Christchurch City Council
City Environment Group

Christchurch Rivers Water Quality Monitoring

Annual Results Summary

May 2012 – April 2013

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Summary

This report summarises the results of the Christchurch City Council (CCC) rivers water quality monitoring programme for the period May 2012 to April 2013. Monthly water samples were collected from 37 sites across the five major catchments of Christchurch City – the Avon, Heathcote, Halswell, Styx and Otukaikino. The results of this monitoring were compared with the ANZECC (2000) water quality guidelines and the water quality standards in the Canterbury Natural Resources Regional Plan (NRRP).

Nitrate-Nitrite Nitrogen (NNN) and Dissolved Reactive Phosphorus (DRP) concentrations in all the catchments were at levels likely to encourage the proliferation of aquatic plants and algae (i.e. concentrations were above the guideline level). In the mainstems of all catchments, NNN concentrations generally decreased downstream. In contrast, DRP concentrations generally increased downstream in the Avon catchment, but there were generally no trends with respect to distance downstream for the Heathcote, Styx or Otukaikino catchments. The highest average levels of NNN were recorded at the 'Halswell River' and 'Heathcote River at Templetons Road' sites. The two Haytons Drain sites (Wigram Road and downstream of the retention basin), recorded substantially higher average DRP concentrations than all other sites in all other catchments.

Ammonia nitrogen concentrations were generally at levels that were not expected to have chronic toxic effects on aquatic life (i.e. concentrations were below the guideline level). The exception was Haytons Drain at Wigram Road, where high ammonia nitrogen concentrations were frequently recorded. A number of tributaries had high ammonia values in comparison to the mainstems, most notably Addington Drain, Dudley Creek and Horseshoe Lake in the Avon catchment, Haytons Drain at Wigram Road in the Heathcote catchment, and Kaputone Stream in the Styx catchment.

Biochemical Oxygen Demand (BOD) levels were generally below the guideline level in all catchments. The exceptions to this were both Hayton Drain sites and the 'Heathcote River at Templetons Road' site in the Heathcote catchment, and the Kaputone Stream at Blakes Road site in the Styx catchment; this suggests there is the potential for bacteria to deplete oxygen levels in the water at these sites.

TSS levels at all sites within all the catchments were generally well below the guideline level, with the exception of Haytons Drain at Wigram Road, Heathcote River at Tunnel Road and Heathcote River at Ferrymead Bridge in the Heathcote catchment. TSS levels generally increased downstream in the Avon River mainstem and tributaries. In contrast, levels were generally similar between sites in both the mainstem and tributaries of the Halswell, Heathcote, Styx and Otukaikino catchments.

E. coli concentrations generally exceeded the guideline level for contact recreation at all sites within all of the catchments, either for mean concentrations overall or during a number of individual sampling events during the monitoring period. Haytons Drain and Otukaikino were the exceptions to this, with neither of these waterways ever exceeding the guideline value. In all of the catchments, *E. coli* levels were similar across sites both in the mainstem and the tributaries.

Heavy metals (copper, lead and zinc) in each of the catchments were generally below their respective hardness modified trigger values. The exception to this was zinc levels in Addington Drain and Dudley Creek in the Avon catchment, Curtletts Road in the Heathcote catchment and Kaputone Stream at Blakes Road in the Styx catchment. Moreover, a number of sites always recorded metal values below the laboratory limit of detection. Concentrations for all three heavy metals were generally similar in the mainstems compared to the tributaries, and did not vary with increasing distance downstream.

Water quality results from this year were also compared to that recorded in previous monitoring years, using trend analyses. These analyses indicated that that *E. coli* concentrations in the catchments are no longer increasing as a result of the earthquakes (with the exception of the Avon catchment, where increases at a number of sites did occur), but levels are also not reducing as of yet to pre-earthquake levels. NNN and turbidity levels across the sites either did not change or showed a decrease. Trends in conductivity levels varied, with some sites not changing, and others increasing or decreasing in conductivity.

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1 Rivers Water Quality Monitoring Programme

1.1 Sample Collection Methods

Water samples are collected as part of Christchurch City Council's baseline surface water quality monitoring programme from sites in the Avon, Heathcote, Styx, Otukaikino and Halswell catchments. There are currently 42 sampling sites in the monitoring programme, covering the main catchments of the city (Table 1 and Figure 1)[1]. Water samples from these sites are collected monthly by the CCC laboratory. This report presents monitoring from May 2012 – April 2013 from 37 of these sites (see Table 1 for details of sites that are not presented in this report). Of these 37 sites, the 'Haytons Drain at Wigram Road' site was only monitored from May – August during this monitoring year, as this waterway was dry at this location at other times of the year. This site has consequently been removed from future sampling; however, the data from May – August is still presented in this report.

[1] The 'Curletts Road Drain at the Motorway' site has recently been removed from the program, as access to this site is no longer possible.

Table 1 River water quality monitoring sites in Christchurch City

Catchment	Site Description	Easting	Northing
Avon	Wairarapa Stream	2478250	5742915
	Waimairi Stream	2478232	5742784
	Avon River at Mona Vale	2478334	5742658
	Avon River at Carlton Mill corner[1]	2479737	5742871
	Riccarton Drain	2479019	5741648
	Addington Drain	2479427	5741438
	Avon River at Manchester St	2480890	5742093
	Dudley Creek	2482575	5743763
	Avon River at Dallington Tce/Gayhurst Rd	2483562	5742822
	Horseshoe Lake discharge	2484344	5744907
	Avon River at Avondale Rd[1]	2484754	5745170
	Avon River at Pages/Seaview Bridge	2487487	5744202
	Avon River at Bridge St	2487694	5742425
Heathcote	Heathcote River at Templetons Rd	2475913	5738508
	Haytons Drain at Wigram Rd[1]	2475219	5739384
	Haytons Drain at Retention Basin	2476019	5739207
	Curletts Road Drain US Heathcote	2476927	5739322
	Heathcote River at Rose St	2478700	5737528
	Cashmere Stream at Sutherlands Road (new site for South-West Stormwater Management Plan)[2]	2476084	5735598
	Cashmere Stream at Worsleys Rd	2479030	5736765
	Heathcote River at Ferniehurst St	2479157	5737222
	Heathcote River at Bowenvale Ave	2481198	5737390
	Heathcote River at Opawa Rd/Clarendon Tce	2483072	5739226
	Heathcote River at MacKenzie Ave[1]	2483521	5739528
	Heathcote River at Catherine St[1]	2484415	5739494
	Heathcote River at Tunnel Rd	2485076	5739154
	Heathcote River at Ferrymead Bridge	2486494	5738760
Styx	Smacks Creek at Gardiners Rd	2476803	5749571
	Styx River at Gardiners Rd	2476789	5748841
	Styx River at Main North Rd	2479066	5748834
	Kaputone at Blakes Rd	2480401	5749645
	Kaputone at Belfast Rd	2482195	5749882
	Styx River at Marshland Rd Bridge	2482359	5749393
	Styx River at Richards Bridge	2483977	5751255
	Styx River at Harbour Rd Bridge	2485000	5756366
Halswell	Halswell Retention Basin inlet[1, 2]	2471698	5738633
	Halswell Retention Basin outlet[1, 2]	2471793	5738525
	Nottingham Stream at Candys Rd	2474530	5734689
	Knights Stream at Sabys Road (new site for South-West Stormwater Management Plan)[2]	2473720	5734461
	Halswell River at Akaroa Highway	2474444	5733330
Otukaikino	Otukaikino at Groynes inlet	2477878	5750484
City Outfall	City Outfall Drain[2]	2485954	5739637

[1] Sites monitored for a reduced suite of parameters, excluding turbidity, total nitrogen, total phosphorus, metals, and dissolved organic carbon

[2] Sites not analysed in this report, although raw data for the Halswell Retention Basin is provided in Appendix 4

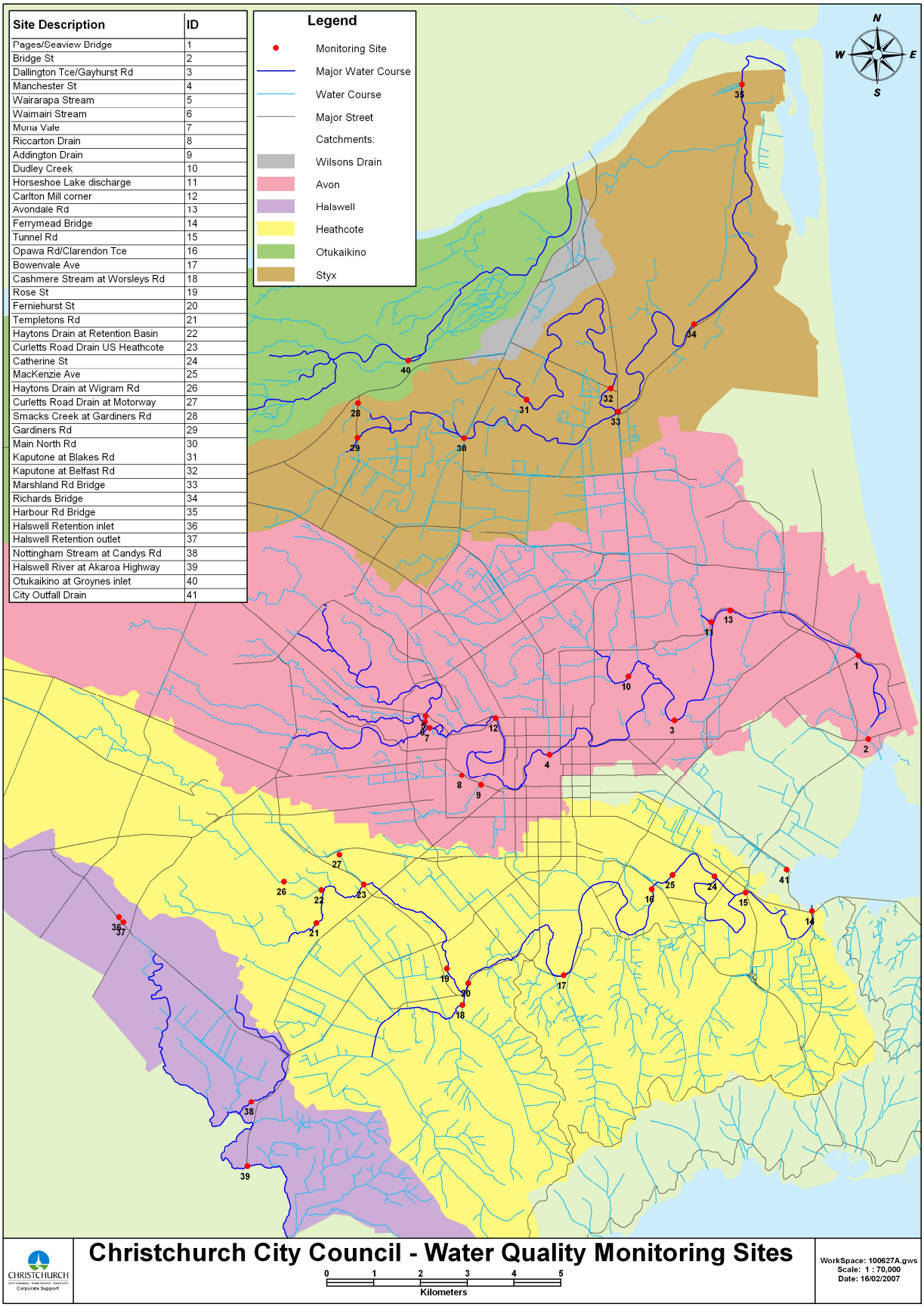

Figure 1 River water quality monitoring sites in Christchurch City

1.2 Parameters and Guideline Values

Water quality at the sites were analysed for the parameters listed in Table 2. This report presents the monitoring results from key parameters of concern to water quality: nitrate-nitrite nitrogen dissolved reactive phosphorous, ammonia nitrogen, biochemical oxygen demand, total suspended solids, *Escherichia coli* and heavy metals (copper, lead and zinc). Summary data of the other parameters that were sampled during the monitoring period can be found in Appendix 1-4.

Table 2 Water quality parameters analysed for Christchurch City river water quality monitoring sites

Parameter
pH
Temperature
Dissolved Oxygen Saturation
Conductivity
Turbidity
Total Suspended Solids
Nitrate Nitrogen
Nitrite Nitrogen
Nitrate-Nitrite Nitrogen
Ammonia Nitrogen
Total Nitrogen
Total Phosphorus
Dissolved Reactive Phosphorus
Faecal Coliforms[1]
Escherichia coli
Enterococci
Cadmium (Dissolved)
Copper (Dissolved)
Lead (Dissolved)
Zinc (Dissolved)
Biochemical Oxygen Demand
Dissolved Organic Carbon

[1] Not analysed at all sites

1.3 Methods for Data Analysis

1.3.1 Summary Statistics

Water quality parameters for each site were summarised by the mean of 12 monthly samples collected between May 2012 and April 2013, which are displayed on bar graphs for each catchment. For the purpose of calculating summary statistics, when water quality results were reported by the laboratory to be 'less than' the laboratory limit of detection, the data were converted to half of this detection limit.

1.3.2 Trend Analyses

To assess changes over time, trend analyses were undertaken for data collected over the six year period between January 2007 (when sampling was first initiated) and December 2012. These analyses were undertaken using the Time Trends software developed by NIWA (NIWA 2011). Analyses were performed on unadjusted and flow adjusted data (to account for variations in water quality over the period of sampling), and the Seasonal Kendall trend test was used to test the significance of trends. The non-parametric Seasonal Kendall Sen Slope Estimator was then used to determine the magnitude and direction of trends. To allow relative comparisons in the magnitude of trends between sites, these slope estimates were then relativised by expressing them as a percentage of the median of the raw data. Time Trends converted data below the laboratory limit of detection to 10% below the detection limit. However, trend analysis can only performed on parameters that do not have a high proportion of data below the laboratory limit of detection.

Trends were therefore assessed for nitrate-nitrite nitrogen, *E. coli*, turbidity and electrical conductivity.

2 Annual results and comparison with guidelines

A summary of the water quality data collected for each catchment between May 2012 and April 2013 is provided in Appendix 1.

2.1 Nitrate-Nitrite Nitrogen (NNN)

Elevated concentrations of Nitrate-Nitrite Nitrogen (NNN) can lead to the proliferation of aquatic plants and algae, because nitrate and nitrite are oxidised forms of nitrogen that are readily available to plants. The ANZECC (2000) water quality guidelines provide a trigger value of 0.444 mg/L for lowland rivers to avoid excessive plant growth.

Mean concentrations of NNN generally decreased downstream in the mainstems of the Avon, Heathcote and Styx Rivers (Figures 2 – 4). Levels between the tributaries and mainstem in these catchments were generally similar. All sites in all of the catchments, excluding Horseshoe Lake and Dudley Creek in the Avon catchment, recorded average NNN concentrations well above the ANZECC 0.444 mg/L guideline. Highest average levels of NNN were recorded at the Halswell River and Heathcote River at Templetons Road sites.

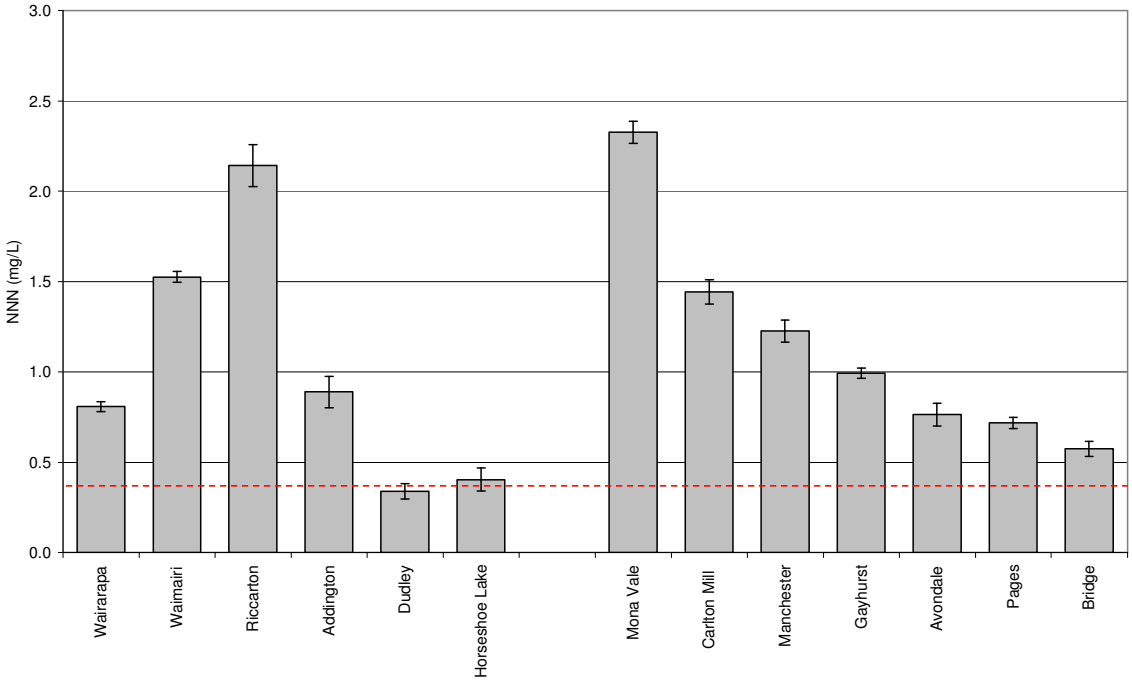

Figure 2 NNN concentrations for sites in the Avon catchment, mean ± SE for monthly samples between May 2012 and April 2013. Tributary sites are displayed on the left side of the graph and mainstem sites to the right, arranged from upstream to downstream (left to right). The guideline value of 0.444 mg/L is shown as a red dotted line.

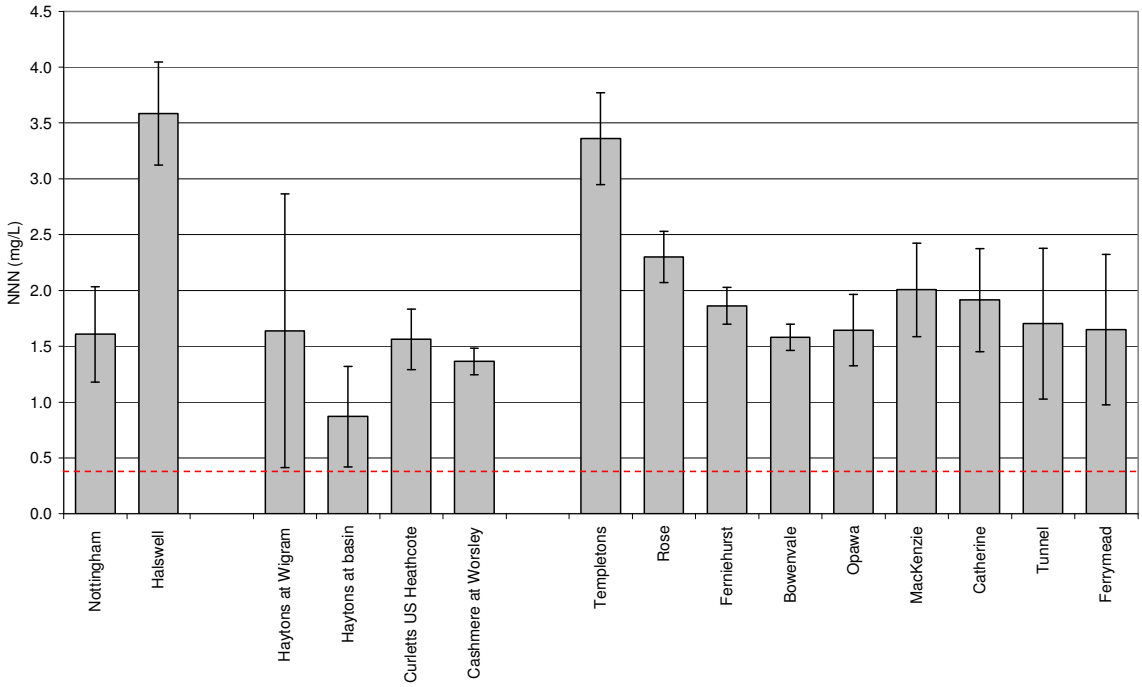

Figure 3 NNN concentrations for sites in the Heathcote and Halswell catchments, mean ± SE for monthly samples between May 2012 and April 2013. Halswell sites are to the left of the graph, followed by Heathcote tributary sites and then Heathcote mainstem sites to the right, arranged from upstream to downstream (left to right). The guideline value of 0.444 mg/L is shown as a red dotted line.

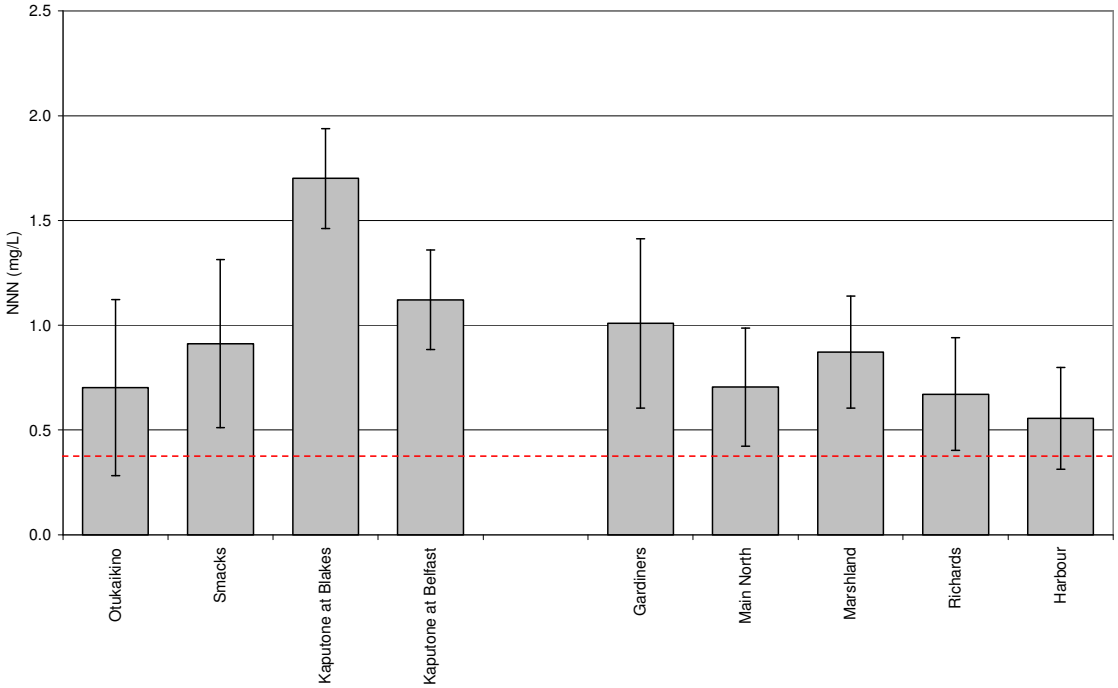

Figure 4 NNN concentrations for sites in the Styx and Otukaikino catchments, mean ± SE for monthly samples between May 2012 and April 2013. Otukaikino and Styx tributary sites are displayed on the left side of the graph and Styx River mainstem sites to the right, arranged from upstream to downstream (left to right). The guideline value of 0.444 mg/L is shown as a red dotted line.

2.2 Dissolved Reactive Phosphorus (DRP)

In combination with high nitrogen concentrations, elevated concentrations of Dissolved Reactive Phosphorus (DRP) can lead to the proliferation of aquatic plants and algae, as this dissolved form

of phosphorus is readily available for plant growth. The ANZECC (2000) water quality guidelines provide a trigger value of 0.01 mg/L for lowland rivers to avoid excessive plant growth. The NRRP water quality standards (detailed in Table WQL16 of this plan) provide a value of 0.016 mg/L for spring-fed-plains and spring-fed-plains-urban waterways, which covers all the monitored waterways. The exception to this is the Cashmere Stream, which is in the Banks Peninsula water quality class and therefore has a NRRP guideline value of 0.025 mg/L.

At most monitoring sites within all the catchments, average DRP concentrations were greater than the ANZECC and NRRP guideline values (Figure 5 – 7). In the Avon catchment, there was generally an increase in concentrations downstream. The Heathcote catchment recorded similar levels of DRP throughout the monitoring sites, with the exception of the two Haytons Drain sites (Wigram Road and downstream of the retention basin), which recorded substantially higher average DRP than all other sites in this catchment, as well as all other sites in the other catchments. Average DRP concentrations in the Halswell catchment were similar between the two sites. In the Styx and Otukaikino catchments, the Kaputone Stream recorded notably higher DRP concentrations than the other sites in this catchment.

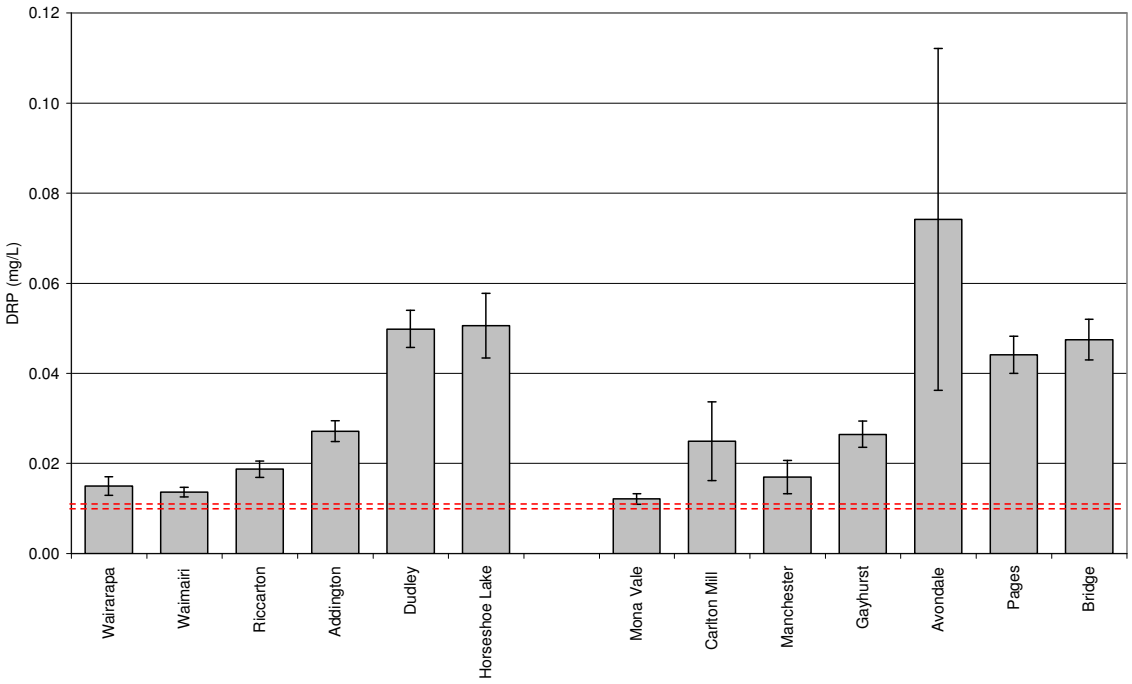

Figure 5 DRP concentrations for sites in the Avon catchment, mean ± SE for monthly samples between May 2012 and April 2013. Tributary sites are displayed on the left side of the graph and mainstem sites to the right, arranged from upstream to downstream (left to right). The top red dotted line represents the ANZECC (2000) guideline value of 0.01 mg/L and the bottom dotted line represents the NRRP water quality standard of 0.016 mg/L.

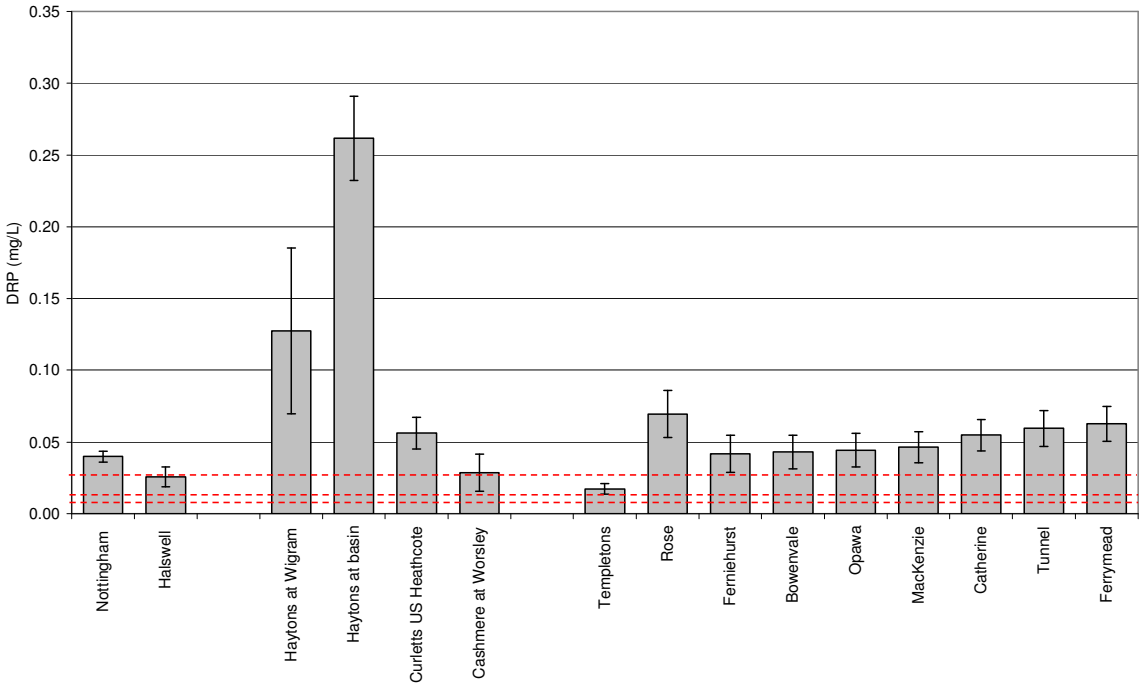

Figure 6 DRP concentrations for sites in the Heathcote and Halswell catchments, mean ± SE for monthly samples between May 2012 and April 2013. Halswell sites are to the left of the graph, followed by Heathcote tributary sites and then Heathcote mainstem sites to the right, arranged from upstream to downstream (left to right). The top red dotted line represents the NRRP water quality standard guideline value of 0.025 mg/L for Cashmere Stream, the middle line represents the NRRP water quality standard guideline value of 0.016 mg/L for all other sites and the bottom dotted line represents the ANZEC (2000) water quality standard of 0.01 mg/L.

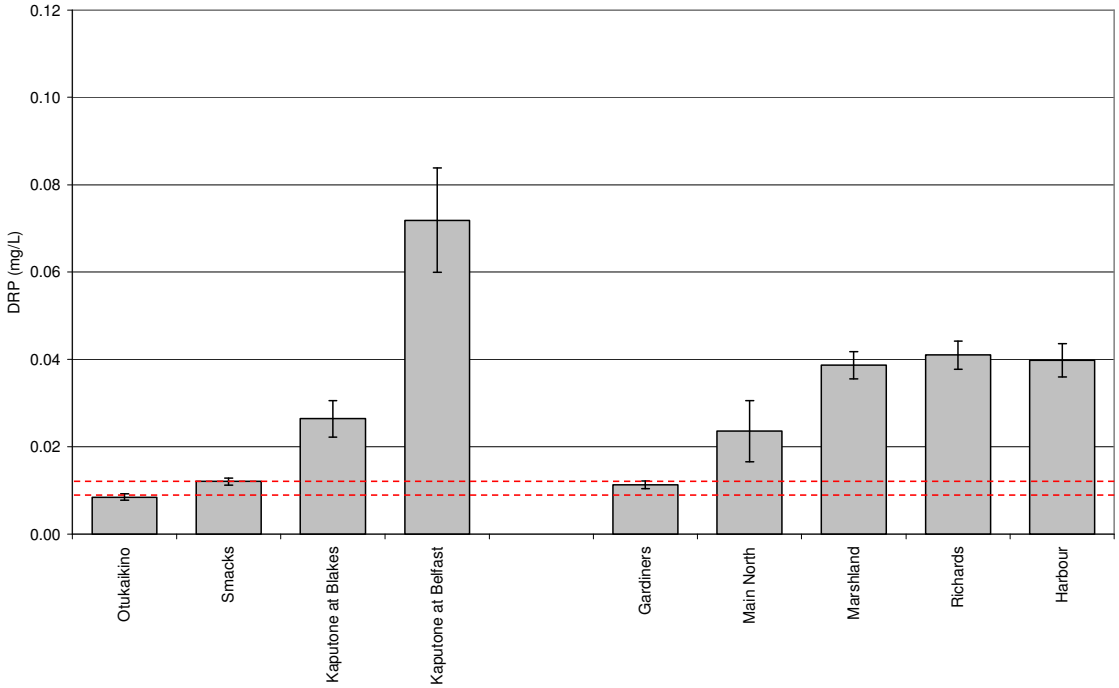

Figure 7 DRP concentrations for sites in the Styx and Otukaikino catchments, mean ± SE for monthly samples between May 2012 and April 2013. Otukaikino and Styx tributary sites are displayed on the left side of the graph and Styx River mainstem sites to the right, arranged from upstream to downstream (left to right). The top red dotted line represents the ANZECC (2000) guideline value of 0.01 mg/L and the bottom dotted line represents the NRRP water quality standard of 0.016 mg/L.

2.3 Ammonia Nitrogen

Ammonia nitrogen is typically a minor component of the nitrogen available for plant growth, but at high levels can have toxic effects on aquatic ecosystems. The toxicity of ammonia varies in relation to pH levels. Consequently, the NRRP maximum total ammonia standards (detailed in Table WQL17.1 of this plan) for protection of 95% of species from chronic ammonia toxicity, which are based on the ANZECC (2000) guidelines, vary depending on pH levels. These standards range from 2.57 mg/L for a pH of 6, to 0.180 mg/L for a pH of 9. A pH of 7.5 is typical for Christchurch waterways and therefore the standard for this pH level is relevant to this monitoring (1.61 mg/L). Ammonia values for acute toxicity will be higher than those discussed above for chronic toxicity.

All waterway monitoring sites recorded average ammonia nitrogen concentrations below the guideline value of 1.61 mg/L (Figures 8 – 10). The exception to this was Haytons Drain at Wigram Road. Although mean concentrations at this site are likely high compared to the other sites as sampling was only able to be conducted during the winter months with higher flow (and therefore potentially higher levels of contaminants), these results still indicate that this site records much higher ammonia nitrogen concentrations during winter compared to other sites. Average concentrations of ammonia nitrogen generally increased downstream for the Avon River. Concentrations were generally consistent between sites for the Halswell, Heathcote, Styx and Otukaikino catchments. However, a number of tributaries had high ammonia values in comparison to the mainstems, most notably Addington Drain, Dudley Creek and Horseshoe Lake in the Avon catchment, Haytons Drain at Wigram Road in the Heathcote catchment and Kaputone Stream in the Styx catchment.

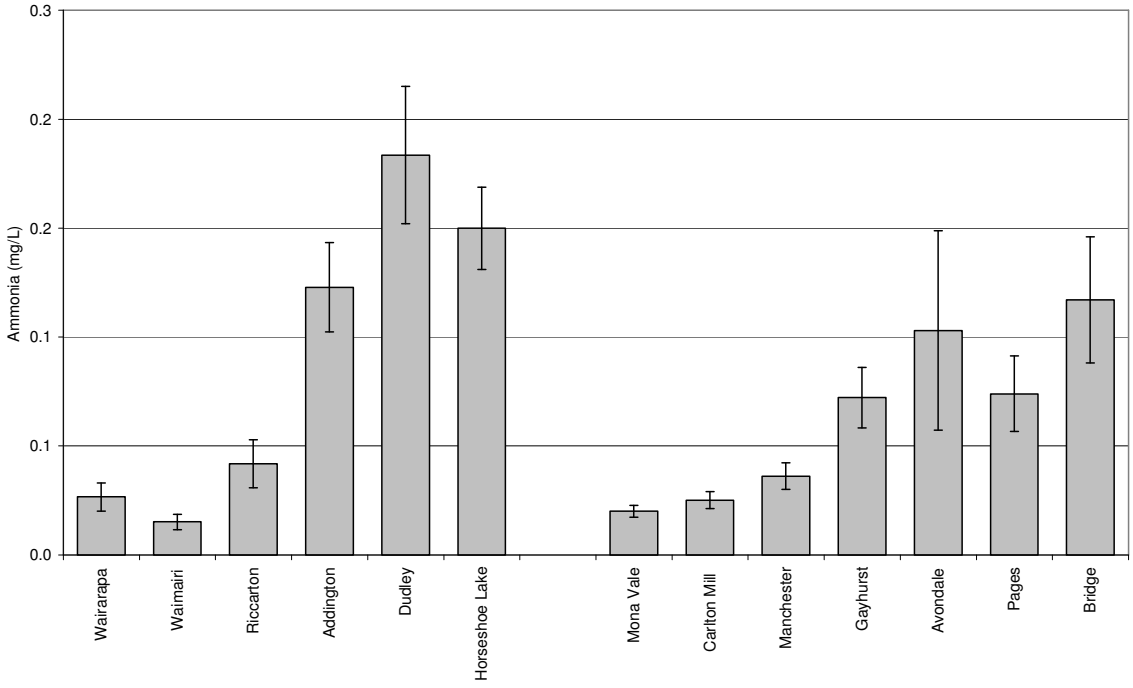

Figure 8 Ammonia Nitrogen concentrations for sites in the Avon catchment, mean ± SE for monthly samples between May 2012 and April 2013. Tributary sites are displayed on the left side of the graph and mainstem sites to the right, arranged from upstream to downstream (left to right). The guideline value of 1.61 mg/L is not shown on this graph because the scale does not extend that high.

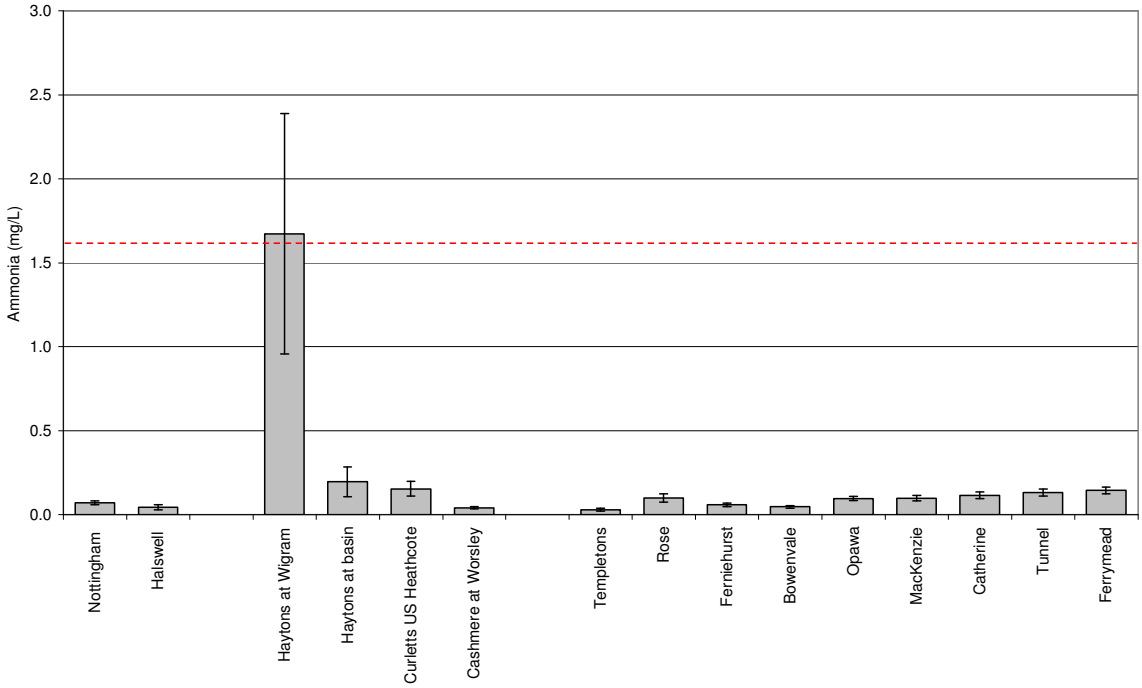

Figure 9 Ammonia Nitrogen concentrations for sites in the Heathcote and Halswell catchments, mean ± SE for monthly samples between May 2012 and April 2013. Halswell sites are to the left of the graph, followed by Heathcote tributary sites and then Heathcote mainstem sites to the right, arranged from upstream to downstream (left to right). The guideline value of 1.61 mg/L (at pH 7.5) is shown as a red dotted line.

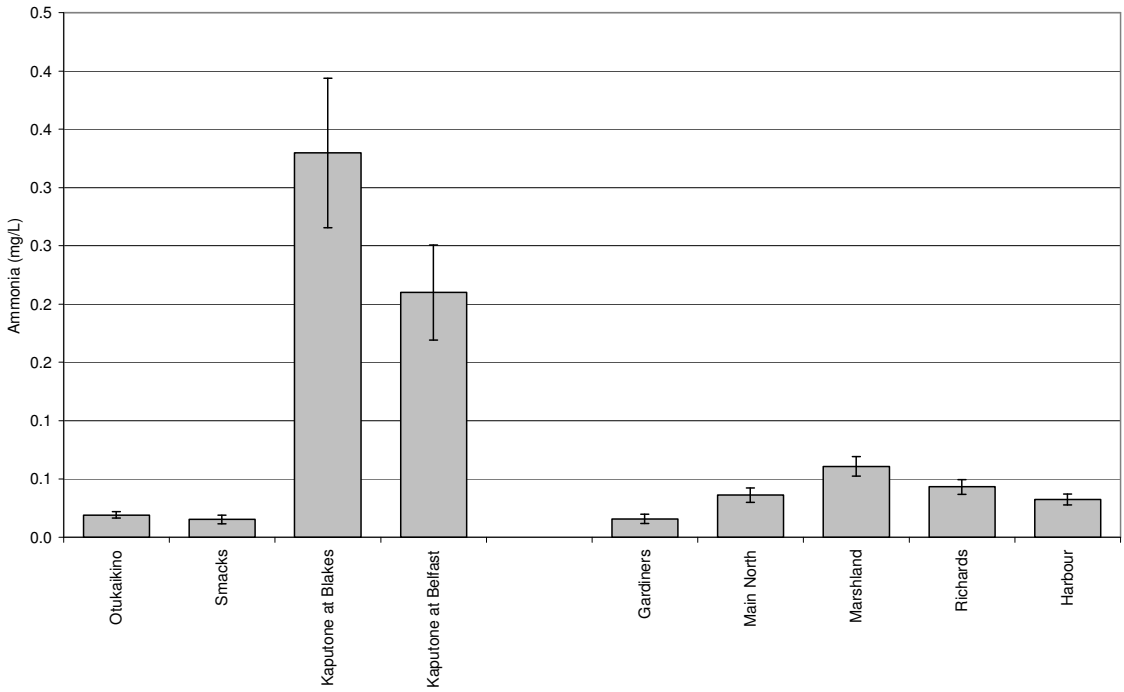

Figure 10 Ammonia nitrogen concentrations for sites in the Styx and Otukaikino catchments, mean ± SE for monthly samples between May 2012 and April 2013. Otukaikino and Styx tributary sites are displayed on the left side of the graph and Styx River mainstem sites to the right, arranged from upstream to downstream (left to right). The guideline value of 1.61 mg/L is not shown on this graph because the scale does not extend that high.

2.4 Biochemical Oxygen Demand (BOD)

Biochemical Oxygen Demand (BOD) is an indicator of the amount of biodegradable organic material in the water and a measure of the amount of oxygen required by bacteria to break down

this organic material. High values of BOD indicate the potential for bacteria to deplete oxygen levels in the water. The Ministry for the Environment guideline value for BOD is 2 mg/L (MfE 1992).

Average BOD values were generally less than the guideline for all sites in the Avon, Heathcote, Halswell, Styx and Otukaikino catchments (Figures 11 – 13). The exceptions to this were the two Haytons Drain sites and the Heathcote River at Templetons Road in the Heathcote catchment, and Kaputone Stream at Blakes Road in the Styx catchment. Although the mean value for the Avon River at Pages Road site did not exceed the guideline, this guideline was exceeded on a number of occasions during individual sampling events throughout the monitoring period. Many of the sites within all catchments frequently recorded values lower than the laboratory limit of detection (1 mg/L). BOD values generally increased downstream in both the tributaries and mainstem of the Avon River. In the Heathcote catchment, values generally decreased downstream in the tributaries, but did not vary substantially downstream in the mainstem. No distinct pattern was apparent in the Styx and Otukaikino catchments. Values between the tributaries and mainstem were generally similar for all catchments.

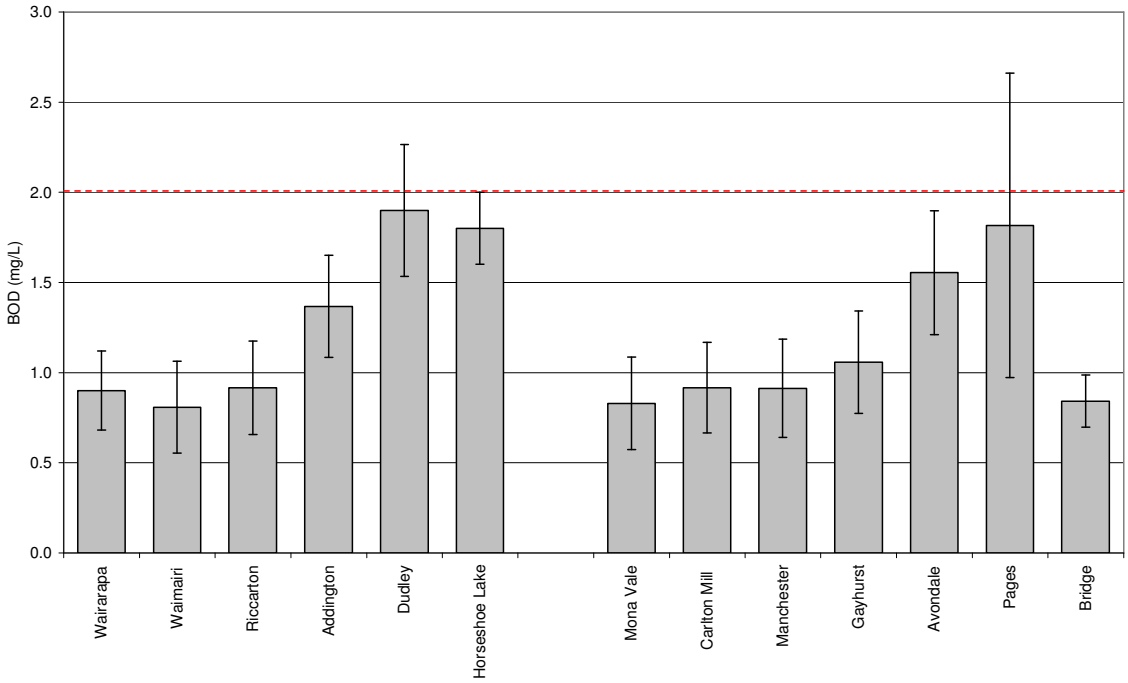

Figure 11 BOD concentrations for sites in the Avon catchment, mean ± SE for monthly samples between May 2012 and April 2013. Tributary sites are displayed on the left side of the graph and mainstem sites to the right, arranged from upstream to downstream (left to right). The guideline value of 2 mg/L is shown as a red dotted line.

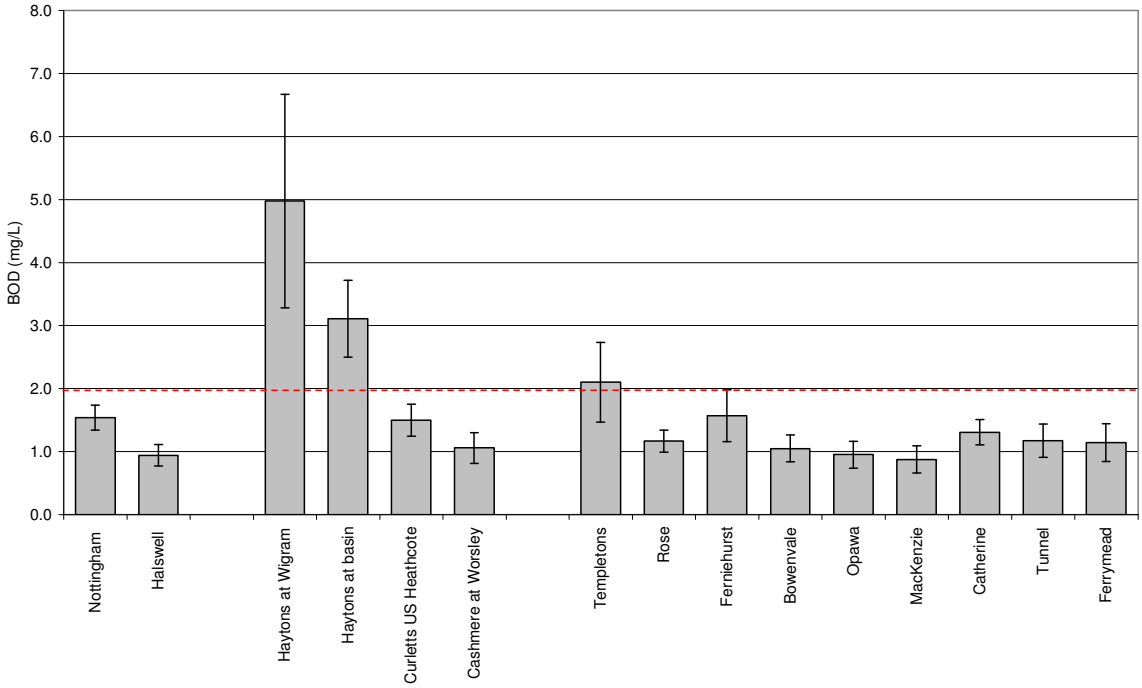

Figure 12 BOD concentrations for sites in the Heathcote and Halswell catchments, mean ± SE for monthly samples between May 2012 and April 2013. Halswell sites are to the left of the graph, followed by Heathcote tributary sites and then Heathcote mainstem sites to the right, arranged from upstream to downstream (left to right). The guideline value of 2 mg/L is shown as a red dotted line.

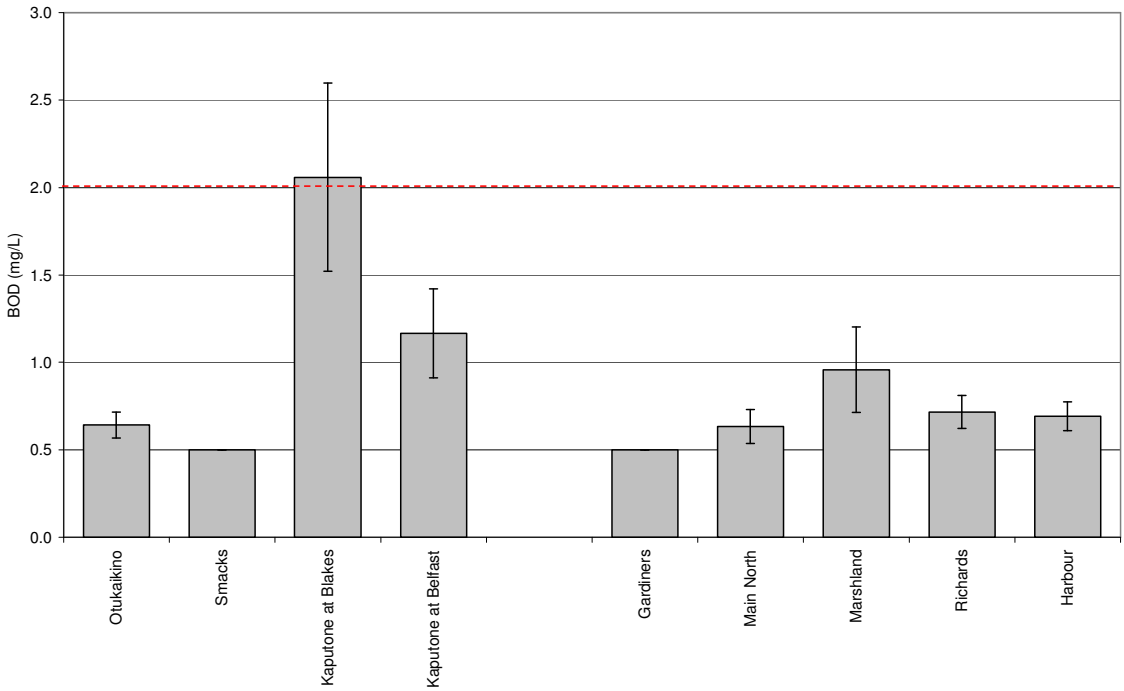

Figure 13 BOD concentrations for sites in the Styx and Otukaikino catchments, mean ± SE for monthly samples between May 2012 and April 2013. Otukaikino and Styx tributary sites are displayed on the left side of the graph and Styx River mainstem sites to the right, arranged from upstream to downstream (left to right). The guideline value of 2 mg/L is shown as a red dotted line. The means with no standard error reflect a lack of variability in the dataset, due to all sampling events recording levels below the limit of detection.

2.5 Total Suspended Solids (TSS)

Elevated levels of suspended sediment in the water column decreases the clarity of the water and can influence the behaviour of invertebrates and fish, as well as the growth of aquatic plants. A

guideline of 25 mg/L for Total Suspended Solids (TSS) (Ryan 1991) provides for the protection of aesthetic values and aquatic ecosystems.

Mean levels of TSS generally increased downstream in the Avon River mainstem and tributaries (Figure 14). In contrast, levels were generally similar between sites in both the mainstem and tributaries of the Halswell, Heathcote, Styx and Otukaikino catchments (Figure 15 & 16). The exception to this was Haytons Drain at Wigram Road, which recorded substantially greater TSS levels (mean of 220 mg/L) compared to all other sites in all of the catchments (Figure 15). Although mean concentrations at this site are likely high compared to the other sites as sampling was only able to be conducted during the winter months with higher flow (and therefore potentially higher levels of contaminants), these results still indicate that this site records much higher TSS during winter compared to other sites. Mean TSS levels at all the sites within the Avon, Halswell, Styx and Otukaikino catchments were well below guideline levels and a large proportion were even below the laboratory limit of detection (3 mg/L). However, three sites within the Heathcote catchment had mean TSS levels above the guideline: Haytons Drain at Wigram Road, Heathcote River at Tunnel Road and Heathcote River at Ferrymead Bridge.

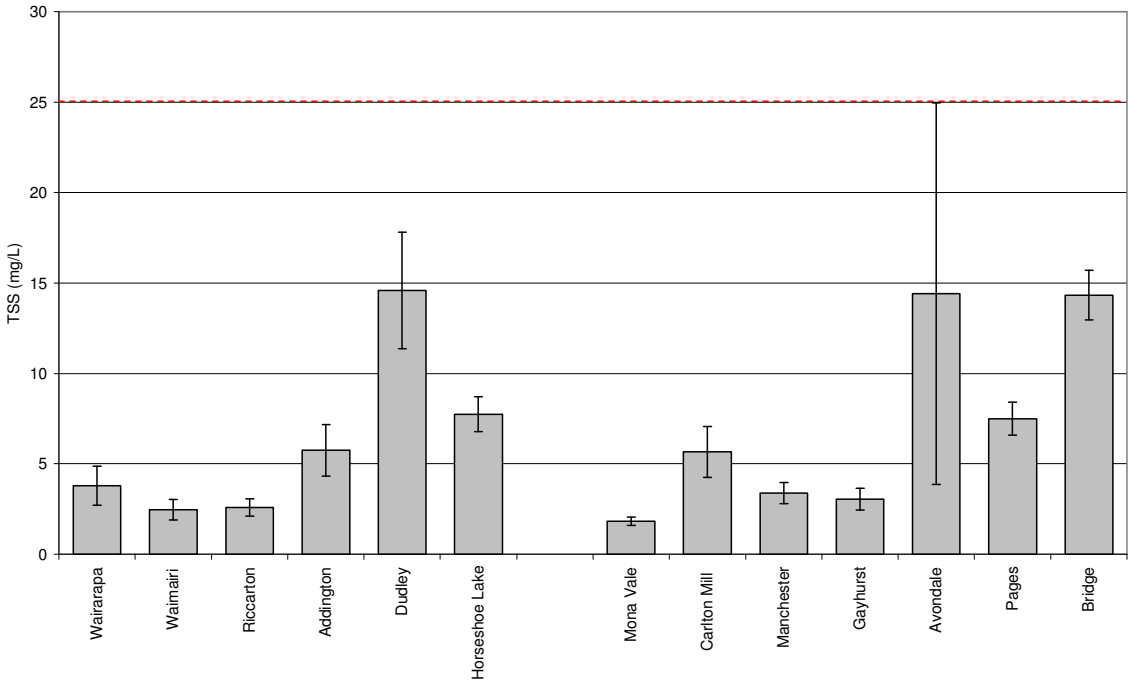

Figure 14 Total suspended solids concentrations for sites in the Avon catchment, mean ± SE for monthly samples between May 2012 and April 2013. Tributary sites are displayed on the left side of the graph and mainstem sites to the right, arranged from upstream to downstream (left to right). The guideline value of 25 mg/L is shown as a red dotted line.

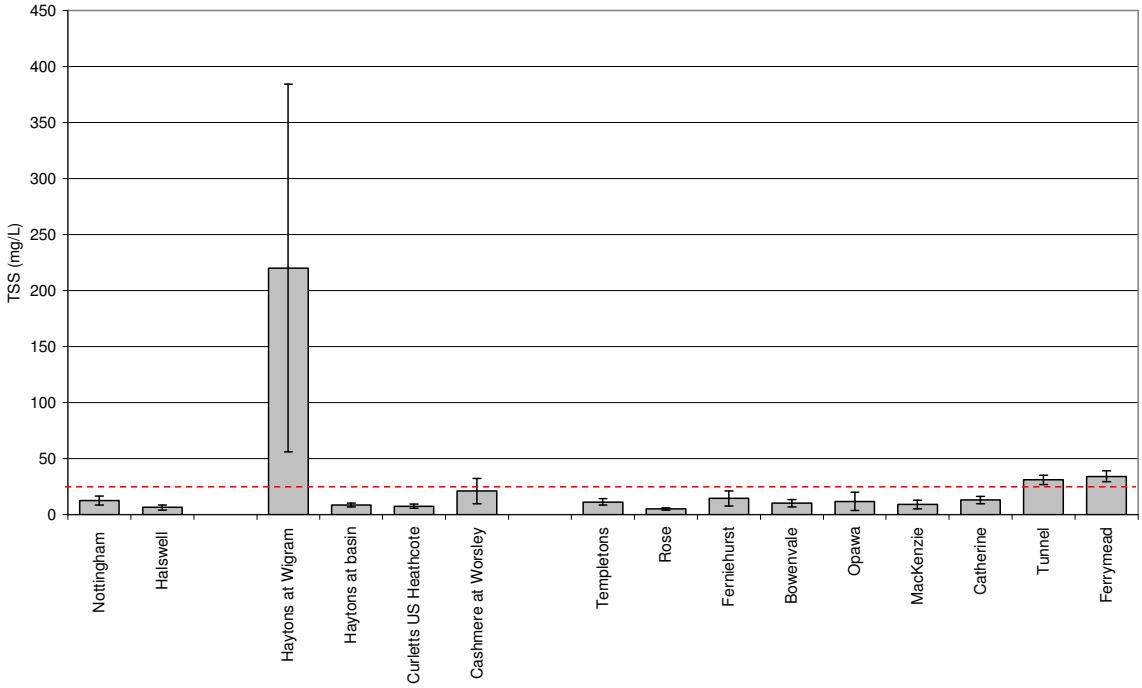

Figure 15 Total suspended solids concentrations for sites in the Heathcote and Halswell catchments, mean ± SE for monthly samples between May 2012 and April 2013. Halswell sites are to the left of the graph, followed by Heathcote tributary sites and then Heathcote mainstem sites to the right, arranged from upstream to downstream (left to right). The guideline value of 25 mg/L is shown as a red dotted line.

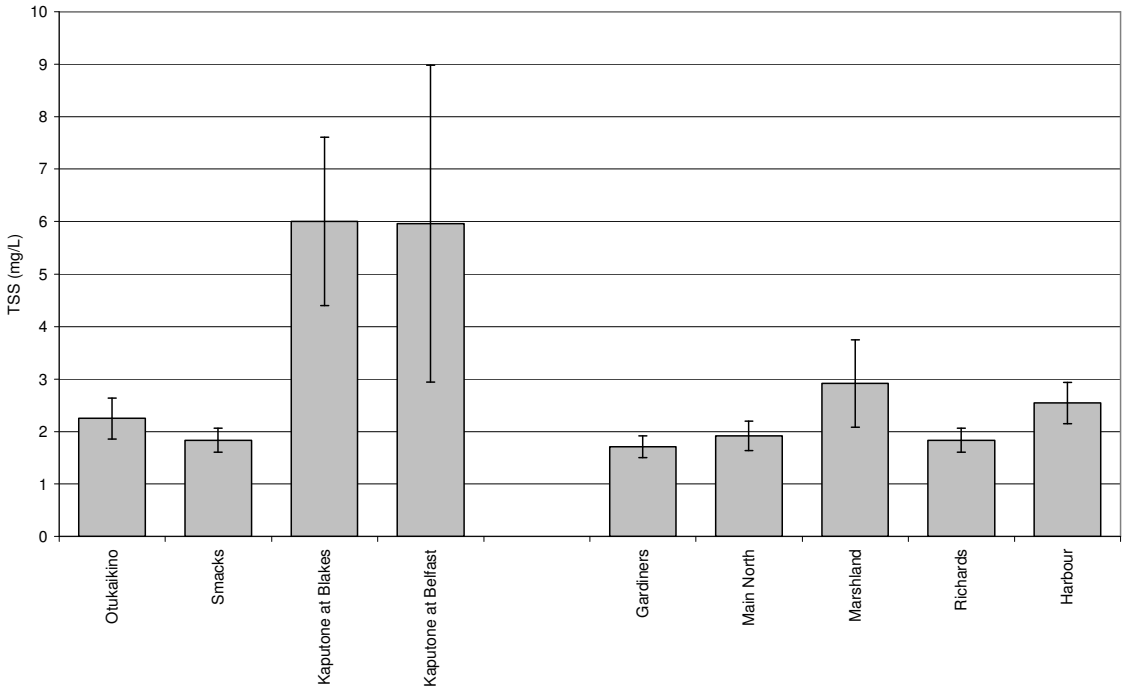

Figure 16 Total suspended solids concentrations for sites in the Styx and Otukaikino catchments, mean ± SE for monthly samples between May 2012 and April 2013. Otukaikino and Styx tributary sites are displayed on the left side of the graph and Styx River mainstem sites to the right, arranged from upstream to downstream (left to right). The guideline value of 25 mg/L is not shown on this graph as the scale does not extend to that value.

2.6 E. coli

Elevated levels of *Escherichia coli* (*E. coli*) may make the water unsuitable for contact recreation. Ministry for the Environment guidelines suggest that *E. coli* concentrations of single samples should not exceed 550 *E. coli* /100 mL to be safe for contact recreation (MfE 2003). This is also the

value indicated by the NRRP water quality standards (detailed in Table WQL16 of this plan) for the water quality classes represented in Christchurch (spring-fed-plains-urban, spring-fed-plains, Banks Peninsula).

In all of the catchments, *E. coli* levels were similar across sites both in the mainstem and the tributaries. In the Avon catchment specifically, nine of the thirteen sites recorded average *E. coli* concentrations above the guideline value, the exceptions being Waimairi Stream, Riccarton Drain, and the Avon River at Mona Vale and Avondale Road (Figure 17). For the Halswell catchment, Nottingham Stream recorded average *E. coli* levels above the guideline level, but the Halswell River site recorded levels below the guideline. All Heathcote tributary sites recorded average *E. coli* levels below the guideline; however, only two sites in the Heathcote mainstem had levels below the guideline – the sites at Templetons Road and at the Ferrymead bridge (Figure 18). In the Styx and Otukaikino catchments, average *E. coli* concentrations were below guideline levels at all sites except the two Kaputone Stream sites (Figure 19). However, for all of the sites in all of the catchments that did not exceed guideline levels for mean *E. coli* concentrations, all but two (Haytons Drain and Otukaikino) exceeded the guideline value on at least one occasion during the monitoring period.

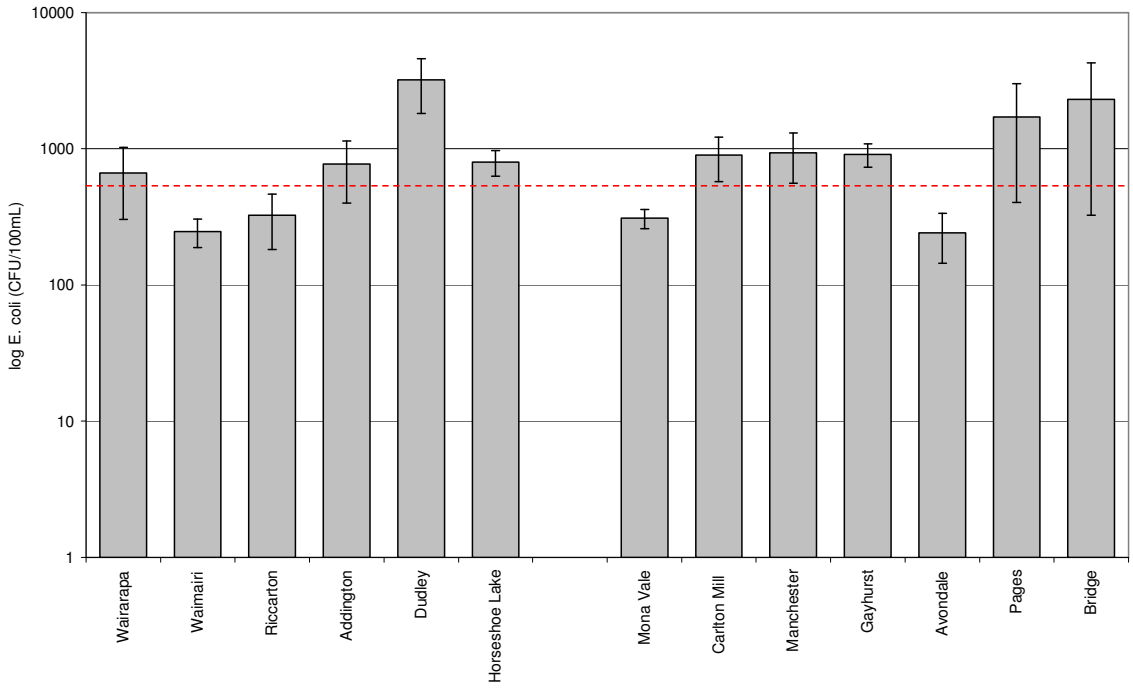

Figure 17 *E. coli* concentrations for sites in the Avon catchment, mean ± SE for monthly samples between May 2012 and April 2013. Tributary sites are displayed on the left side of the graph and mainstem sites to the right, arranged from upstream to downstream (left to right). A guideline value of 550 *E. coli* per 100 mL is shown as a red dotted line.

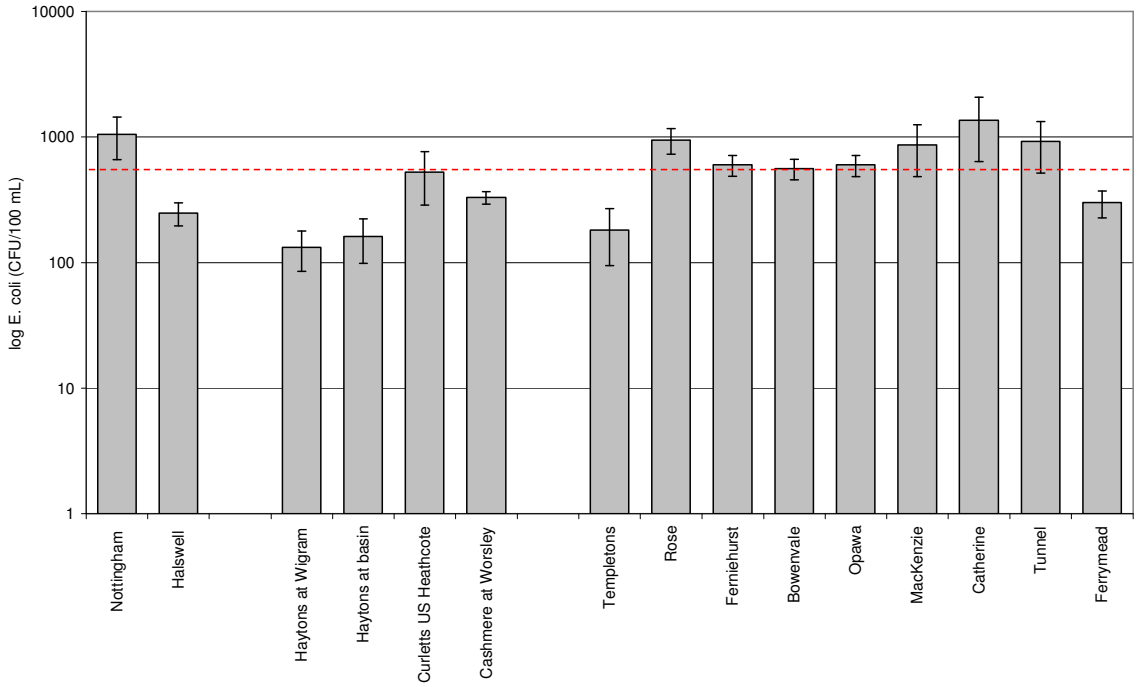

Figure 18 *E. coli* concentrations for sites in the Heathcote and Halswell catchments, mean ± SE for monthly samples between May 2012 and April 2013. Halswell sites are to the left of the graph, followed by Heathcote tributary sites and then Heathcote mainstem sites to the right, arranged from upstream to downstream (left to right). A guideline value of 550 *E. coli* per 100 mL is shown as a red dotted line.

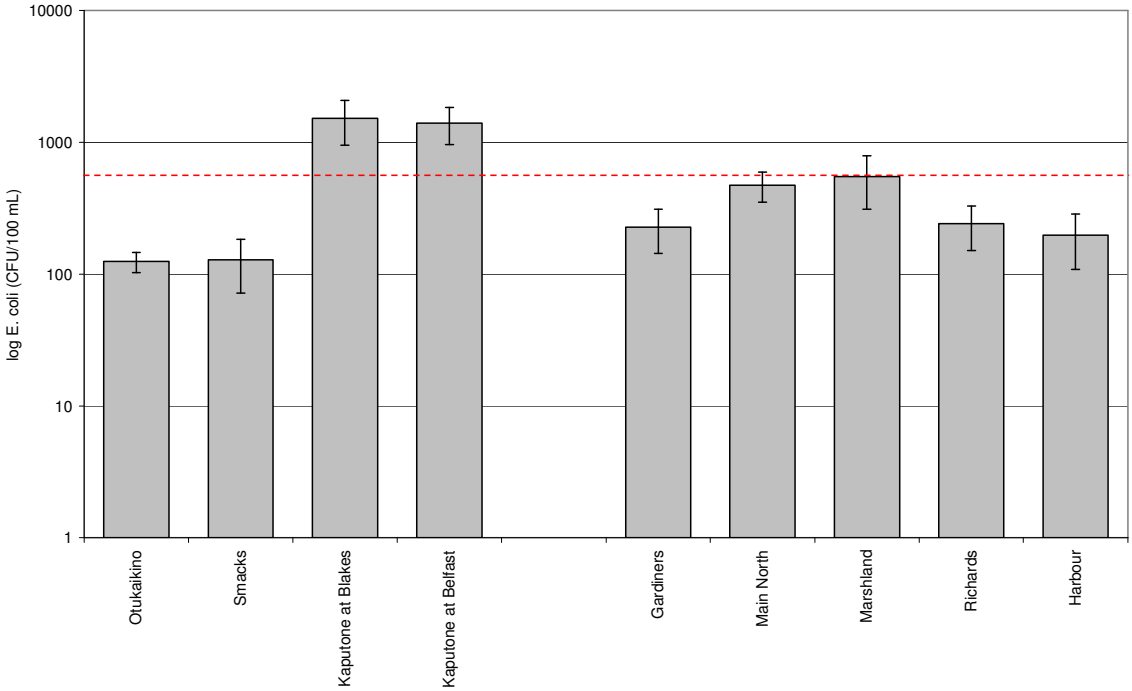

Figure 19 *E. coli* concentrations for sites in the Styx and Otukaikino catchments, mean ± SE for monthly samples between May 2012 and April 2013. Otukaikino and Styx tributary sites are displayed on the left side of the graph and Styx River mainstem sites to the right, arranged from upstream to downstream (left to right). A guideline value of 550 *E. coli* per 100 mL is shown as a red dotted line.

2.7 Heavy Metals

Water samples from a subset of the water quality monitoring sites in each catchment were analysed each month for dissolved concentrations of cadmium, copper, lead and zinc. These sites included eleven in the Avon catchment, ten in the Heathcote catchment, eight in the Styx catchment, one in the Otukaikino catchment and two in the Halswell catchment (see Table 1 for site details). Until December 2011, heavy metals at these sites were analysed as total metals.

However, total metal measurements tend to overestimate the bioavailable fraction of metals (ANZECC 2000). The dissolved fraction is bioavailable and has the greatest potential to cause toxic effects to instream life, making it a more relevant measure for trigger values. Consequently, monitoring of metals is now assessed using dissolved metals.

The ANZECC (2000) water quality guidelines set trigger values for each of these heavy metals to provide a specified level of protection for aquatic life. The NRRP toxicant water quality standards (detailed in Table WQL17 of this plan) use the same trigger values as ANZECC (2000) and specify levels of species protection for each water quality management unit. The water quality management units represented within Christchurch City are spring-fed-plains-urban (requiring 90% species protection), spring-fed-plains (requiring 95% species protection) and Banks Peninsula (requiring 99% species protection). All monitoring sites within the Avon and Heathcote catchments are spring-fed-plains-urban, with the exception of Cashmere Stream, which is in the Banks Peninsula water quality management unit. The Styx and Halswell catchment sites are in the spring-fed-plains management unit. ANZECC (2000) provides default trigger values for metals at each level of species protection and also provides a method for determining hardness modified trigger values (HMTV) that are relevant to local conditions. Hardness modified trigger values calculated for Christchurch rivers are provided in Appendix 5.

2.7.1 Dissolved Copper

Average copper concentrations for all sites in all of the catchments were below their respective HMTV (Figures 20 – 22). However, a number of sites exceeded this trigger value on a number of sampling occasions, including Styx River at Marshland Road Bridge and Kaputone Stream at Belfast Road (in the Styx catchment), and Curletts Road Drain (in the Heathcote catchment). Concentrations were generally similar in the mainstems compared to the tributaries, and did not vary with increasing distance downstream. A number of sites always recorded values below the laboratory limit of detection (0.2 mg/L), especially in the Styx and Otukaikino catchments.

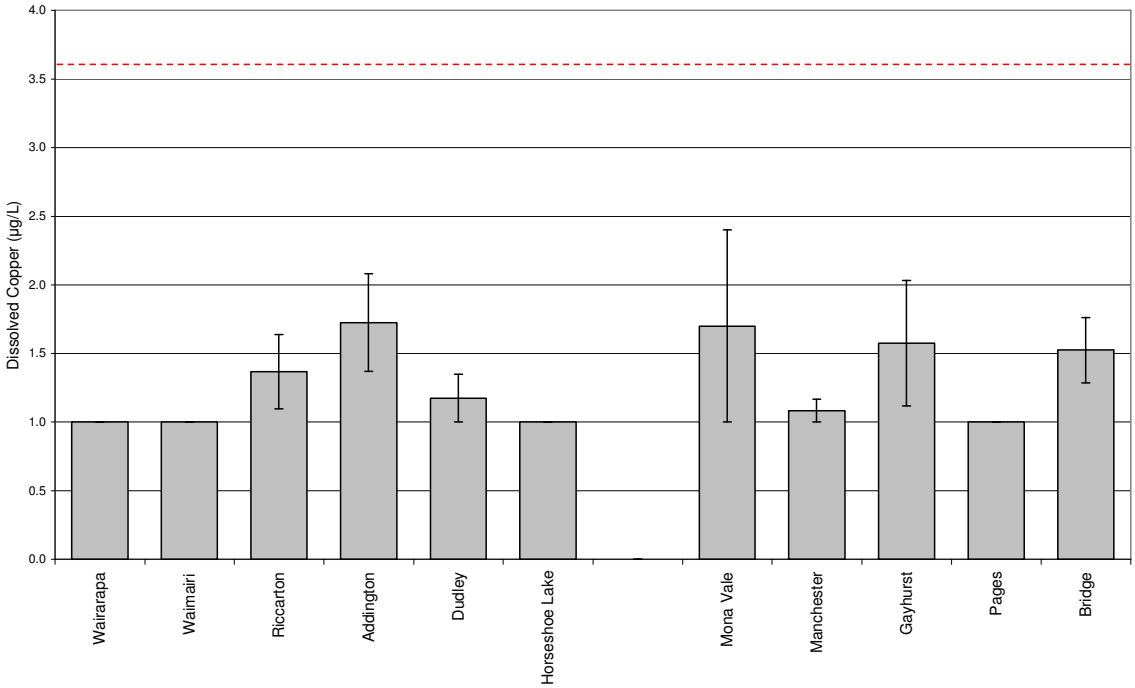

Figure 20 Dissolved copper concentrations for sites in the Avon catchment, mean ± SE for monthly samples between May 2012 and April 2013. Tributary sites are displayed on the left side of the graph and mainstem sites to the right, arranged from upstream to downstream (left to right). The ANZECC (2000) hardness modified trigger value of 3.56 µg/L (for 90% species protection) is displayed as a red dotted line on the graph. The means with no standard error reflect a lack of variability in the dataset, due to all sampling events recording levels below the limit of detection.

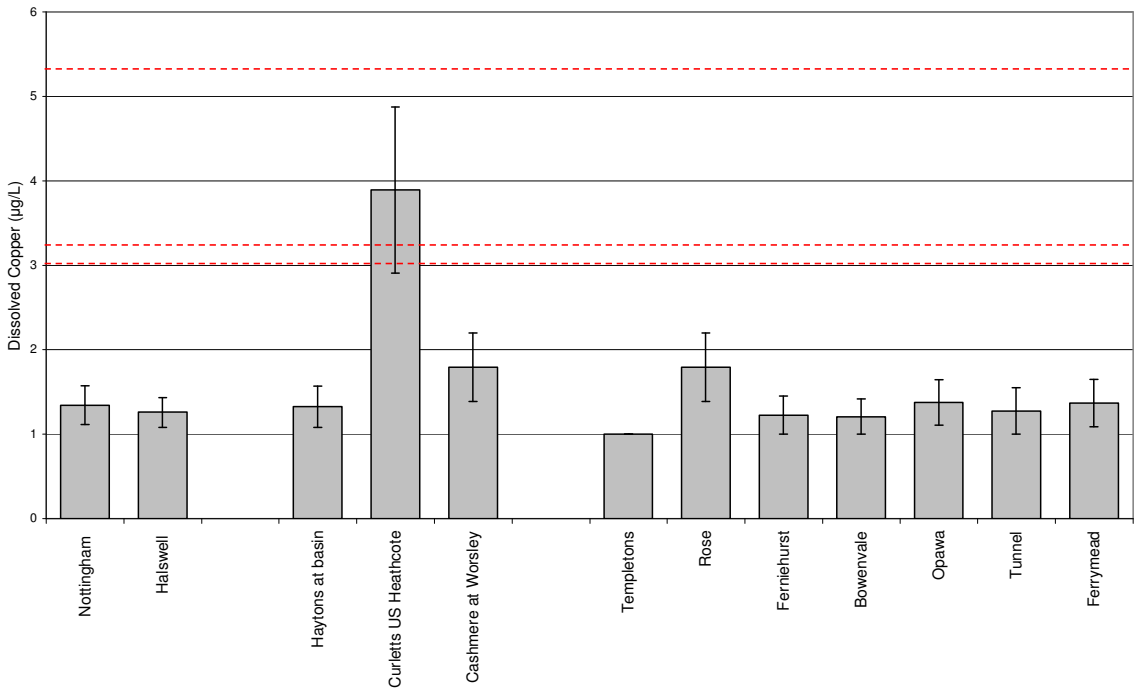

Figure 21 Dissolved copper concentrations for sites in the Heathcote and Halswell catchments, mean ± SE for monthly samples between May 2012 and April 2013. Halswell sites are to the left of the graph, followed by Heathcote tributary sites and then Heathcote mainstem sites to the right, arranged from upstream to downstream (left to right). The red dotted lines represent the ANZECC (2000) hardness modified trigger values – the bottom line is for Cashmere Stream for 99% species protection (3.02 µg/L), the top line is for all other Heathcote sites for 90% species protection (5.43 µg/L) and the middle line is for Halswell sites for 95% species protection (3.36 µg/L). The mean with no standard error reflect a lack of variability in the dataset, due to all sampling events recording levels below the limit of detection.

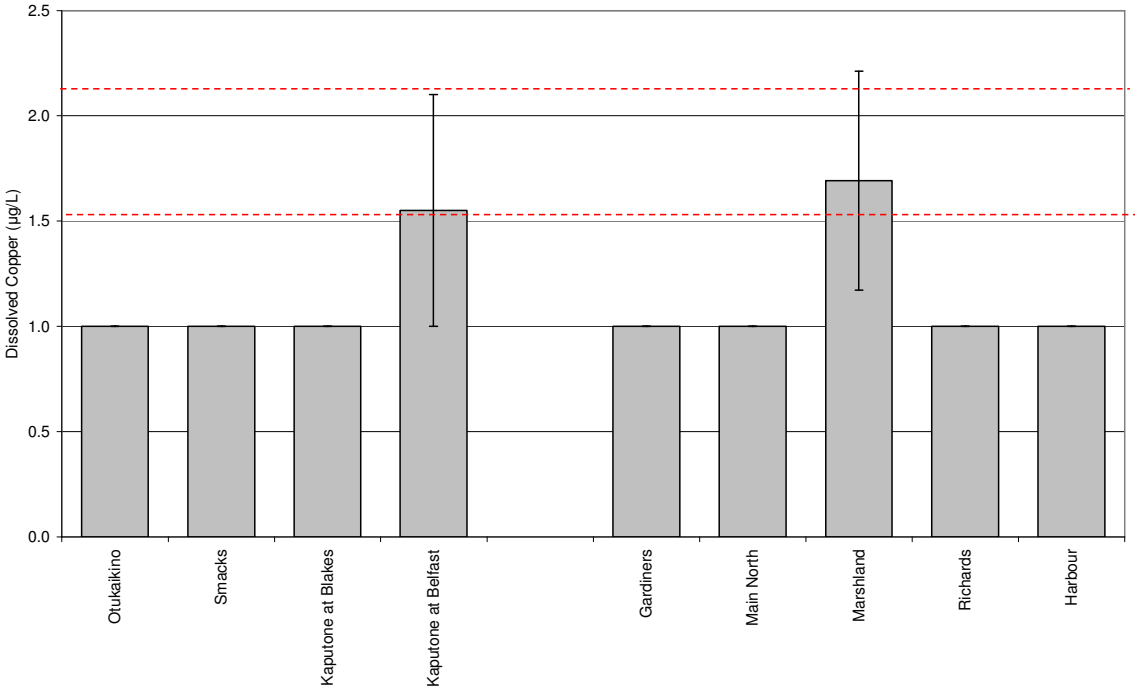

Figure 22 Dissolved copper concentrations for sites in the Styx and Otukaikino catchments, mean ± SE for monthly samples between May 2012 and April 2013. Otukaikino and Styx tributary sites are displayed on the left side of the graph and Styx River mainstem sites to the right, arranged from upstream to downstream (left to right). The red dotted lines represent the ANZECC (2000) hardness modified trigger values – the bottom line is for Outukaikino for 95% species protection (1.52 µg/L) and the top line is for all other sites for 95% species protection (2.12 µg/L). The means with no standard error reflect a lack of variability in the dataset, due to all sampling events recording levels below the limit of detection.

2.7.2 Dissolved Lead

The average lead concentrations for all sites in all of the catchments were below their respective HMTV (Figures 23 – 25). Moreover, some sites in all of the catchments always recorded values below the laboratory limit of detection (1.5 mg/L). Only two exceedances of the HMTV trigger values were recorded within all catchments throughout the monitoring period, one at Gardiners Road and one at Outukaikino. Concentrations were generally similar in the mainstems compared to the tributaries, and did not vary with increasing distance downstream.

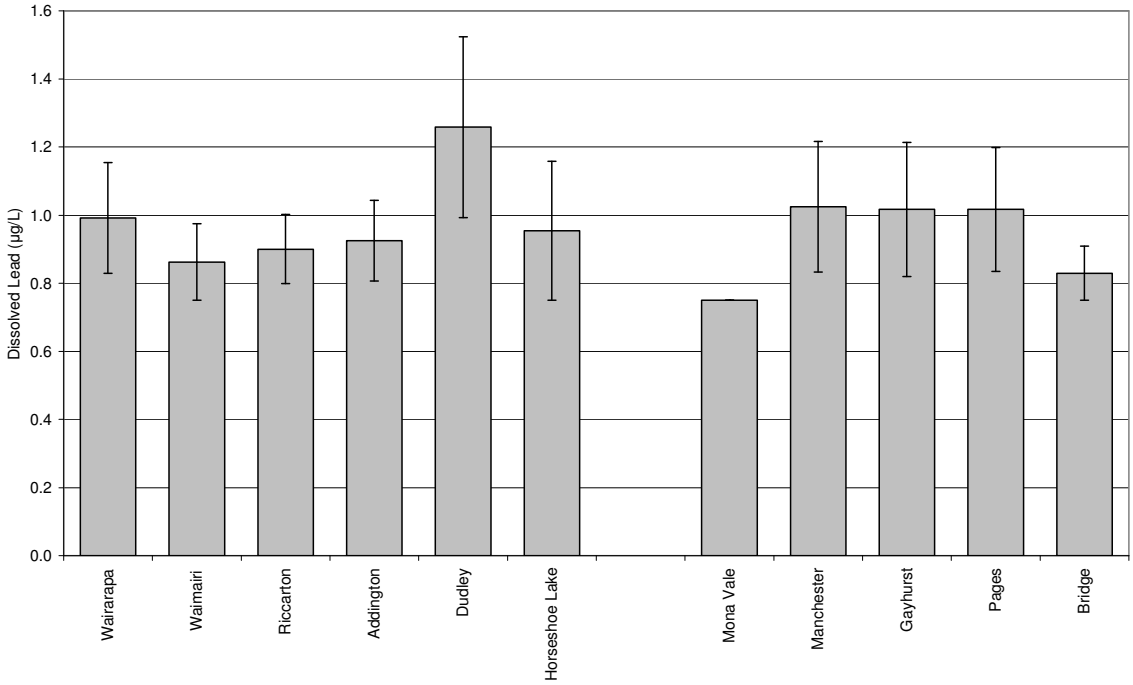

Figure 23 Dissolved lead concentrations for sites in the Avon catchment, mean ± SE for monthly samples between May 2012 and April 2013. Tributary sites are displayed on the left side of the graph and mainstem sites to the right, arranged from upstream to downstream (left to right). The ANZECC (2000) hardness modified trigger value of 15.54 µg/L is not shown on this graph as the scale does not extend to that value. The mean with no standard error reflecst a lack of variability in the dataset, due to all sampling events recording levels below the limit of detection.

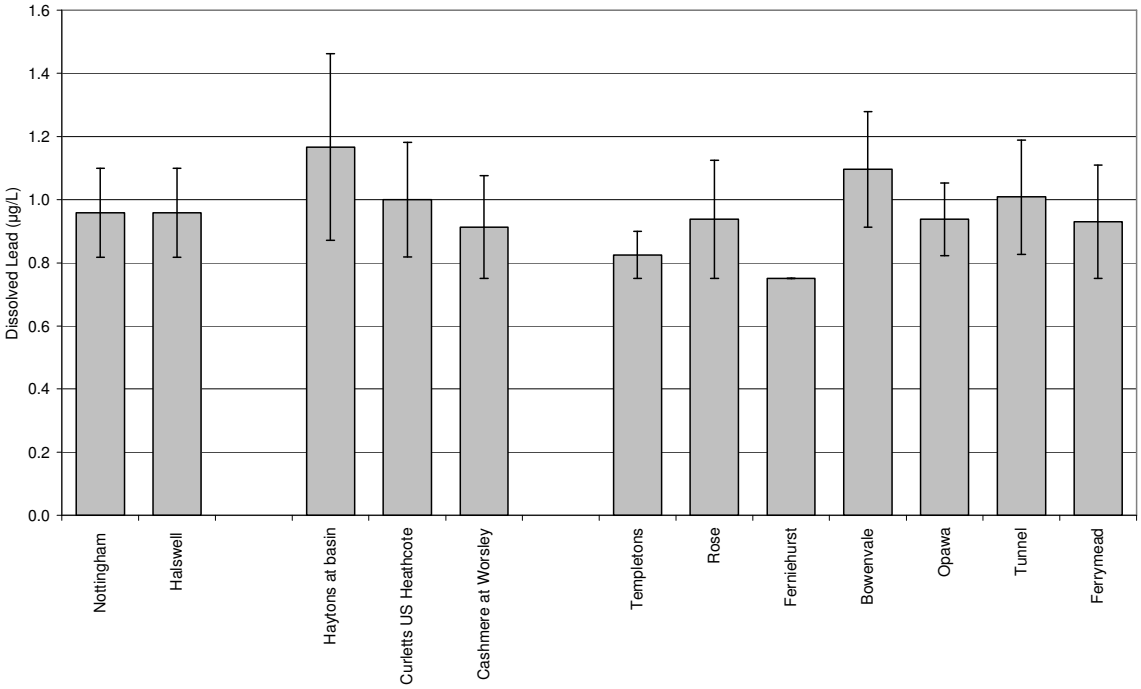

Figure 24 Dissolved lead concentrations for sites in the Heathcote and Halswell catchments, mean ± SE for monthly samples between May 2012 and April 2013. Halswell sites are to the left of the graph, followed by Heathcote tributary sites and then Heathcote mainstem sites to the right, arranged from upstream to downstream (left to right). ANZECC (2000) hardness modified trigger values (5.21 µg/L for Cashmere Stream for 99% species protection, 29.16 µg/L for all other Heathcote sites for 90% species protection and 12.57 µg/L for Halswell sites for 95% species protection) are not displayed on the graph, because all trigger values are much greater than the extent of the scale on this graph. The mean with no standard error reflects a lack of variability in the dataset, due to all sampling events recording levels below the limit of detection.

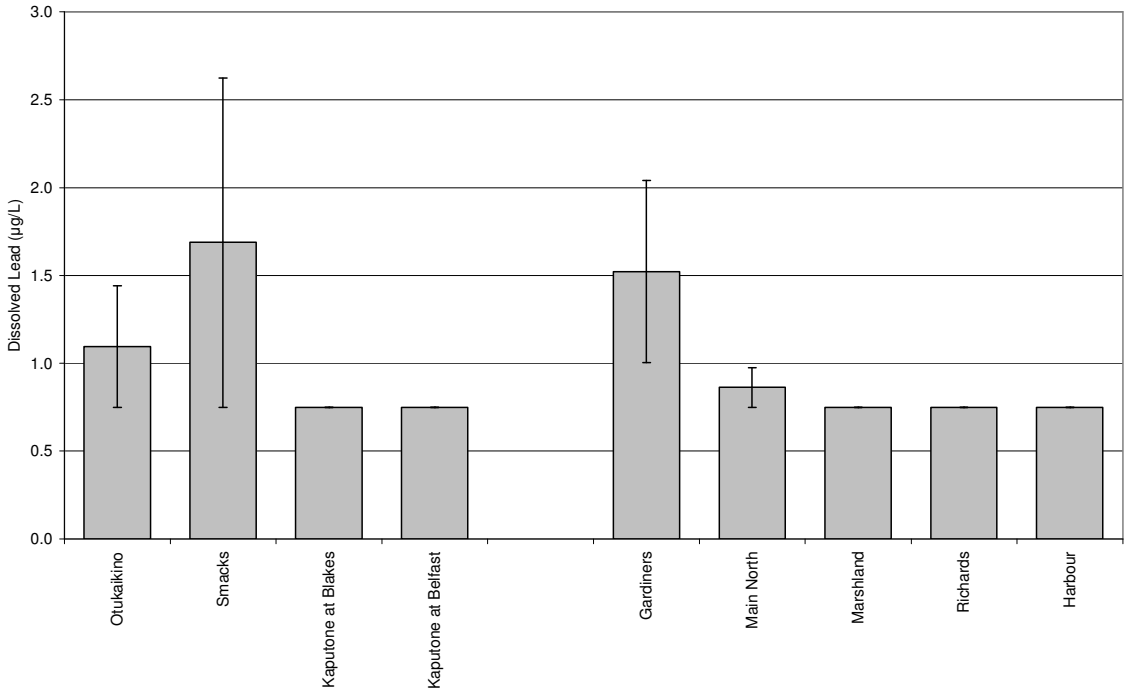

Figure 25 Dissolved lead concentrations for sites in the Styx and Otukaikino catchments, mean ± SE for monthly samples between May 2012 and April 2013. Otukaikino and Styx tributary sites are displayed on the left side of the graph and Styx River mainstem sites to the right, arranged from upstream to downstream (left to right). ANZECC (2000) hardness modified trigger values (3.84 µg/L for Outukaikino for 95% species protection and 6.34 µg/L for all other sites for 95% species protection) are not displayed on the graph, because all trigger values are much greater than the extent of the scale on this graph. The means with no standard error reflect a lack of variability in the dataset, due to all sampling events recording levels below the limit of detection.

2.7.3 Dissolved Zinc

The majority of sites in all of the catchments had average zinc concentrations below the ANZECC HMTV (Figures 26 – 28), with the exception of Addington Drain and Dudley Creek in the Avon catchment, Curtletts Road in the Heathcote catchment and Kaputone Stream at Blakes Road. However, the Haytons Drain at the retention basin and Heathcote River at Rose Street sites both recorded exceedances of the HMTV in July and August 2012. A number of sites within all catchments recorded levels below the laboratory limit of detection (1 µg/L) on a number of sampling occasions. There were no apparent trends in zinc concentrations between tributaries and the mainstem, or with increasing distance downstream, for any of the catchments.

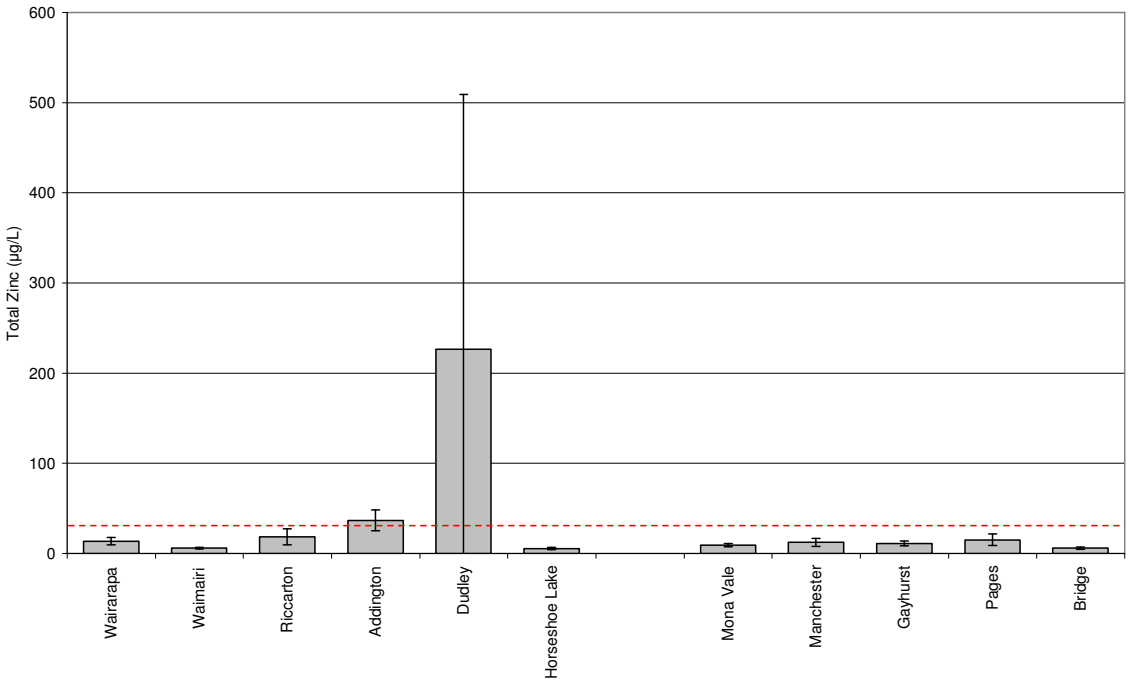

Figure 26 Dissolved zinc concentrations for sites in the Avon catchment, mean ± SE for monthly samples between May 2012 and April 2013. Tributary sites are displayed on the left side of the graph and mainstem sites to the right, arranged from upstream to downstream (left to right). The ANZECC (2000) default trigger value of 29.70 µg/L for 90% species protection is displayed as a red dotted line on the graph.

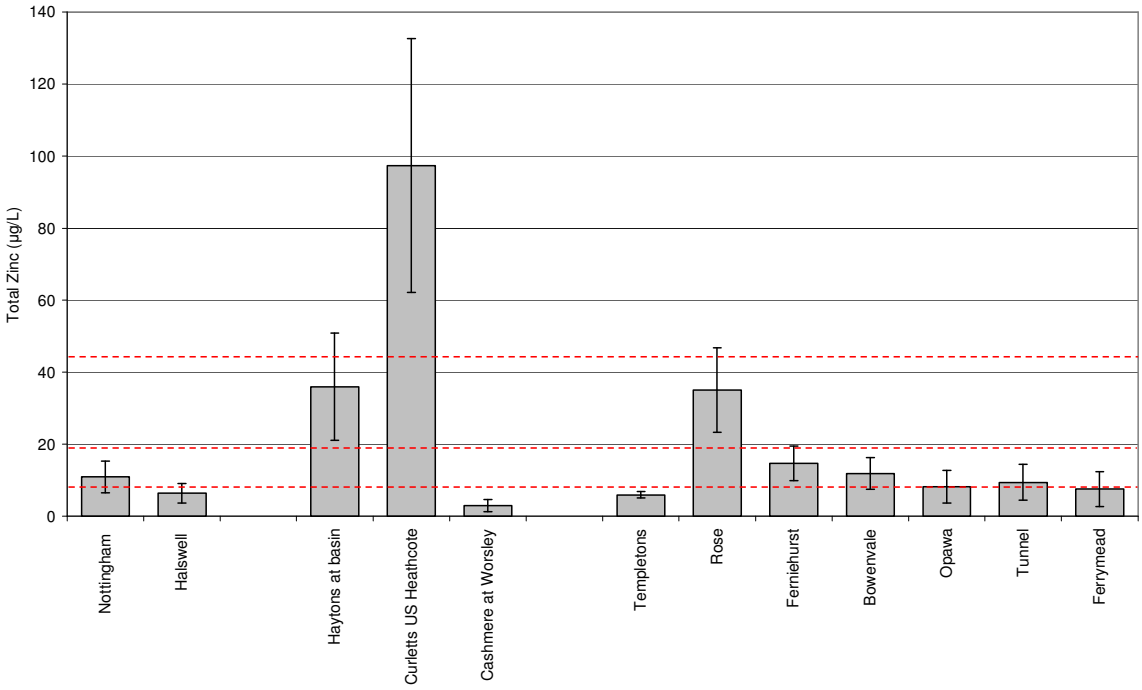

Figure 27 Dissolved zinc concentrations for sites in the Heathcote and Halswell catchments, mean ± SE for monthly samples between May 2012 and April 2013. Halswell sites are to the left of the graph, followed by Heathcote tributary sites and then Heathcote mainstem sites to the right, arranged from upstream to downstream (left to right). The red dotted lines represent the ANZECC (2000) hardness modified trigger values – the bottom line is for Cashmere Stream for 99% species protection (7.24 µg/L), the top line is for all other Heathcote sites for 90% species protection (45.26 µg/L) and the middle line is for Halswell sites for 95% species protection (19.19 µg/L).

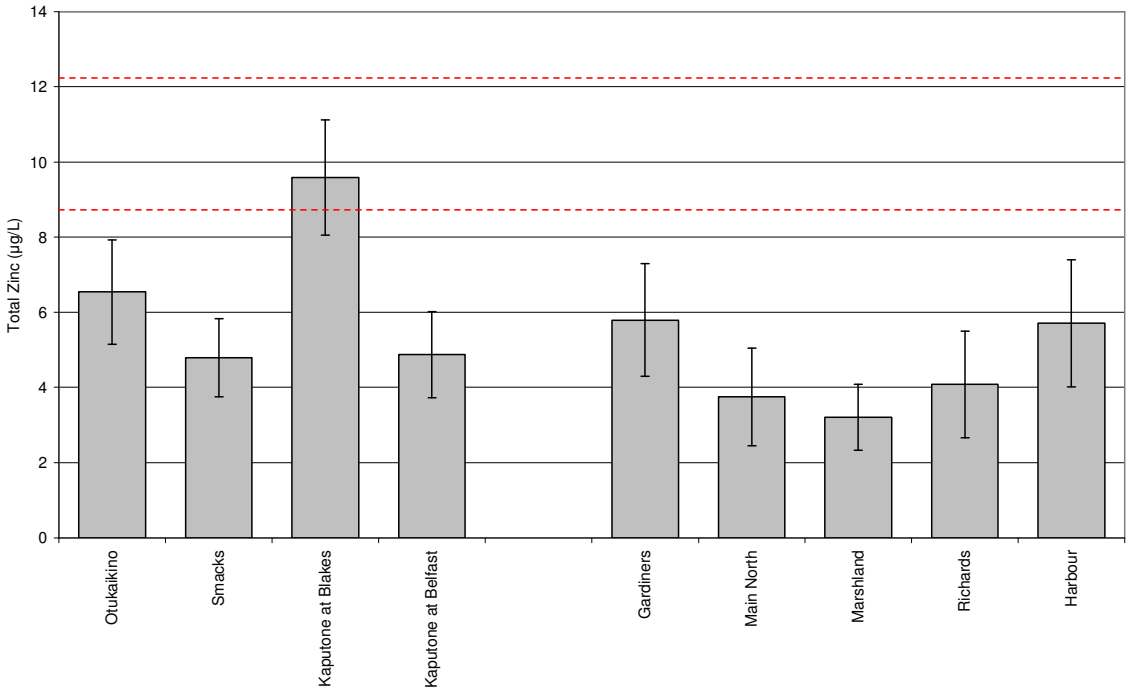

Figure 28 Dissolved zinc concentrations for sites in the Styx and Otukaikino catchments, mean ± SE for monthly samples between May 2012 and April 2013. Otukaikino and Styx tributary sites are displayed on the left side of the graph and Styx River mainstem sites to the right, arranged from upstream to downstream (left to right). The red dotted lines represent the ANZECC (2000) hardness modified trigger values – the bottom line is for Outukaikino for 95% species protection (8.68 µg/L) and the top line is for all other sites for 95% species protection (12.14 µg/L).

3 Water Quality Trends

3.1 Nitrate-Nitrite Nitrogen (NNN)

Over all catchments, NNN concentrations decreased during the monitoring period at twelve of the sites and increased at three of the sites (Table 3). Twenty-two sites recorded no change in NNN concentrations. The Avon catchment typically recorded no change or a decrease in concentrations, with the exception of Riccarton Drain, which recorded a 15% increase. In the Styx catchment, concentrations typically decreased, with the exception of the Kaputone Stream, which recorded increases in NNN at both sampling locations. The Halswell catchment recorded either no change or a decrease in NNN levels. No changes in concentrations were recorded at any of the sites in the Heathcote or Otukaikino catchment. There were no apparent differences in trends between the mainstems and tributaries, or with increasing distance downstream, in any of the catchments.

Table 3 Direction and magnitude of significant ($p<0.05$) trends for Nitrate-Nitrite Nitrogen (NNN), *E. coli*, turbidity and Electrical Conductivity (EC) for river water quality monitoring sites in Christchurch City from January 2007 to December 2011. Sites with no values did not record significant trends. N/A = Not Applicable, as these sites have only recently been monitored for this parameter, so trend analyses cannot be undertaken.

Catchment	Site Description	NNN	*E. coli*	Turbidity	EC
Avon	Avon River at Mona Vale		↑ +9%	↓ -13%	
	Avon River at Carlton Mill corner	↓ -10%		N/A	↓ -3%
	Avon River at Manchester St	↓ -11%			
	Avon River at Gayhurst Rd		↑ +17%		
	Avon River at Avondale Rd	↓ -14%		N/A	
	Avon River at Pages/Seaview Bridge	↓ -4%	↑ +30%		↑ +19%
	Avon River at Bridge St	↓ -14%	↑ +21%		↑ +30%
	Wairarapa Stream		↑ +8%		
	Waimairi Stream	↓ -3%		↓ -12%	
	Riccarton Drain	↑ +15%			↑ +8%
	Addington Drain				
	Dudley Creek			↑ +36%	
	Horseshoe Lake discharge				
Heathcote	Heathcote River at Templetons Rd				↑ +4%
	Heathcote River at Rose St				
	Heathcote River at Ferniehurst St				
	Heathcote River at Bowenvale Ave				
	Heathcote River at Opawa Rd			↓ -16%	↑ +2%
	Heathcote River at MacKenzie Ave			N/A	
	Heathcote River at Catherine St			N/A	
	Heathcote River at Tunnel Rd				
	Heathcote River at Ferrymead Bridge				
	Haytons Drain at Wigram Rd			N/A	
	Haytons Drain at Retention Basin				
	Curletts Road Drain US Heathcote				
	Cashmere Stream at Worsleys Rd				
Styx	Styx River at Gardiners Rd	↓ -10%		↓ -20%	↓ -4%
	Styx River at Main North Rd	↓ -9%		↓ -28%	↓ -4%
	Styx River at Marshland Rd Bridge			↓ -23%	↓ -2%
	Styx River at Richards Bridge	↓ -11%			↓ -4%
	Styx River at Harbour Rd Bridge	↓ -11%			↓ -4%
	Smacks Creek at Gardiners Rd	↓ -7%	↓ -15%	↓ -19%	↓ -6%
	Kaputone at Blakes Rd	↑ +12%			
	Kaputone at Belfast Rd	↑ +3%		↓ -25%	
Halswell	Nottingham Stream at Candys Rd	↓ -15%		↑ +23%	↓ -6%
	Halswell River at Akaroa Highway				
Otukaikino	Otukaikino at Groynes inlet				

3.2 E. coli

Overall, *E. coli* concentrations within the catchments generally did not change in concentration (31 sites in total), with only one site in the Styx catchment recording a decrease and five sites in the Avon catchment recording an increase (Table 3). For the Avon River catchment, the majority of sites either increased or recorded no change in *E. coli* concentrations. In contrast, concentrations typically did not change at the sites within the Heathcote, Styx, Halswell and Otukaikino catchments. There were no apparent differences in trends with increasing distance downstream, or between the mainstems and tributaries for any of the catchments.

In the previous years monitoring, significantly more sites recorded a positive trend in *E. coli* concentrations across all catchments (with the exception of the Otukaikino), which was considered to be due to discharges of raw wastewater following the earthquakes during 2010-2011. It would appear that levels are now no longer increasing overall (with the exception of a number of sites in the Avon catchment); however, it is noted that only one site recorded a decrease in concentrations, so levels still do not appear to be returning to pre-earthquake levels.

3.3 Turbidity

Elevated levels of suspended sediment in the water column decrease the clarity of the water and can influence the behaviour of invertebrates and fish, as well as the growth of aquatic plants. Turbidity is a measure of the passage of light through the water column, rather than a direct measure of the quantity of suspended solids in the water column. Turbidity and total suspended solids (TSS) are both measured as part of the ongoing rivers water quality monitoring programme, but turbidity is a more useful measure for looking at trends over time, because TSS is frequently recorded as below laboratory detection limits for many sites, making it unreliable for detecting trends in the data. ANZECC (2000) provides a guideline of 5.6 NTU for turbidity in lowland rivers.

The majority of sites in the catchments recorded no change in turbidity levels (Table 3). Only Dudley Creek in the Avon catchment and Nottingham Stream in the Halswell catchment recorded a significant increase in turbidity. Eight sites within all the catchments (with the exception of the Otukaikino) recorded a decrease in turbidity levels. In the Avon catchment specifically, there were mixed trends, with some sites not changing turbidity levels, and others increasing or decreasing turbidity levels. Levels in the Heathcote and Otukaikino catchments typically did not change significantly. Levels in the Styx catchment either decreased or did not change, and levels within the Halswell catchment either increased or did not change. There were no apparent differences in trends between the mainstems and tributaries, or with increasing distance downstream, in any of the catchments.

3.4 Electrical Conductivity (EC)

Electrical conductivity is a measure of the ability of water to conduct an electrical current. Pure water has very low conductivity and the presence of dissolved ions in the water increases its ability to conduct electricity. For this reason, conductivity is often used as an indicator of water quality, with higher conductivity generally representing poorer water quality (with the exception of saline water which has very high conductivity).

Conductivity at the majority of sites did not change (total of 24 sites), although an increase and decrease was recorded at five and eight sites, respectively (Table 3). In the Avon catchment, conductivity generally increased or did not change. Sites within the Heathcote and Otukaikino catchments typically did not change in conductivity. Levels within the Styx generally decreased, and levels in the Halswell catchment either decreased or did not change. There were no apparent differences in trends with increasing distance downstream, or between the mainstems and tributaries for any of the catchments.

4 References

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Ryan, P.A., 1991. Environmental effects of sediment on New Zealand streams: a review. *New Zealand Journal of Marine and Freshwater Research 25:* 207-221.

5 Appendices

Appendix 1: Avon catchment water quality summary statistics
Appendix 2: Heathcote catchment water quality summary statistics
Appendix 3: Styx and Otukaikino catchments water quality summary statistics
Appendix 4: Halswell catchment water quality summary statistics
Appendix 5: Water hardness results for Christchurch rivers

APPENDIX 1: Avon catchment water quality summary statistics		Ammonia N	BOD5	Conductivity	Dissolved Copper	Total Copper	Dissolved Oxygen Saturation	Dissolved Oxygen	Dissolved Organic Carbon	*E. coli*	Faecal Coliforms	Dissolved Lead	Total Lead
	Unit	mg/L	mg/L	µS/cm	mg/L	mg/L	%	mg/L	mg/L	CFU/100mL	CFU/100mL	mg/L	mg/L
Avon at Pages/Seaview Bridge (AVON01)	Mean	0.074	1.8	1436	0.0010		87	9.0	2.8	1707	1120	0.0010	
	Std dev	0.060	2.9	1407	0.0000		12	0.9	1.0	4517	2384	0.0006	
	Min	0.005	0.5	25	0.0010		66	6.7	1.4	55	100	0.0008	
	Max	0.220	11.0	4780	0.0010		110	9.9	4.4	16000	8600	0.0026	
Avon at Bridge Street (AVON02)	Mean	0.117	0.8	10685	0.0015		79	8.9	3.7	2299	1622	0.0008	
	Std dev	0.100	0.5	7326	0.0008		23	0.9	5.5	6838	4218	0.0003	
	Min	0.023	0.5	22	0.0010		9	6.8	0.5	27	45	0.0008	
	Max	0.400	2.1	20900	0.0032		92	10.3	21.0	24000	15000	0.0017	
Avon at Dallington Terrace/Gayhurst Road (AVON03)	Mean	0.072	1.1	180	0.0016		79	8.4	0.9	910	1085	0.0010	
	Std dev	0.048	1.0	74	0.0016		9	1.3	0.5	618	940	0.0007	
	Min	0.005	0.5	116	0.0010		67	6.7	0.4	30	250	0.0008	
	Max	0.190	3.9	397	0.0064		94	9.9	1.8	2300	3700	0.0030	
Avon at Manchester Street (AVON04)	Mean	0.036	0.9	147	0.0011		90	9.6	0.9	933	869	0.0010	
	Std dev	0.021	0.9	31	0.0003		7	0.7	0.5	1296	726	0.0007	
	Min	0.005	0.5	95	0.0010		76	8.7	0.3	100	130	0.0008	
	Max	0.077	3.7	188	0.0020		100	11.1	2.3	4900	2900	0.0028	
Wairarapa Stream (AVON05)	Mean	0.027	0.9	130	0.0010		79	8.4	0.7	666	550	0.0010	
	Std dev	0.023	0.8	23	0.0000		7	0.9	0.5	1254	910	0.0006	
	Min	0.005	0.4	87	0.0010		68	7.5	0.1	80	100	0.0008	
	Max	0.079	3.0	157	0.0010		96	10.6	1.9	4600	3400	0.0023	
Waimairi Stream (AVON06)	Mean	0.015	0.8	134	0.0010		82	8.7	0.4	247	473	0.0009	
	Std dev	0.012	0.9	26	0.0000		4	0.5	0.2	205	742	0.0004	
	Min	0.005	0.4	84	0.0010		73	8.1	0.1	50	100	0.0008	
	Max	0.041	3.5	160	0.0010		89	9.6	0.7	700	2800	0.0021	
Avon at Mona Vale (AVON07)	Mean	0.020	0.8	157	0.0017		88	9.3	0.4	309	371	0.0008	
	Std dev	0.009	0.9	28	0.0024		4	0.5	0.2	173	232	0.0000	
	Min	0.005	0.5	101	0.0010		78	8.6	0.2	140	110	0.0008	
	Max	0.035	3.5	187	0.0094		95	10.1	0.8	700	760	0.0008	
Riccarton Main Drain (AVON08)	Mean	0.042	0.9	195	0.0014		90	9.5	0.8	325	222	0.0009	
	Std dev	0.038	0.9	35	0.0009		3	0.3	0.9	492	210	0.0004	
	Min	0.016	0.4	118	0.0010		84	9.1	0.2	9	18	0.0008	
	Max	0.150	3.4	230	0.0041		94	10.1	3.7	1700	580	0.0017	
Addington Drain (AVON09)	Mean	0.123	1.4	306	0.0017		66	7.7	2.5	773	605	0.0009	
	Std dev	0.071	1.0	106	0.0012		21	1.2	0.5	1294	729	0.0004	
	Min	0.032	0.5	133	0.0010		7	6.0	1.6	41	90	0.0008	
	Max	0.230	4.0	569	0.0049		92	10.1	3.1	4600	2300	0.0019	
Dudley Creek (AVON10)	Mean	0.184	1.9	142	0.0012		82	8.8	2.5	3208	3198	0.0013	
	Std dev	0.109	1.3	35	0.0006		4	0.8	1.4	4800	4033	0.0009	
	Min	0.062	0.5	97	0.0010		76	7.6	0.9	250	350	0.0008	
	Max	0.410	4.3	199	0.0031		88	10.1	5.0	16000	13000	0.0037	
Horseshoe Lake discharge (AVON11)	Mean	0.150	1.8	173	0.0010		66	7.1	5.5	798	942	0.0010	
	Std dev	0.066	0.7	54	0.0000		11	1.3	2.7	594	943	0.0007	
	Min	0.069	1.2	86	0.0010		53	5.1	2.3	27	55	0.0008	
	Max	0.260	3.7	264	0.0010		86	9.0	9.6	2400	3700	0.0032	
Carlton Mill corner (AVON12)	Mean	0.025	0.9	136			94	10.0		898	1066		
	Std dev	0.014	0.9	26			6	0.6		1118	1132		
	Min	0.012	0.5	89			81	9.1		150	260		
	Max	0.062	3.5	171			100	11.3		4100	4200		
Avondale Road stormwater (AVON13)	Mean	0.103	1.6	199			89	9.2		241	240		
	Std dev	0.158	1.2	135			12	0.8		330	329		
	Min	0.012	0.5	97			75	7.7		9	5		
	Max	0.590	3.8	581			110	10.4		1000	1200		

APPENDIX 1 (continued): Avon catchment water quality summary statistics

Site	Nitrate (NO3)	Nitrite (NO2)	Nitrate - Nitrite	pH	Dissolved Reactive Phosphorus	Total P	Total Suspended Solids	Water Temperature	Total N	Turbidity	Dissolved Zinc	Total Zinc	Enterococci
	mg/L	mg/L	mg/L		mg/L	mg/L	mg/L	℃	mg/L	NTU	mg/L	mg/L	MPN/100mL
AVON01	0.73	0.01	0.72	7.7	0.044	0.074	7.5	14.0	1.11	5.5	0.0151		
	0.10	0.01	0.10	0.4	0.014	0.015	3.2	4.0	0.45	2.6	0.0225		
	0.58	0.01	0.57	7.0	0.014	0.050	3.0	8.2	0.74	1.8	0.0005		
	0.87	0.02	0.88	8.3	0.067	0.100	15.0	19.8	2.40	10.0	0.0830		
AVON02	0.57	0.01	0.57	7.7	0.048	0.080	14.3	14.0	1.00	8.3	0.0059		351
	0.15	0.01	0.14	0.3	0.016	0.017	4.8	4.1	0.49	2.1	0.0047		962
	0.27	0.01	0.28	7.3	0.024	0.058	7.0	8.0	0.55	3.9	0.0005		15
	0.76	0.02	0.76	8.3	0.074	0.110	23.0	19.9	2.40	12.0	0.0150		3400
AVON03	0.97	0.01	0.99	7.7	0.027	0.039	3.0	13.2	1.41	2.1	0.0111		
	0.11	0.00	0.10	0.2	0.010	0.017	2.1	2.6	0.32	1.1	0.0089		
	0.77	0.01	0.78	7.2	0.008	0.010	1.5	9.9	0.91	0.5	0.0010		
	1.10	0.02	1.10	7.9	0.040	0.060	7.0	17.2	2.00	3.7	0.0280		
AVON04	1.22	0.01	1.23	7.7	0.017	0.029	3.4	12.6	1.62	2.4	0.0124		
	0.21	0.00	0.21	0.3	0.013	0.025	2.0	1.9	0.35	1.5	0.0153		
	0.60	0.01	0.61	7.2	0.004	0.010	1.5	10.4	1.20	0.4	0.0005		
	1.40	0.01	1.40	8.5	0.053	0.100	7.0	15.7	2.50	4.9	0.0560		
AVON05	0.81	0.01	0.81	7.3	0.015	0.020	3.8	12.6	1.11	1.8	0.0136		
	0.09	0.00	0.09	0.2	0.007	0.015	3.7	1.5	0.25	2.0	0.0140		
	0.54	0.01	0.54	7.0	0.007	0.010	1.5	11.0	0.74	0.2	0.0020		
	0.89	0.01	0.90	7.5	0.033	0.061	13.0	14.7	1.50	6.0	0.0540		
AVON06	1.52	0.01	1.53	7.4	0.014	0.018	2.5	12.7	1.87	1.0	0.0059		
	0.09	0.00	0.11	0.2	0.004	0.022	1.9	0.9	0.37	0.9	0.0035		
	1.40	0.01	1.40	7.1	0.008	0.010	1.5	11.6	1.40	0.2	0.0005		
	1.70	0.01	1.70	7.7	0.022	0.088	7.0	13.9	2.70	2.9	0.0110		
AVON07	2.33	0.01	2.33	7.4	0.012	0.015	1.8	12.6	2.81	0.7	0.0092		
	0.21	0.00	0.21	0.1	0.004	0.009	0.8	1.1	0.43	0.4	0.0058		
	2.10	0.01	2.10	7.1	0.005	0.010	1.5	10.8	2.20	0.3	0.0020		
	2.80	0.01	2.80	7.6	0.017	0.036	4.0	14.1	3.70	1.5	0.0190		
AVON08	2.14	0.01	2.14	7.6	0.019	0.023	2.6	13.0	2.87	1.7	0.0184		
	0.40	0.00	0.40	0.2	0.006	0.014	1.7	1.1	0.46	2.0	0.0299		
	1.20	0.01	1.20	7.2	0.008	0.010	1.5	11.2	1.90	0.4	0.0010		
	2.60	0.02	2.60	7.8	0.030	0.051	6.0	14.8	3.50	7.5	0.1100		
AVON09	0.86	0.03	0.89	7.6	0.027	0.067	5.8	12.5	1.71	5.6	0.0366		
	0.28	0.02	0.30	0.3	0.008	0.029	5.0	2.6	0.78	3.9	0.0404		
	0.45	0.01	0.46	7.2	0.014	0.024	1.5	9.4	0.89	1.3	0.0010		
	1.50	0.07	1.60	8.0	0.038	0.120	18.0	16.4	3.80	15.0	0.1500		
AVON10	0.33	0.02	0.34	7.7	0.050	0.094	14.6	12.2	1.29	10.7	0.2264		
	0.15	0.01	0.15	0.3	0.014	0.033	11.2	2.4	0.97	11.0	0.9791		
	0.13	0.01	0.14	7.1	0.025	0.034	5.0	8.4	0.18	1.7	0.0000		
	0.57	0.04	0.59	7.9	0.074	0.160	38.0	15.4	3.10	42.0	8.0000		
AVON11	0.39	0.01	0.40	7.4	0.051	0.112	7.8	12.5	1.62	6.4	0.0054		
	0.22	0.01	0.22	0.2	0.025	0.043	3.4	3.0	1.26	3.1	0.0043		
	0.16	0.01	0.17	7.1	0.012	0.034	3.0	8.5	0.35	3.3	0.0005		
	0.85	0.03	0.87	7.7	0.087	0.220	16.0	16.8	4.30	14.0	0.0130		
AVON12	1.44	0.01	1.44	7.6	0.025		5.7	12.6					
	0.23	0.00	0.23	0.2	0.030		4.9	1.5					
	0.81	0.01	0.81	7.2	0.008		1.5	10.7					
	1.80	0.01	1.80	7.9	0.120		17.0	14.7					
AVON13	0.75	0.02	0.76	7.7	0.074		14.4	14.1					
	0.22	0.01	0.22	0.4	0.131		36.6	3.6					
	0.13	0.01	0.15	7.3	0.018		1.5	8.6					
	1.00	0.02	1.00	8.4	0.490		130.0	19.2					

APPENDIX 2: Heathcote catchment water quality summary statistics		Ammonia N	BOD5	Conductivity	Dissolved Copper	Total Copper	Dissolved Oxygen Saturation	Dissolved Oxygen	Dissolved Organic Carbon	*E. coli*	Faecal Coliforms	Dissolved Lead	Total Lead
	Unit	mg/L	mg/L	µS/cm	mg/L	mg/L	%	mg/L	mg/L	CFU/100mL	CFU/100mL	mg/L	mg/L
Heathcote at Ferrymead Bridge (HEATH01)	Mean	0.143	1.1	19427	0.0014		87	8.9	4.6	300	402	0.0009	
	Std	0.071	1.0	10011	0.0010		6	0.6	8.4	254	489	0.0006	
	Min	0.048	0.5	408	0.0010		75	7.9	0.2	91	40	0.0008	
	Max	0.280	3.8	37400	0.0043		100	9.8	29.0	830	1200	0.0029	
Heathcote at Tunnel Road (HEATH02)	Mean	0.131	1.2	4424	0.0013		84	8.6	2.9	923	1148	0.0010	
	Std	0.075	0.9	3403	0.0010		11	0.8	3.2	1416	2096	0.0006	
	Min	0.011	0.5	237	0.0010		73	7.8	0.6	130	130	0.0008	
	Max	0.260	3.0	12500	0.0043		110	10.7	12.0	5100	7600	0.0027	
Heathcote at Opawa Road/Clarendon Terrace (HEATH03)	Mean	0.095	1.0	255	0.0014		79	8.3	2.5	598	475	0.0009	
	Std	0.045	0.7	73	0.0009		15	1.4	2.8	396	323	0.0004	
	Min	0.039	0.5	81	0.0010		62	6.2	0.8	130	160	0.0008	
	Max	0.180	2.6	332	0.0040		120	11.8	11.0	1500	1300	0.0020	
Heathcote at Bowenvale Avenue (HEATH04)	Mean	0.047	1.1	237	0.0012		85	8.9	2.7	559	525	0.0011	
	Std	0.026	0.7	70	0.0007		8	0.7	3.1	359	395	0.0006	
	Min	0.016	0.5	72	0.0010		65	7.5	0.9	120	140	0.0008	
	Max	0.092	2.5	317	0.0035		98	10.3	12.0	1100	1200	0.0024	
Cashmere Stream at Worsleys Road (HEATH05)	Mean	0.041	1.1	221	0.0018	0.0014	83	8.8	2.7	330		0.0009	0.0022
	Std	0.026	0.8	66	0.0014	0.0010	10	1.0	3.4	131		0.0006	0.0028
	Min	0.010	0.3	64	0.0010	0.0010	59	6.7	0.7	190		0.0008	0.0008
	Max	0.100	3.1	303	0.0052	0.0040	96	10.2	13.0	610		0.0027	0.0084
Heathcote at Rose Street (HEATH06)	Mean	0.099	1.2	239	0.0018	0.0025	92	9.7	2.7	946		0.0009	0.0021
	Std	0.086	0.6	69	0.0014	0.0019	15	1.4	1.2	765		0.0006	0.0017
	Min	0.021	0.3	80	0.0010	0.0010	75	7.6	1.5	170		0.0008	0.0008
	Max	0.300	2.2	309	0.0052	0.0071	120	12.7	4.4	2610		0.0030	0.0054
Heathcote at Ferniehurst Street (HEATH07)	Mean	0.058	1.6	231	0.0012	0.0019	81	8.6	2.9	599		0.0008	0.0024
	Std	0.035	1.4	67	0.0008	0.0011	10	1.1	3.1	387		0.0000	0.0022
	Min	0.022	0.4	71	0.0010	0.0010	59	6.8	0.9	260		0.0008	0.0008
	Max	0.120	4.5	311	0.0037	0.0044	100	10.9	12.0	1600		0.0008	0.0069
Heathcote at Templetons Road (HEATH08)	Mean	0.029	2.1	327	0.0010	0.0010	69	7.3	1.7	181		0.0008	0.0043
	Std	0.028	2.0	54	0.0000	0.0000	22	2.4	1.0	275		0.0002	0.0071
	Min	0.005	0.5	207	0.0010	0.0010	40	4.0	0.5	10		0.0008	0.0008
	Max	0.099	6.8	388	0.0010	0.0010	110	12.6	4.1	900		0.0015	0.0170
Haytons Drain at Retention Basin (HEATH09)	Mean	0.195	3.1	157	0.0013	0.0023	94	9.7	4.3	161		0.0012	0.0016
	Std	0.309	2.1	72	0.0008	0.0014	9	1.3	0.6	215		0.0010	0.0017
	Min	0.005	0.5	74	0.0010	0.0010	83	8.3	3.4	5		0.0008	0.0008
	Max	1.100	7.2	325	0.0038	0.0049	110	12.4	5.2	660		0.0040	0.0051
Curletts Road Drain above Heathcote confluence (HEATH10)	Mean	0.153	1.5	351	0.0039	0.0050	63	6.5	3.8	524		0.0010	0.0017
	Std	0.151	0.9	159	0.0034	0.0044	47	4.7	2.1	825		0.0006	0.0007
	Min	0.017	0.5	136	0.0010	0.0010	18	1.8	1.8	9		0.0008	0.0008
	Max	0.450	3.0	769	0.0110	0.0150	140	15.2	7.7	2900		0.0028	0.0027
Catherine Street stormwater (HEATH11)	Mean	0.115	1.3	316			75	7.8		1353	1545		
	Std	0.069	0.7	114			9	0.6		2479	2792		
	Min	0.005	0.5	80			66	6.6		91	140		
	Max	0.270	2.4	568			93	9.2		8500	9000		
Heathcote at MacKenzie Avenue footbridge (HEATH12)	Mean	0.097	0.9	256			76	7.9		865	892		
	Std	0.060	0.7	73			13	1.3		1322	1415		
	Min	0.012	0.4	84			63	6.4		98	160		
	Max	0.210	2.7	338			110	11.3		4800	5300		
Haytons Drain at Wigram Road (HEATH13)	Mean	1.673	5.0	157			52	6.1		132	112.0		
	Std	1.432	3.4	35			21	2.6		93	61.0		
	Min	0.290	1.7	113			22	2.6		45	55.0		
	Max	3.100	9.7	195			68	8.5		240	190.0		
Cashmere Stream at Sutherlands Road (HEATH16)	Mean	0.025	0.9	318	0.0010	0.0014	51	5.3		644			
	Std	0.022	0.9	3	0.0000	0.0011	11	1.0		2128			
	Min	0.005	0.5	312	0.0010	0.0010	37	3.9		1			
	Max	0.073	3.4	324	0.0010	0.0049	68	6.9		7400			

APPENDIX 2 (continued): Heathcote catchment water quality summary statistics

Site	Nitrate (NO3)	Nitrite (NO2)	Nitrate - Nitrite	pH	Dissolved Reactive Phosphorus	Total P	Total Suspended Solids	Water Temperature	Total N	Turbidity	Dissolved Zinc	Total Zinc	Enterococci
	mg/L	mg/L	mg/L		mg/L	mg/L	mg/L	℃	mg/L	NTU	mg/L	mg/L	MPN/100mL
HEATH01	1.58	0.02	1.65	7.5	0.06	0.11	34.2	14.4	2.10	23.7	0.0075		115
	2.24	0.01	2.34	0.7	0.04	0.06	17.4	3.2	2.24	27.5	0.0168		138
	0.11	0.01	0.15	6.0	0.03	0.06	19.0	9.8	0.52	7.8	0.0005		5
	7.80	0.04	7.80	8.2	0.19	0.29	86.0	18.0	8.20	110.0	0.0600		460
HEATH02	1.67	0.03	1.70	7.6	0.060	0.116	31.1	14.2	2.44	22.9	0.0094		
	2.35	0.04	2.34	0.5	0.043	0.058	14.2	3.1	2.10	20.2	0.0173		
	0.03	0.01	0.04	6.5	0.014	0.072	17.0	10.1	1.10	11.0	0.0005		
	7.50	0.15	7.50	8.2	0.180	0.280	71.0	17.7	8.80	85.0	0.0620		
HEATH03	1.56	0.02	1.64	7.6	0.044	0.071	11.8	13.5	3.26	8.9	0.0082		
	1.09	0.01	1.11	0.4	0.040	0.068	27.9	2.3	1.97	22.1	0.0156		
	0.32	0.01	0.34	6.9	0.020	0.020	1.5	9.7	1.40	0.8	0.0005		
	4.70	0.03	4.70	8.3	0.170	0.280	100.0	16.2	7.20	79.0	0.0560		
HEATH04	1.56	0.02	1.58	7.6	0.043	0.070	10.1	13.1	3.14	8.3	0.0118		
	0.40	0.00	0.41	0.4	0.041	0.060	11.6	2.2	1.67	16.4	0.0152		
	0.77	0.01	0.79	6.9	0.017	0.035	3.0	9.3	1.60	1.1	0.0005		
	2.10	0.02	2.10	8.0	0.170	0.250	46.0	15.5	6.80	60.0	0.0570		
HEATH05	1.31	0.01	1.36	7.5	0.03	0.05	21.1	12.8	2.85	14.4	0.0030	0.0104	
	0.43	0.00	0.41	0.4	0.04	0.07	38.7	1.9	1.64	22.9	0.0058	0.0155	
	0.64	0.01	0.64	6.9	0.01	0.01	1.5	9.5	1.30	0.7	0.0005	0.0030	
	1.80	0.02	1.80	7.9	0.17	0.26	140.0	14.8	6.70	76.0	0.0210	0.0580	
HEATH06	2.15	0.02	2.30	7.5	0.070	0.111	5.1	13.1	4.34	3.7	0.0350	0.0505	
	0.87	0.01	0.80	0.3	0.057	0.077	3.6	2.5	2.19	4.5	0.0408	0.0392	
	0.74	0.01	1.30	6.9	0.032	0.049	1.5	9.1	1.80	0.9	0.0010	0.0190	
	3.70	0.04	3.80	7.8	0.200	0.300	12.0	16.0	8.50	15.0	0.1300	0.1300	
HEATH07	1.78	0.02	1.86	7.5	0.04	0.07	14.5	13.3	3.47	10.4	0.0147	0.0232	
	0.59	0.01	0.57	0.4	0.04	0.06	23.6	2.8	1.78	17.6	0.0167	0.0153	
	0.97	0.01	0.99	6.9	0.02	0.02	1.5	9.4	1.80	0.9	0.0005	0.0090	
	2.60	0.02	2.60	7.8	0.18	0.25	84.0	18.0	7.10	50.0	0.0470	0.0530	
HEATH08	3.33	0.02	3.36	7.1	0.017	0.039	11.3	13.1	5.12	3.7	0.0059	0.0080	
	1.32	0.02	1.30	0.3	0.012	0.051	9.3	3.4	1.76	7.1	0.0028	0.0069	
	1.40	0.01	1.50	6.7	0.004	0.010	1.5	6.9	3.10	0.1	0.0010	0.0010	
	6.30	0.05	6.30	7.6	0.047	0.180	27.0	17.6	8.20	23.0	0.0090	0.0250	
HEATH09	0.80	0.01	0.87	7.6	0.262	0.383	8.5	14.3	2.21	6.5	0.0360	0.0592	
	1.51	0.01	1.56	0.4	0.102	0.123	6.0	3.8	2.16	5.7	0.0515	0.0467	
	0.03	0.01	0.01	7.0	0.130	0.240	1.5	8.9	0.18	1.5	0.0005	0.0060	
	4.40	0.03	4.40	8.4	0.430	0.600	23.0	19.5	6.40	23.0	0.1800	0.1700	
HEATH10	1.47	0.03	1.56	7.3	0.056	0.117	7.5	13.3	3.18	5.1	0.0974	0.1518	
	0.95	0.02	0.94	0.4	0.038	0.044	6.5	3.2	1.93	4.7	0.1221	0.1355	
	0.22	0.01	0.24	7.0	0.013	0.047	1.5	9.0	1.10	1.2	0.0005	0.0150	
	2.80	0.09	2.80	8.2	0.140	0.200	23.0	19.0	8.30	18.0	0.4300	0.4300	
HEATH11	1.79	0.02	1.91	7.6	0.05		13.1	13.5					
	1.57	0.01	1.60	0.3	0.04		11.0	2.5					
	0.65	0.01	0.76	7.1	0.02		3.0	9.6					
	43.00	16.70	0.00	0.0	0.00		0.0	0.0					
HEATH12	8.96	13.43	2.01	7.6	0.05		9.0	13.4					
	13.77	2.36	1.45	0.3	0.04		13.8	2.4					
	1.50	9.80	0.68	7.0	0.02		1.5	9.8					
	47.00	16.30	5.70	8.2	0.16		47.0	16.3					
HEATH13	220.00	8.05	1.64	7.1	0.13		220.0	8.1					
	328.39	1.68	2.45	0.2	0.12		328.4	1.7					
	14.00	6.10	0.14	7.0	0.04		14.0	6.1					
	710.00	10.00	5.30	7.4	0.29		710.0	10.0					
HEATH16	2.42	0.01		6.8	0.029		1.5	14.1				0.0030	
	0.69	0.00		0.1	0.036		0.0	1.5				0.0022	
	0.33	0.01		6.8	0.004		1.5	12.5				0.0005	
	2.90	0.01		6.9	0.110		1.5	17.3				0.0080	

APPENDIX 3: Styx and Otukaikino catchments water quality summary statistics		Ammonia N	BOD5	Conductivity	Dissolved Copper	Total Copper	Dissolved Oxygen Saturation	Dissolved Oxygen	Dissolved Organic Carbon	*E. coli*	Faecal Coliforms	Dissolved Lead	Total Lead
	Unit	mg/L	mg/L	µS/cm	mg/L	mg/L	%	mg/L	mg/L	CFU/100mL	CFU/100mL	mg/L	mg/L
Smacks Creek at Gardiners Road (STYX01)	Mean	0.015	0.5	101	0.0010		73	7.1	0.9	128	135	0.0017	
	Std dev	0.013	0.0	13	0.0000		16	0.7	0.3	195	154	0.0032	
	Min	0.005	0.5	76	0.0010		58	5.9	0.3	5	5	0.0000	
	Max	0.050	0.5	121	0.0010		120	8.0	1.4	700	550	0.0120	
Styx at Gardiners Road near Styx Mill Road (STYX02)	Mean	0.016	0.5	101	0.0010		70	6.6	0.6	227	253	0.0015	
	Std dev	0.013	0.0	11	0.0000		25	0.4	0.3	289	433	0.0018	
	Min	0.005	0.5	81	0.0010		59	6.2	0.1	9	40	0.0008	
	Max	0.040	0.5	120	0.0010		150	7.3	1.0	1100	1600	0.0069	
Styx River at Main North Road (STYX03)	Mean	0.036	0.6	106	0.0010		88	9.1	1.1	473	463	0.0009	
	Std dev	0.021	0.3	14	0.0000		7	0.7	0.3	425	367	0.0004	
	Min	0.005	0.5	79	0.0010		77	8.1	0.5	27	30	0.0008	
	Max	0.080	1.6	123	0.0010		100	10.1	1.4	1500	1300	0.0021	
Kaputone Stream at Blakes Road (STYX04)	Mean	0.330	2.1	130	0.0010		81	7.6	1.1	1518	1649	0.0008	
	Std dev	0.222	1.9	24	0.0000		16	0.5	0.4	1966	2997	0.0000	
	Min	0.005	0.5	84	0.0010		69	6.8	0.5	150	230	0.0008	
	Max	0.640	7.2	163	0.0010		130	8.3	2.0	7300	11000	0.0008	
Kaputone Stream at Belfast Road (STYX05)	Mean	0.210	1.2	134	0.0016		76	7.7	1.5	1402	1110	0.0008	
	Std dev	0.141	0.9	25	0.0019		13	1.0	0.4	1522	1116	0.0000	
	Min	0.090	0.5	88	0.0010		65	6.6	1.0	260	160	0.0008	
	Max	0.530	3.3	168	0.0076		110	9.3	2.3	5200	4000	0.0008	
Styx River at Marshland Road Bridge (STYX06)	Mean	0.061	1.0	117	0.0017		80	8.3	1.3	549	470	0.0008	
	Std dev	0.029	0.8	21	0.0018		12	1.3	0.5	832	599	0.0000	
	Min	0.020	0.5	80	0.0010		64	6.3	0.5	91	120	0.0008	
	Max	0.120	3.3	148	0.0070		100	10.0	2.0	3100	2300	0.0008	
Styx River at Richards Bridge (STYX07)	Mean	0.043	0.7	117	0.0010		79	8.0	1.8	240	309	0.0008	
	Std dev	0.022	0.3	22	0.0000		16	1.5	0.6	309	577	0.0000	
	Min	0.010	0.5	78	0.0010		51	4.8	1.0	27	55	0.0008	
	Max	0.080	1.3	156	0.0010		110	10.9	2.6	1100	2100	0.0008	
Styx River at Harbour Road Bridge (STYX08)	Mean	0.033	0.7	143	0.0010		77	7.7	2.2	197	192	0.0008	
	Std dev	0.017	0.3	44	0.0000		20	1.6	0.8	307	229	0.0000	
	Min	0.010	0.5	79	0.0010		50	4.7	1.4	5	24	0.0008	
	Max	0.060	1.1	222	0.0010		120	9.6	3.7	1000	700	0.0008	
Otukaikino at Groynes Inlet (OTUKAI01)	Mean	0.019	0.6	79	0.0010		92	9.7	0.8	125	112	0.0011	
	Std dev	0.010	0.3	18	0.0000		6	0.7	0.4	76	73	0.0012	
	Min	0.005	0.5	53	0.0010		83	8.5	0.1	9	10	0.0008	
	Max	0.030	1.1	109	0.0010		100	10.7	1.4	240	260	0.0049	

APPENDIX 3 (continued): Styx and Otukaikino catchments water quality summary statistics

Site	Nitrate (NO3)	Nitrite (NO2)	Nitrate - Nitrite	pH	Dissolved Reactive Phosphorus	Total P	Total Suspended Solids	Water Temperature	Total N	Turbidity	Dissolved Zinc	Total Zinc	Enterococci
	mg/L	mg/L	mg/L		mg/L	mg/L	mg/L	℃	mg/L	NTU	mg/L	mg/L	MPN/100mL
STYX01	0.91	0.01	0.91	7.3	0.01	0.02	1.8	14.4	1.57	0.4	0.0048		
	1.39	0.00	1.39	0.2	0.00	0.01	0.8	1.7	1.72	0.4	0.0036		
	0.30	0.01	0.31	7.1	0.01	0.01	1.5	11.7	0.46	0.1	0.0005		
	5.30	0.01	5.30	7.9	0.02	0.04	4.0	17.4	6.40	1.5	0.0150		
STYX02	1.01	0.01	1.01	7.2	0.011	0.019	1.7	13.3	1.64	0.4	0.0058		
	1.40	0.00	1.40	0.2	0.003	0.011	0.7	0.8	1.73	0.3	0.0052		
	0.33	0.01	0.33	7.0	0.007	0.010	1.5	12.2	0.32	0.2	0.0005		
	5.40	0.02	5.40	7.9	0.018	0.042	4.0	14.4	6.50	1.1	0.0180		
STYX03	0.70	0.01	0.71	7.6	0.024	0.035	1.9	14.0	1.07	0.7	0.0038		
	0.98	0.00	0.98	0.3	0.024	0.037	1.0	2.1	1.02	0.3	0.0045		
	0.32	0.01	0.32	7.4	0.011	0.010	1.5	10.1	0.45	0.2	0.0005		
	3.80	0.02	3.80	8.4	0.100	0.150	4.0	17.1	4.20	1.4	0.0170		
STYX04	1.67	0.03	1.70	7.5	0.026	0.061	6.0	15.8	2.57	1.6	0.0096		
	0.80	0.01	0.83	0.3	0.014	0.044	5.6	3.3	1.10	1.0	0.0053		
	1.30	0.01	1.30	7.3	0.013	0.030	1.5	11.0	1.70	0.3	0.0020		
	4.20	0.04	4.30	8.3	0.065	0.190	22.0	21.4	5.70	3.4	0.0190		
STYX05	1.10	0.03	1.12	7.7	0.072	0.108	6.0	14.2	1.95	3.0	0.0049		
	0.83	0.01	0.82	0.2	0.042	0.051	10.5	2.9	1.13	4.8	0.0040		
	0.70	0.01	0.72	7.5	0.030	0.044	1.5	9.8	0.95	0.5	0.0005		
	3.70	0.04	3.70	8.1	0.160	0.200	38.0	19.7	5.00	17.0	0.0110		
STYX06	0.86	0.02	0.87	7.6	0.039	0.062	2.9	13.6	1.38	1.6	0.0032		
	0.93	0.01	0.93	0.7	0.011	0.020	2.9	2.6	1.05	1.3	0.0030		
	0.49	0.01	0.49	5.8	0.018	0.026	1.5	9.7	0.60	0.6	0.0005		
	3.80	0.02	3.80	9.0	0.053	0.099	11.0	18.8	4.50	4.7	0.0090		
STYX07	0.66	0.01	0.67	7.6	0.041	0.071	1.8	13.6	1.34	1.4	0.0041		
	0.90	0.00	0.93	0.7	0.011	0.009	0.8	3.3	1.10	0.4	0.0049		
	0.14	0.01	0.14	6.1	0.024	0.048	1.5	8.9	0.27	0.8	0.0005		
	3.50	0.01	3.60	9.1	0.056	0.083	4.0	19.4	4.30	2.1	0.0170		
STYX08	0.55	0.01	0.56	7.5	0.040	0.072	2.5	13.8	1.08	1.8	0.0057		148
	0.84	0.00	0.84	0.5	0.013	0.020	1.4	4.0	1.07	0.8	0.0059		271
	0.03	0.01	0.05	6.3	0.023	0.036	1.5	8.3	0.28	1.0	0.0005		5
	3.20	0.01	3.20	8.3	0.057	0.099	5.0	20.7	4.30	3.3	0.0180		780
OTUKAI01	0.70	0.01	0.70	7.5	0.009	0.013	2.3	13.1	1.19	0.5	0.0065		
	1.46	0.00	1.46	0.2	0.002	0.005	1.4	2.2	1.74	0.4	0.0048		
	0.12	0.01	0.12	7.3	0.005	0.010	1.5	9.3	0.15	0.2	0.0005		
	5.30	0.01	5.30	8.1	0.014	0.022	6.0	15.6	6.40	1.4	0.0160		

APPENDIX 4: Halswell catchment water quality summary statistics		Ammonia N	BOD5	Conductivity	Dissolved Copper	Total Copper	Dissolved Oxygen Saturation	Dissolved Oxygen	Dissolved Organic Carbon	*E. coli*	Faecal Coliforms	Dissolved Lead	Total Lead
	Unit	mg/L	mg/L	µS/cm	mg/L	mg/L	%	mg/L	mg/L	CFU/100mL	CFU/100mL	mg/L	mg/L
Retention Basin Inlet (HALS01)	Mean			151			86	8.2		13594	3104		
	Std dev			69			43	3.8		26189	4857		
	Min			56			47	4.9		9	18		
	Max			261			170	15.1		70900	16000		
Retention Basin Outlet (HALS02)	Mean	4.057	5.2	130			85	8.4		327	299		
	Std dev	3.656	2.0	50			40	3.9		353	527		
	Min	0.070	2.6	64			42	4.0		5	9		
	Max	11.000	8.9	209			150	14.6		910	1700		
Nottingham Stream at Candys Road (HALS03)	Mean	0.070	1.5	206	0.0013	0.0013	84	9.0	1.6	1049		0.0010	0.0014
	Std dev	0.038	0.7	64	0.0008	0.0007	4	0.5	1.0	1352		0.0005	0.0014
	Min	0.020	0.5	62	0.0010	0.0010	77	8.3	0.7	45		0.0008	0.0008
	Max	0.150	2.9	277	0.0031	0.0033	91	9.8	3.6	3900		0.0021	0.0048
Halswell River at Akaroa Highway (HALS04)	Mean	0.043	0.9	198	0.0013	0.0016	86	9.8	1.4	247		0.0010	0.0012
	Std dev	0.051	0.6	62	0.0006	0.0014	26	1.2	1.7	177		0.0005	0.0008
	Min	0.005	0.4	58	0.0010	0.0010	14	8.3	0.5	110		0.0008	0.0008
	Max	0.200	2.0	284	0.0028	0.0056	110	11.8	6.6	760		0.0021	0.0030
Knights Stream at Sabys Road (HALS05)	Mean	0.052	0.9	200	0.0010	0.0010	80	9.4		645		0.0010	0.0009
	Std dev	0.071	0.4	61	0.0000	0.0000	27	1.0		638		0.0006	0.0004
	Min	0.013	0.5	56	0.0010	0.0010	8	8.1		140		0.0008	0.0008
	Max	0.250	1.4	274	0.0010	0.0010	100	10.8		2000		0.0025	0.0020

APPENDIX 4 (continued): Halswell catchment water quality summary statistics

Site	Nitrate (NO3)	Nitrite (NO2)	Nitrate - Nitrite	pH	Dissolved Reactive Phosphorus	Total P	Total Suspended Solids	Water Temperature	Total N	Turbidity	Dissolved Zinc	Total Zinc	Enterococci
	mg/L	mg/L	mg/L		mg/L	mg/L	mg/L	℃	mg/L	NTU	mg/L	mg/L	MPN/100mL
HALS01	1.81	0.22	2.01	8.4	0.141		30.4	16.9					
	2.06	0.27	2.03	0.9	0.185		16.3	4.1					
	0.37	0.04	0.53	7.1	0.006		11.0	9.5					
	6.00	0.97	6.00	9.7	0.640		57.0	21.2					
HALS02	1.46	0.15	1.60	8.2	0.062		24.5	16.0					
	1.80	0.17	1.78	0.9	0.047		10.4	4.4					
	0.06	0.02	0.16	7.0	0.008		7.0	7.8					
	5.30	0.57	5.40	9.6	0.140		36.0	20.5					
HALS03	1.60	0.01	1.61	7.7	0.040	0.101	12.4	12.1	2.60	4.8	0.0109	0.0244	
	1.48	0.00	1.48	0.2	0.013	0.054	14.0	2.1	1.88	5.8	0.0152	0.0126	
	0.55	0.01	0.56	7.0	0.024	0.045	1.5	8.4	0.93	0.6	0.0005	0.0100	
	5.60	0.02	5.60	7.9	0.073	0.180	51.0	14.7	6.70	20.0	0.0520	0.0500	
HALS04	3.33	0.01	3.58	7.7	0.026	0.045	6.3	18.3	4.64	5.7	0.0064	0.0084	
	1.88	0.01	1.61	0.3	0.024	0.036	7.3	19.7	2.07	10.1	0.0092	0.0080	
	0.03	0.01	1.80	7.1	0.013	0.010	1.5	9.8	0.86	0.5	0.0005	0.0030	
	8.20	0.02	8.30	8.1	0.100	0.130	28.0	80.6	10.00	37.0	0.0290	0.0250	
HALS05	3.46	0.01	3.46	7.5	0.018		6.5	12.4		1.7	0.0070	0.0102	
	2.31	0.00	2.31	0.2	0.017		8.6	1.4		1.9	0.0076	0.0179	
	0.95	0.01	0.96	7.0	0.004		1.5	10.6		0.4	0.0005	0.0010	
	9.20	0.01	9.20	7.7	0.066		30.0	15.2		6.7	0.0220	0.0590	