0.168421053	16.84210526	Yes	Yes
Spring Creek at flood gates	SPC-1	Conductivity	No	70.4	26	192	1.8	0.07	0.9	0.19	1.53	0.012784091	1.278409091	No	n/a

Spring Creek at flood gates	SPC-1	DRP	No	13	11	177.67	0.75	0.45	0	0	0.66	0	0	No	n/a
Spring Creek at flood gates	SPC-1	E. coli	No	48	32	188	2.26	0.02	6	1.47	10.26	0.125	12.5	Yes	Yes
Spring Creek at flood gates	SPC-1	Nitrate	No	250	26	190	1.81	0.07	9.65	1.1	23.3	0.0386	3.86	No	n/a
Spring Creek at flood gates	SPC-1	pH	No	7.1	24	180	1.71	0.09	0.05	0	0.1	0.007042254	0.704225352	No	n/a
Spring Creek at flood gates	SPC-1	Turbidity	No	0.6	31	175.67	2.26	0.02	0.05	0	0.1	0.083333333	8.333333333	Yes	Yes
Tuamarina at Wairau confluence	TMR-1	Conductivity	No	114	-41	191	-2.89	0	-3.98	-6.83	-1.94	-0.034912281	-3.49122807	Yes	Yes
Tuamarina at Wairau confluence	TMR-1	DRP	No	14	23	185	1.62	0.11	0.87	0	1.51	0.062142857	6.214285714	No	n/a
Tuamarina at Wairau confluence	TMR-1	E. coli	No	48	35	189	2.47	0.01	7.6	2.69	10.83	0.158333333	15.83333333	Yes	Yes
Tuamarina at Wairau confluence	TMR-1	Nitrate	No	346	-18	190	-1.23	0.22	-15.11	-39	3.51	-0.04367052	-4.367052023	No	n/a
Tuamarina at Wairau confluence	TMR-1	pH	No	7	28	181.33	2.01	0.04	0.07	0	0.13	0.01	1	Yes	Yes
Tuamarina at Wairau confluence	TMR-1	Turbidity	No	2.2	6	190	0.36	0.72	0.04	-0.14	0.27	0.018181818	1.818181818	No	n/a
Taylor River at Rail Bridge	TYR-1	Conductivity	No	139	22	182	1.56	0.12	1.88	-0.03	4.49	0.01352518	1.352517986	No	n/a
Taylor River at Rail Bridge	TYR-1	DRP	No	17	17	187	1.17	0.24	0.66	-0.5	1.5	0.038823529	3.882352941	No	n/a
Taylor River at Rail Bridge	TYR-1	E. coli	No	59	28	184	1.99	0.05	12.79	2.78	26.55	0.216779661	21.6779661	Yes	Yes
Taylor River at Rail Bridge	TYR-1	Nitrate	No	1356	-40	192	-2.81	0	-126.04	-238.67	-58.75	-0.092949853	-9.294985251	Yes	Yes
Taylor River at Rail Bridge	TYR-1	pH	No	7.1	43	183	3.1	0	0.1	0.05	0.1	0.014084507	1.408450704	Yes	Yes
Taylor River at Rail Bridge	TYR-1	Turbidity	No	1.6	70	190	5.01	0	0.34	0.23	0.68	0.2125	21.25	Yes	Yes
Waima at SH1 bridge	WaiM	Conductivity	No	335	-54	134	-4.58	0	-15.23	-21.5	-11.68	-0.045462687	-4.546268657	Yes	Yes
Waima at SH1 bridge	WaiM	DRP	No	6	-3	122.33	-0.18	0.86	0	-1	0.69	0	0	No	n/a
Waima at SH1 bridge	WaiM	E. coli	No	27	5	133	0.35	0.73	1.83	-4.92	11.07	0.067777778	6.777777778	No	n/a
Waima at SH1 bridge	WaiM	Nitrate	No	90	-21	133	-1.73	0.08	-35.22	-60.3	-0.51	-0.391333333	-39.13333333	No	n/a
Waima at SH1 bridge	WaiM	pH	No	8.1	26	116.67	2.31	0.02	0.05	0	0.1	0.00617284	0.617283951	Yes	No
Waima at SH1 bridge	WaiM	Turbidity	No	0.4	25	124.33	2.15	0.03	0.1	0	0.14	0.25	25	Yes	Yes
Wairau Diversion at Neals Road	WDV-1	Conductivity	No	93.4	17	112.33	1.51	0.13	3.95	-0.19	8.33	0.042291221	4.229122056	No	n/a
Wairau Diversion at Neals Road	WDV-1	DRP	No	12	23	139	1.87	0.06	1.37	0	2.01	0.114166667	11.41666667	No	n/a
Wairau Diversion at Neals Road	WDV-1	E. coli	No	46	45	143	3.68	0	13.83	7.1	21.01	0.300652174	30.06521739	Yes	Yes
Wairau Diversion at Neals Road	WDV-1	Nitrate	No	160	-17	141	-1.35	0.18	-7.55	-33.43	0.77	-0.0471875	-4.71875	No	n/a
Wairau Diversion at Neals Road	WDV-1	pH	No	7.4	20	136	1.63	0.1	0.05	0	0.1	0.006756757	0.675675676	No	n/a
Wairau Diversion at Neals Road	WDV-1	Turbidity	No	3.2	24	142	1.93	0.05	0.43	0.07	0.9	0.134375	13.4375	Yes	Yes
Waihopai at SH63 bridge	WHR-1	Conductivity	No	70.4	-18	192	-1.23	0.22	-1.56	-2.71	0.68	-0.022159091	-2.215909091	No	n/a
Waihopai at SH63 bridge	WHR-1	DRP	No	10	25	187	1.76	0.08	1	0	1.56	0.1	10	No	n/a
Waihopai at SH63 bridge	WHR-1	E. coli	No	12	-3	189	-0.15	0.88	-0.25	-3.21	2.08	-0.020833333	-2.083333333	No	n/a
Waihopai at SH63 bridge	WHR-1	Nitrate	No	73	-17	183.67	-1.18	0.24	-6.15	-22.17	0.24	-0.084246575	-8.424657534	No	n/a
Waihopai at SH63 bridge	WHR-1	pH	No	7.6	36	179.33	2.61	0.01	0.09	0.02	0.1	0.011842105	1.184210526	Yes	Yes
Waihopai at SH63 bridge	WHR-1	Turbidity	No	1.9	28	190	1.96	0.05	0.38	0.04	0.91	0.2	20	Yes	Yes
Waihopai at flow station	WHR-5	Conductivity	No	69.1	-10	144	-0.75	0.45	-0.71	-3.13	0.91	-0.010274964	-1.027496382	No	n/a
Waihopai at flow station	WHR-5	Conductivity	Yes	69.46	-4	144	-0.25	0.8	-0.42	-2.47	0.95	-0.006046646	-0.604664555	No	n/a
Waihopai at flow station	WHR-5	DRP	No	12	2	138	0.09	0.93	0	-1.01	1.01	0	0	No	n/a
Waihopai at flow station	WHR-5	DRP	Yes	12.24	2	144	0.08	0.93	0.14	-0.79	0.94	0.011437908	1.14379085	No	n/a
Waihopai at flow station	WHR-5	E. coli	Yes	23.47	0	144	0	1	-0.14	-10.89	13.6	-0.005965062	-0.596506178	No	n/a
Waihopai at flow station	WHR-5	E. coli	No	30	5	143	0.33	0.74	0.83	-5.75	5.12	0.027666667	2.766666667	No	n/a
Waihopai at flow station	WHR-5	Nitrate	No	5	14	102.67	1.28	0.2	0	0	0.56	0	0	No	n/a
Waihopai at flow station	WHR-5	Nitrate	Yes	1.46	20	144	1.58	0.11	3.03	0.25	6.05	2.075342466	207.5342466	No	n/a
Waihopai at flow station	WHR-5	pH	Yes	7.7	-2	144	-0.08	0.93	-0.01	-0.07	0.05	-0.001298701	-0.12987013	No	n/a
Waihopai at flow station	WHR-5	pH	No	7.7	-3	131.67	-0.17	0.86	0	-0.09	0.04	0	0	No	n/a
Waihopai at flow station	WHR-5	Turbidity	No	2.1	24	144	1.92	0.06	0.45	0.07	1.48	0.214285714	21.42857143	No	n/a
Waihopai at flow station	WHR-5	Turbidity	Yes	1.5	28	144	2.25	0.02	1.14	0.44	2.55	0.76	76	Yes	Yes
Wakamarina at SH Bridge	WKR-1	Conductivity	No	44	-42	190	-2.97	0	-2.2	-3.45	-1.18	-0.05	-5	Yes	Yes
Wakamarina at SH Bridge	WKR-1	DRP	No	12	38	181.33	2.75	0.01	1	0.5	1.01	0.083333333	8.333333333	Yes	Yes
Wakamarina at SH Bridge	WKR-1	E. coli	No	22	22	182	1.56	0.12	1.38	-0.05	4.95	0.062727273	6.272727273	No	n/a
Wakamarina at SH Bridge	WKR-1	Nitrate	No	17	-13	157.67	-0.96	0.34	0	-3.11	0	0	0	No	n/a
Wakamarina at SH Bridge	WKR-1	pH	No	7.3	26	179.33	1.87	0.06	0.05	0	0.1	0.006849315	0.684931507	No	n/a
Wakamarina at SH Bridge	WKR-1	Turbidity	No	0.3	27	180.33	1.94	0.05	0.07	0	0.1	0.233333333	23.33333333	Yes	Yes

Wairau River at Tuamarina	WRR-2	Conductivity	Yes	62.82	-22	200	-1.48	0.14	-0.93	-1.33	0.1	-0.014804202	-1.480420248	No	n/a
Wairau River at Tuamarina	WRR-2	Conductivity	No	63.15	-8	200	-0.49	0.62	-0.54	-1.56	1.04	-0.008551069	-0.855106888	No	n/a
Wairau River at Tuamarina	WRR-2	DRP	Yes	3.87	32	200	2.19	**0.03**	0.34	0.04	0.48	0.087855297	8.785529716	Yes	Yes
Wairau River at Tuamarina	WRR-2	DRP	No	4	35	181	2.53	**0.01**	0.64	0	0.99	0.16	16	Yes	Yes
Wairau River at Tuamarina	WRR-2	E. coli	Yes	6.8	-16	192	-1.08	0.28	-0.48	-2.19	0.5	-0.070588235	-7.058823529	No	n/a
Wairau River at Tuamarina	WRR-2	E. coli	No	7.4	-14	185.33	-0.95	0.34	-0.52	-2.21	0.34	-0.07027027	-7.027027027	No	n/a
Wairau River at Tuamarina	WRR-2	Nitrate	Yes	116.4	6	200	0.35	0.72	1.52	-9.48	8	0.013058419	1.305841924	No	n/a
Wairau River at Tuamarina	WRR-2	Nitrate	No	119	10	198	0.64	0.52	4.1	-3.14	9.04	0.034453782	3.445378151	No	n/a
Wairau River at Tuamarina	WRR-2	pH	No	7.65	-39	195	-2.72	**0.01**	-0.04	-0.08	-0.01	-0.005228758	-0.522875817	Yes	No
Wairau River at Tuamarina	WRR-2	pH	Yes	7.65	-34	200	-2.33	**0.02**	-0.04	-0.07	-0.02	-0.005228758	-0.522875817	Yes	No
Wairau River at Tuamarina	WRR-2	Turbidity	Yes	1.7	8	200	0.49	0.62	0.09	-0.13	0.2	0.052941176	5.294117647	No	n/a
Wairau River at Tuamarina	WRR-2	Turbidity	No	1.75	15	197	1	0.32	0.17	-0.05	0.65	0.097142857	9.714285714	No	n/a
Wairau River at Dip Flat	WRR-6	Conductivity	No	47.4	6	200	0.35	0.72	0.11	-0.77	0.69	0.002320675	0.232067511	No	n/a
Wairau River at Dip Flat	WRR-6	Conductivity	Yes	47.1	12	200	0.78	0.44	0.25	-0.13	0.56	0.005307856	0.530785563	No	n/a
Wairau River at Dip Flat	WRR-6	DRP	No	3	17	159.67	1.27	0.21	0	0	0.28	0	0	No	n/a
Wairau River at Dip Flat	WRR-6	DRP	Yes	3	8	200	0.49	0.62	0.06	-0.1	0.13	0.02	2	No	n/a
Wairau River at Dip Flat	WRR-6	E. coli	No	3	11	164.33	0.78	0.44	0.01	-0.02	0.63	0.003333333	0.333333333	No	n/a
Wairau River at Dip Flat	WRR-6	E. coli	Yes	1.53	14	176	0.98	0.33	0.21	-0.14	0.81	0.137254902	13.7254902	No	n/a
Wairau River at Dip Flat	WRR-6	Nitrate	Yes	10	-28	200	-1.91	0.06	-0.64	-1.64	-0.04	-0.064	-6.4	No	n/a
Wairau River at Dip Flat	WRR-6	Nitrate	No	11.5	2	193.33	0.07	0.94	0	-1.57	1.58	0	0	No	n/a
Wairau River at Dip Flat	WRR-6	pH	No	7.64	-38	198	-2.63	**0.01**	-0.03	-0.05	-0.01	-0.003926702	-0.392670157	Yes	No
Wairau River at Dip Flat	WRR-6	pH	Yes	7.63	-24	200	-1.63	0.1	-0.02	-0.03	0	-0.002621232	-0.262123198	No	n/a
Wairau River at Dip Flat	WRR-6	Turbidity	Yes	0.84	6	200	0.35	0.72	0.02	-0.08	0.13	0.023809524	2.380952381	No	n/a
Wairau River at Dip Flat	WRR-6	Turbidity	No	0.91	10	200	0.64	0.52	0.08	-0.07	0.37	0.087912088	8.791208791	No	n/a
Waitohi Stream at SH bridge	WTS-009	Conductivity	No	103	-4	144	-0.25	0.8	-0.21	-4	2.19	-0.002038835	-0.203883495	No	n/a
Waitohi Stream at SH bridge	WTS-009	DRP	No	15	6	140	0.42	0.67	0.5	-1.01	1.51	0.033333333	3.333333333	No	n/a
Waitohi Stream at SH bridge	WTS-009	E. coli	No	81	13	143	1	0.32	5.54	-6.33	18.47	0.068395062	6.839506173	No	n/a
Waitohi Stream at SH bridge	WTS-009	Nitrate	No	18	-11	127.67	-0.89	0.38	0	-4.94	0	0	0	No	n/a
Waitohi Stream at SH bridge	WTS-009	pH	No	7.9	-8	142	-0.59	0.56	-0.09	-0.23	0.1	-0.011392405	-1.139240506	No	n/a
Waitohi Stream at SH bridge	WTS-009	Turbidity	No	1.1	19	139	1.53	0.13	0.09	0	0.2	0.081818182	8.181818182	No	n/a