Healthy Estuary and Rivers of the City:

Water quality and ecosystem health monitoring programme of Ihutai

Water quality of the Avon and Heathcote rivers

Summary report on data collected in 2007

Environment Canterbury
Your regional council

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Report prepared by
Michele Stevenson, Environment Canterbury
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58 Kilmore Street
PO Box 345
Christchurch
Phone (03) 365 3828
Fax (03) 365 3194

75 Church Street
PO Box 550
Timaru
Phone (03) 688 9069
Fax (03) 688 9067

Website: www.ecan.govt.nz
Customer Services Phone 0800 324 636

Introduction

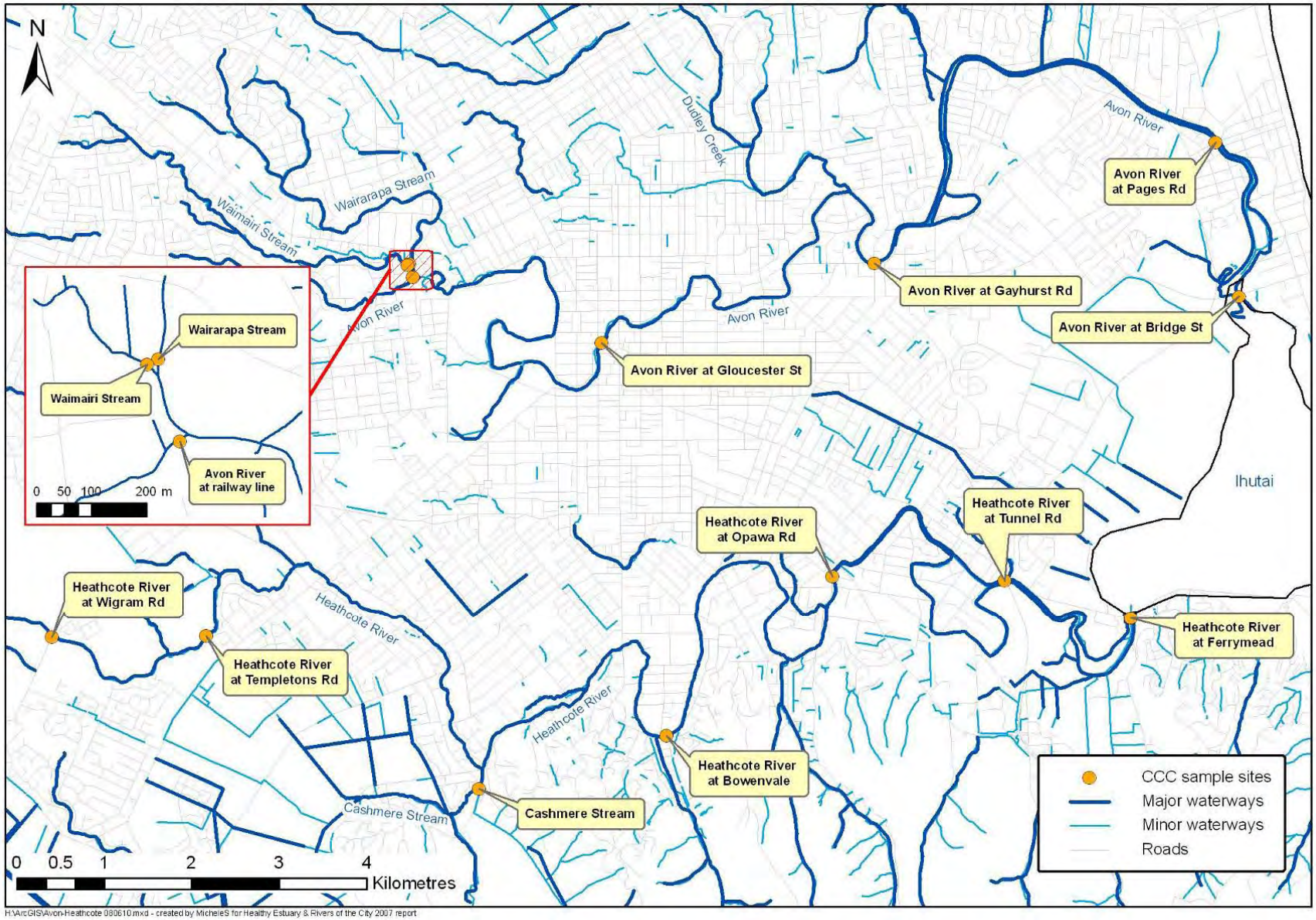
The Healthy Estuary and Rivers of the City: Water quality and ecosystem health monitoring programme of Ihutai was written in 2006. It includes monitoring programmes for the four environmental values. This report summarises data collected in 2007 from the Avon and Heathcote rivers as part of Value B – Healthy Ecosystems – water quality. Other parts of this value include water quality of the estuary and beyond, river habitat and its biota, and the soft sediments of estuary and tidal reaches. These aspects are covered by separate summary reports.

The Avon and Heathcote rivers drain a large part of the city of Christchurch and flow to the Avon-Heathcote Estuary/Ihutai. Both rivers are spring-fed and slow-flowing and have a number of tributaries that include both natural streams and man-made drains. The quality of the water in these rivers is influenced by both the quality of groundwater in the shallow aquifers that feed the springs and the quality of stormwater that runs off the land into the rivers and tributaries when it rains. Stormwater quality is strongly influenced by land use in the river catchment. Other factors that can affect water quality in these urban rivers include catchment geology, point source discharges from industrial sites, infrequent sewage overflows, and the presence of large numbers of waterfowl.

Good water quality is required for the plants and animals that live in the water, and on the bed of the rivers, to function normally. For the water to be of good quality it should not contain unnaturally high concentrations of nutrients or sediment and must contain sufficient oxygen for living things. High concentrations of nutrients and sediment and low concentrations of oxygen can be detrimental to the plants and animals that live in the water, and on the river bed. Some contaminants from the urban environment, such as ammonia and heavy metals, can be toxic to aquatic life even at low concentrations.

Water quality is monitored[1] at sites on both the Avon and Heathcote rivers as well as some of their tributary streams in the upper parts of their catchments. This is a summary report of the water quality data collected at these sites and an overall evaluation of their water quality in 2007. This is the first annual summary report to be produced. A report including more detailed analysis, such as analysis of trends over time, will be produced following five years of data collection at these sites.

[1] Monitoring is the routine collection of data over time in order to assess the state of the environment and identify changes over time.



H:\ArcGIS\Avon-Heathcote 080610.mxd - created by MicheleS for Healthy Estuary & Rivers of the City 2007 report

Figure 1. The location of the water quality sampling sites

Sampling

Sampling sites

The sites sampled are shown in Figure 1.

Water samples were collected once a month by staff of the City Water and Waste Unit, Christchurch City Council. The Heathcote River site at Wigram Road was frequently dry when visited for sampling. In 2007 it was only possible to collect samples on 4 occasions from this site, rather then the 12 occasions at all other sites.

Water quality parameters

The water samples were analysed for a range of water quality parameters including:

- Dissolved oxygen
- Biochemical oxygen demand
- Total suspended solids
- Turbidity
- *Escherichia coli*
- Ammonia nitrogen
- Nitrate-nitrite nitrogen
- Dissolved reactive phosphorus
- Heavy metals – zinc, copper, lead, cadmium, mercury

Results

The results are presented on the following pages. The data are presented as bar graphs. The height of the bar depicts the median[2] value from the samples taken at a site. The bars have been positioned on a map and below each bar are the minimum and maximum values recorded at the site. This form of presentation makes it easy to see the similarities and differences between sites.

Guidelines and trigger values

Guidelines are established to protect different waterway values, such as ecosystem health and suitability for contact recreation. Comparison of water quality results with relevant guidelines is useful to determine whether the water quality state may be impacting on the values that a community considers are important for a waterway.

The ANZECC (2000)[3] guidelines specify trigger values for nutrients, turbidity and toxic chemicals in freshwater. Where concentrations are below these trigger values there is a low risk of impacts on aquatic life occurring. Where the trigger values are exceeded by water quality results this does not necessarily mean that an environmental problem exists but indicates that there is a potential risk. The trigger values used here are those that apply to slightly-moderately disturbed freshwater ecosystems, and in the case of toxicants (ammonia-nitrogen and heavy metals) provide for protection of 95% of species.

There are a range of other water quality guidelines in use in New Zealand, however not all of these guidelines are appropriate to apply to the lowland urban rivers of Christchurch. Guidelines are typically derived for specific river types or river conditions and do not necessarily represent achievable or appropriate target values for all types of river systems.

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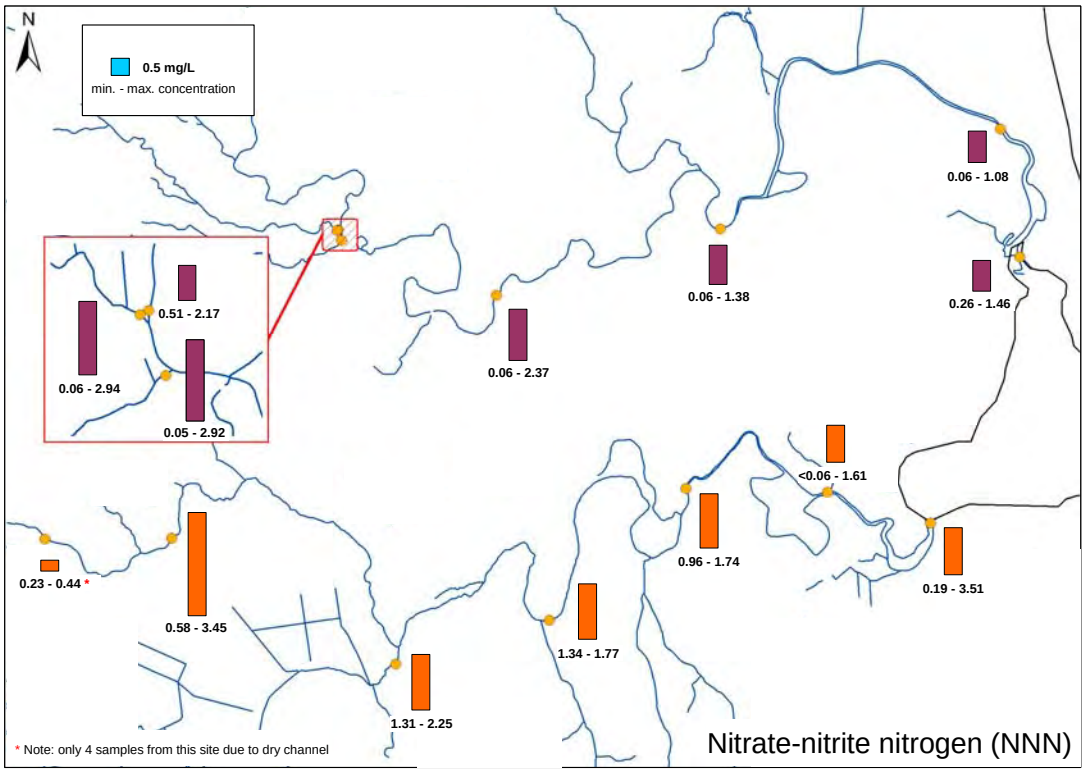
[2] The median is the middle number when all numbers are ordered from lowest to highest. When there is an even number of numbers it is the average of the middle two numbers.

[3] ANZECC 2000. Australia and New Zealand guidelines for fresh and marine water quality, Volume 1, The guidelines. Australian and New Zealand Environment and Conservation Council, Agriculture and Resource Management Council of Australia and New Zealand, Canberra.

Nitrate-nitrite nitrogen (NNN)

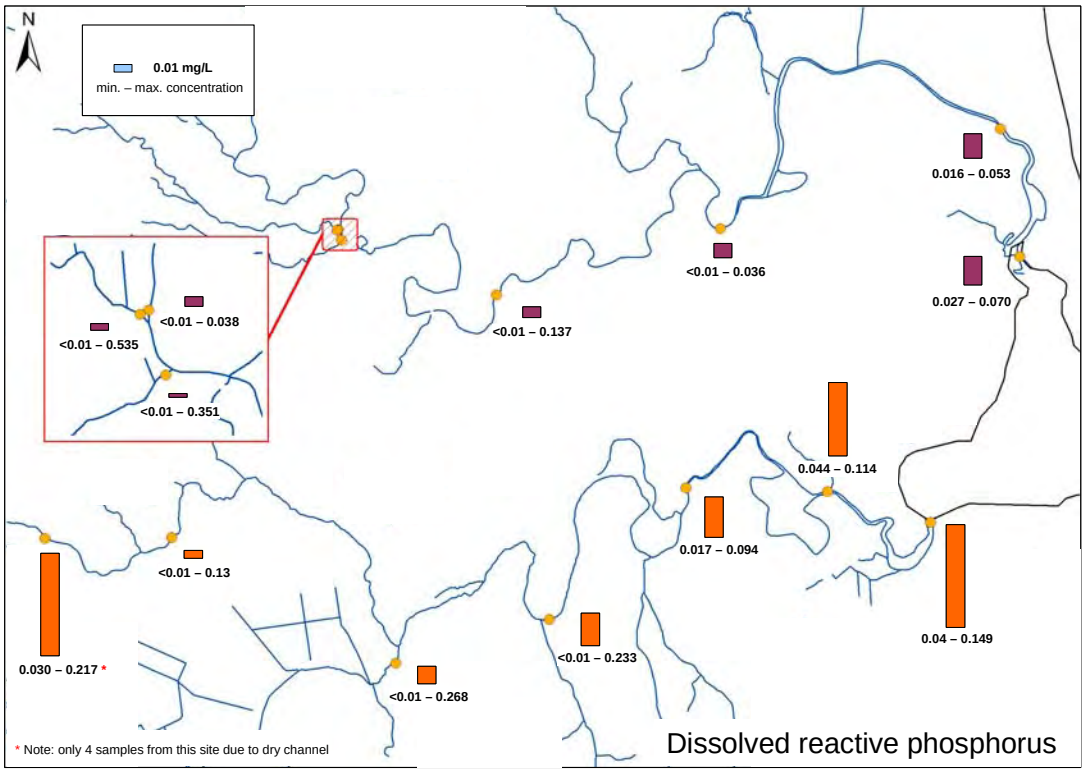


Nitrate-nitrite nitrogen (NNN) represents the majority of nitrogen in waters that is immediately available to plants and elevated concentrations can result in excessive growth of aquatic plants or algae. Plants and algae are an important part of an aquatic ecosystem, however excessive growths can negatively impact on waterway values, for example by reducing flows, reducing in-stream habitat diversity, consuming large amounts of oxygen through decay, or reducing visual appeal. Nitrate is the common form of nitrogen found in natural waters. It is changed by biochemical processes to nitrite when there is no oxygen; when oxygen is present the nitrite quickly forms nitrate. Nitrate and nitrite are formed during the biochemical breakdown of ammonia-nitrogen. Fertilisers that are applied to land to promote plant growth are often a significant source of nitrate and nitrite.

In both the Avon and Heathcote rivers the concentrations of NNN were highest near the headwater springs and decreased downstream towards the estuary. This is due to the high nitrate concentrations that are found in groundwater in the shallow aquifers of the Christchurch-West Melton area, which are the source of flow from the springs. As the rivers flow through the urban area of Christchurch the NNN concentrations decrease due to dilution by water from other sources, such as tributaries and stormwater pipes, that have lower NNN concentrations.

The ANZECC (2000) trigger value for NNN in lowland rivers is 0.444 mg/L. The majority of samples taken at all sites were greater than this value. The exception was the Heathcote River at Wigram Road site, where the four samples taken all had concentrations less than the trigger value. This site does not receive consistent spring flow and is often a dry channel. The water that has been sampled from the site is therefore likely to be runoff from the agricultural land in the area, rather than water sourced from high nitrate groundwater.

Dissolved reactive phosphorus (DRP)



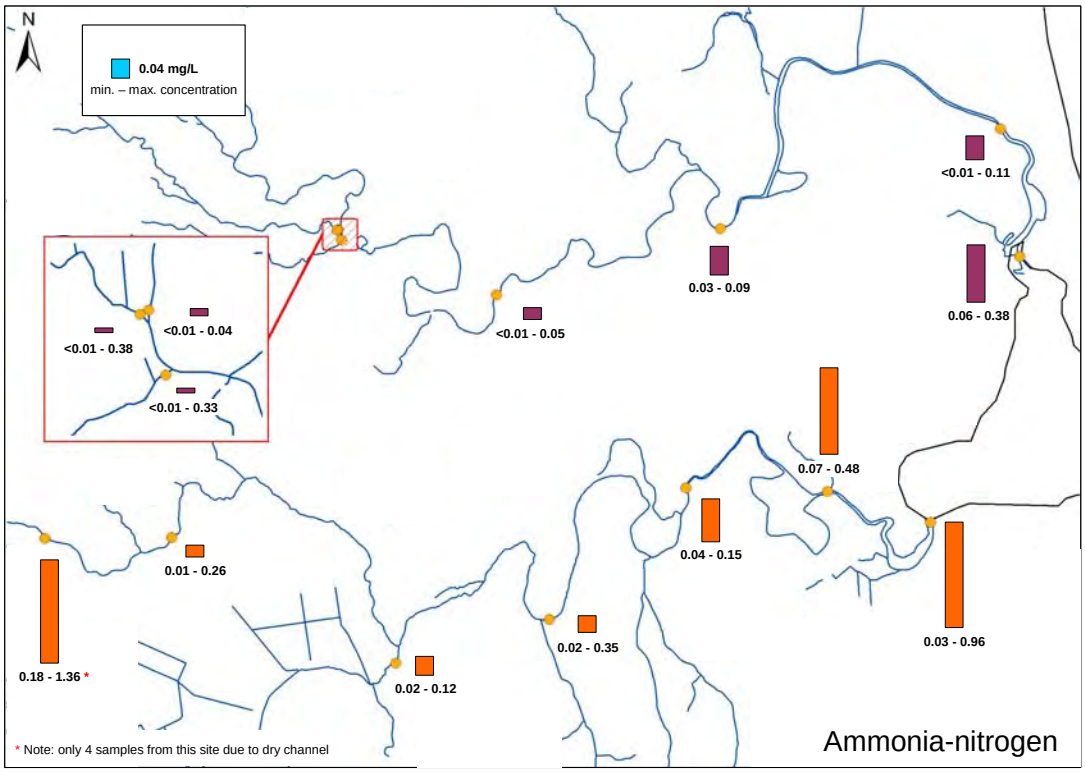
Dissolved reactive phosphorus (DRP) is the dissolved form of phosphorus that is available for plant growth. Plants and algae in water require suitable concentrations of nitrogen and phosphorus to grow, as well as other factors such as sunlight. Plants and algae are an important part of the aquatic ecosystem but excessive growth can be an indicator of a degraded system.

Phosphorus naturally occurs in waters with the concentrations typically reflecting the concentrations in the surrounding soil and rock. Phosphorus occurs in fertilisers applied to land to enhance plant growth. However in contrast to nitrate, the concentrations in groundwater are generally low as soils are good at absorbing excess phosphorus. Phosphorus is also a constituent of detergents and washing powders and hence is present in wastewater.

In the Avon River DRP concentrations were relatively low, with the highest concentrations occurring at the downstream sites. Estuarine water containing effluent from the wastewater discharge is brought up the river by tides and is the most likely source of the high DRP concentrations. The same pattern was found on the Heathcote River, however concentrations of DRP were generally higher and this is likely to be due to the high phosphorus content of Port Hills loess soils. The highest DRP concentrations were again found at the downstream sites. The Wigram Road site was an exception with high DRP concentrations possibly due to fertiliser runoff from surrounding agricultural land.

The ANZECC (2000) trigger value for DRP is 0.01 mg/L. The median concentrations at most sites exceeded this trigger value in 2007, and combined with high NNN concentrations indicate the potential for excessive macrophyte (aquatic plant) and algal growth in these rivers.

Ammonia-nitrogen (NH_3N)



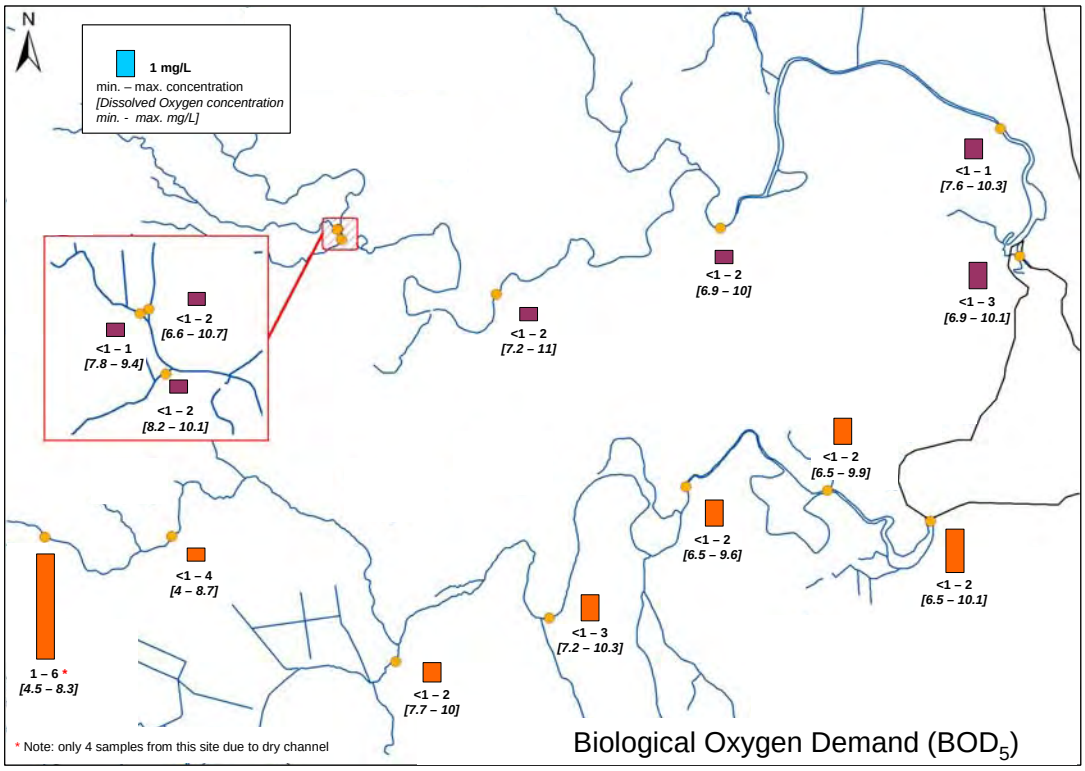
The ammonia-nitrogen (NH_3N) that occurs naturally in water is from the breakdown of once living and non-living nitrogen-based matter and from gas exchange with the atmosphere. The main concern with ammonia-nitrogen (NH_3N) concentrations in waterways is its toxicity effects on aquatic ecosystems and the large amount of oxygen used when ammonia breaks down to nitrate.

The Avon River had low concentrations of NH_3N at the upstream sites, with the highest concentrations occurring at the sites nearest the estuary. These high concentrations are likely to be due to the influence of estuarine water that has elevated NH_3N concentrations as a result of the wastewater discharge. Higher NH_3N concentrations at the downstream sites, especially above the tidal influence, may also reflect the impact of industrial and residential land use. The potential sources of this NH_3N to the rivers and tributary waterways via stormwater flows include industrial processes, household cleaners and sewage overflows.

The same trend for increasing NH_3N concentrations with distance downstream was seen on the Heathcote River, with the exception of the Wigram Road site. The water sampled from the site was often poorly oxygenated and on one sampling occasion contained highly elevated NH_3N concentrations, which may be due to the presence of waste matter from farm animals.

The ANZECC (2000) toxicity trigger value for NH_3N is 0.9 mg/L at pH 8, however the toxicity decreases with decreasing pH. The pH ranges for the two sites with high NH_3N concentrations were 6.4 – 7.1 at Wigram Road and 6.8 – 7.9 at Ferry Road. In these pH conditions the NH_3N concentrations detected have a low risk of causing toxic effects on aquatic life.

Biological oxygen demand (BOD_5)



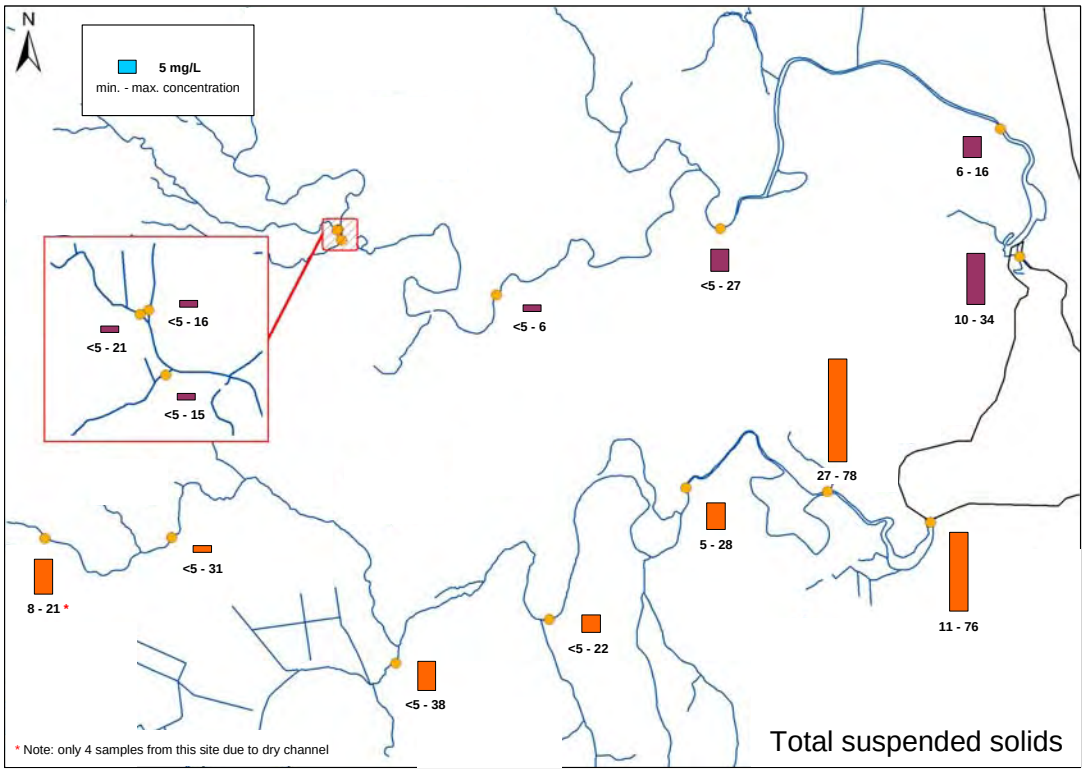
Biological oxygen demand (BOD_5) is a measure of the oxygen consumed by micro-organisms, such as bacteria, as they degrade organic material in the water. High amounts of organic material, such as from a wastewater discharge or decaying aquatic plants, result in high BOD_5 concentrations. High BOD_5 concentrations cause decreased dissolved oxygen in the water.

Adequate dissolved oxygen (DO) concentrations are essential for aquatic animals and any reduction in DO in water reduces the physiological efficiency of fish and non-air breathing invertebrates. Usually it is not the concentration of DO as such that is important but the percentage of oxygen saturation, which varies with water temperature. The percent saturation affects the ease with which aquatic animals respire.

The DO results from sampling of the Avon and Heathcote rivers in 2007 have only been reported as concentrations (mg/L) rather than percent saturation, but they do give an indication of when DO levels in the water have been reduced.

At most of the sites on both the Avon and Heathcote rivers the majority of BOD_5 concentrations were less than the limit of detection, indicating that organic matter decay is not a significant issue. The exceptions were the tidal sites at the downstream end of both rivers, which are affected by the wastewater discharge into the estuary, and the Wigram Road site on the Heathcote River. This site, and others with occasional high BOD_5 concentrations such as Templetons Road, may be influenced by macrophyte growth and decay or by faecal contamination from farm land. The DO concentration ranges for each site that are shown on the figure above show that where high BOD_5 concentrations are experienced there are corresponding decreases in dissolved oxygen, which may affect aquatic life in these areas.

Total suspended solids (TSS)



Total suspended solids (TSS) are sediment particles of all sizes that are washed into waterways during rainfall or are eroded from the bed or banks of the river channel. Fine sediments that are carried in the water column affect the clarity of the water. Visual clarity is important for aesthetic and safety aspects of recreational use of waterways. Reduction in clarity can also affect the behaviour of fish and macroinvertebrates, especially the migratory and predatory species, and primary production, such as algal growth.

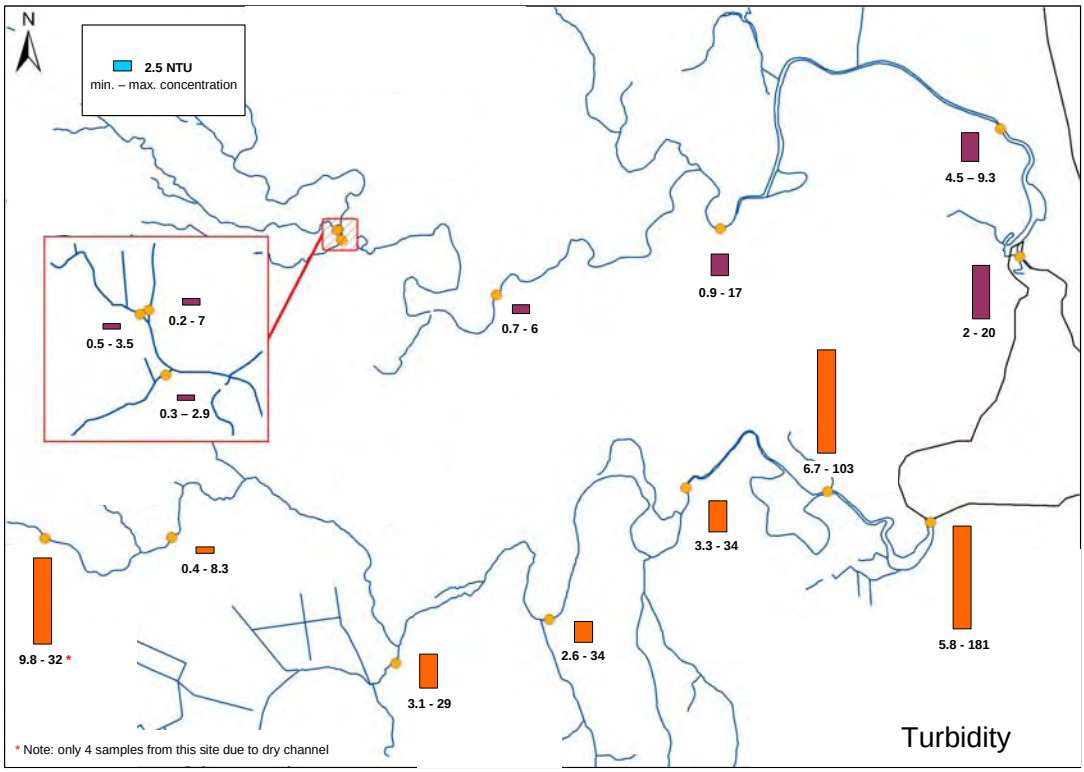
Larger sediment particles settle to the river bed and can smother habitats for aquatic life including spawning areas for fish. Fine sediments also settle out in areas of low flow such as pools and estuaries. Contaminants such as nutrients and heavy metals attach to sediment particles and are washed into waterways where they settle with the sediment or detach and become soluble in the water column.

Factors that can contribute to high TSS concentrations include bank erosion due to lack of vegetation and/or stock trampling, soil erosion due to vegetation clearance, and earthworks during construction.

TSS concentrations in the Avon River were generally low in the upper reaches with an increase downstream as the river passes through the city. The highest concentrations were found at the tidal sites, which is probably due to the re-suspension of bed sediments with tidal flows.

On the Heathcote River a similar pattern was seen. Low TSS concentrations were found at the Templetons Road site near the springs and median concentrations increased at sites downstream, with the highest concentrations at the tidal sites. Occasional high concentrations at Cashmere Stream, Bowenvale and Opawa Road are likely to be due to the Port Hills soils, which are easily eroded, and sediment-laden runoff during rainfall.

Turbidity

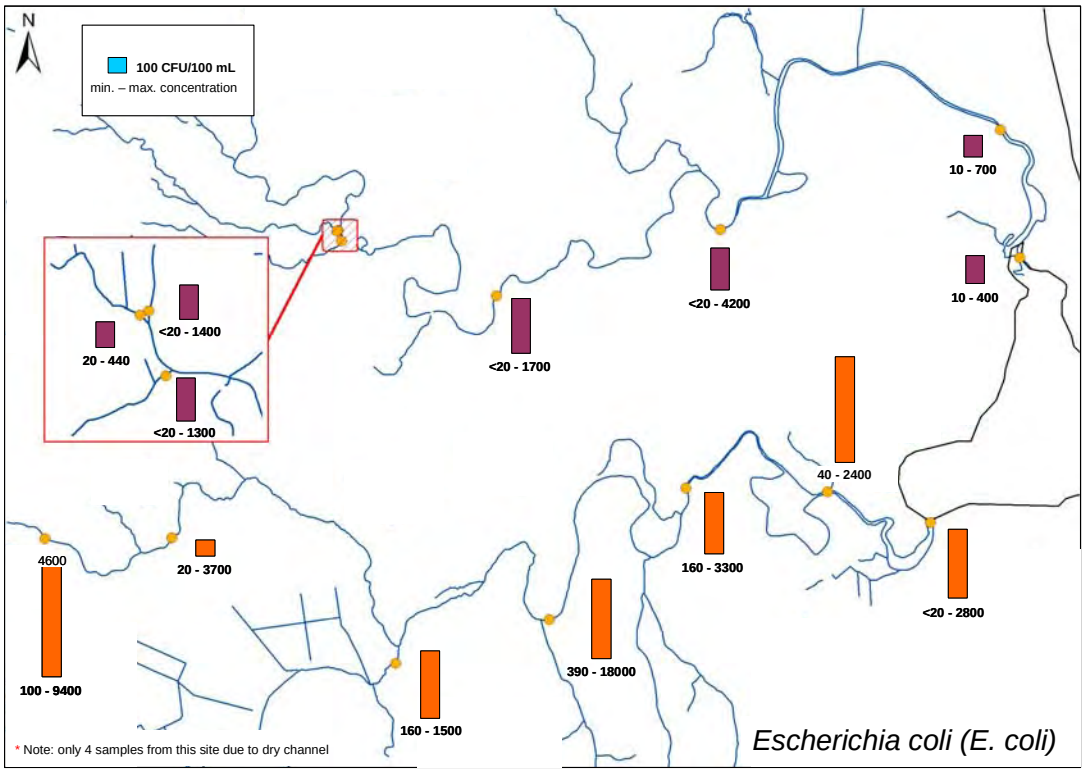


Turbidity is a measure of the degree to which light travelling through water is scattered by the suspended particles present. Turbidity measurements are therefore strongly related to suspended solids concentrations, although the relationship differs depending on the properties of the particles. Increased water turbidity can affect the healthy growth of plants and algae on the river bed by reducing light penetration through the water. High turbidity also infers the same effects as high suspended solids concentrations, such as impairment of fish that feed visually, smothering of habitats and spawning areas, and reduced amenity values.

The patterns in measured turbidity at the sample sites on the Avon and Heathcote rivers were very similar to those for total suspended solids. One notable difference was higher turbidity levels at the Wigram Road site on the Heathcote River relative to other sites. This is likely to be due to the particular light scattering properties of the suspended sediments at this site, which is not typically connected by flow to the sites downstream. Turbidity values were generally higher at the Heathcote River sites compared to the Avon River sites.

ANZECC (2000) provides a trigger value for turbidity of 5.6 NTU (nephelometric turbidity units). The majority of samples from sites in the lower half of each river had median turbidity measurements greater than this value, while sites nearer the springs had median turbidity values lower than the trigger value.

Escherichia coli (E. coli)



Escherichia coli (E. coli) is a bacteria that is found in high numbers in the stomachs and intestines of warm-blooded animals (including birds) and people. The presence of high concentrations of *E. coli* in water indicates the likely presence of faecal material and, with it, the possibility that other disease-causing organisms may be present. Faecal contamination of waters can occur through inadequately treated sewage, stormwater drains, septic tanks, runoff from pastoral farm land, and from wildlife such as waterfowl living in and around waterways. *E. coli* concentrations in freshwater are used to determine if water quality is suitable for contact recreation or as a source of drinking water.

E. coli concentrations sampled in the Avon and Heathcote rivers were highly variable across the year. Most sites had low bacteria concentrations at times as well as some very high concentrations. High concentrations indicate that there has been recent faecal contamination of the water and the occasional low concentrations show that contamination events are not constant.

Guidelines from the Ministry for the Environment and Ministry of Health (MfE/MoH 2002[4]) suggest that median concentrations of *E. coli* greater than 126 cfu/100 mL are a potential risk to the health of people that come into contact with the water. Based on the results presented here the Avon and Heathcote rivers are not considered to be safe for contact recreation.

During the summer months Environment Canterbury samples weekly at Kerrs Reach on the Avon River and at Catherine Street on the Heathcote River as part of its recreational water quality monitoring programme. This sampling also indicates that these sites are not suitable for contact recreation.

[4] MfE/MoH 2002. Microbiological water quality guidelines for marine and freshwater recreational areas. Ministry for the Environment, Wellington

Heavy metals

Heavy metals are those metals with high atomic weights (e.g. lead and zinc) that can be toxic to plant and animal life even at low concentrations. The metals copper, chromium, cadmium, lead, nickel and zinc are used in a wide range of industrial processes and some are also used in motor vehicle components and building materials, e.g. roofs and pipes. Metals are added to waterways via stormwater and accidental spills and can be a particular problem in urban waterways.

The table below summarises the results for heavy metals from samples collected at the Avon and Heathcote river sites in 2007.

The most frequently detected metals were zinc, lead and copper. These contaminants are commonly associated with stormwater runoff from roads and roofs. The ANZECC (2000) trigger values for the protection of aquatic ecosystems were exceeded at a number of sites, with the Heathcote River at Wigram Road site having the highest recorded concentration for these three metals. The concentrations of zinc in both the Avon and Heathcote rivers, and of copper and lead in the Heathcote River in particular, are a potential risk to the health of aquatic life.

	Total number of samples	**Laboratory detection limit (mg/L)**	**Number of sample results greater than or equal to detection limit**	**ANZECC (2000) trigger value for fresh water**	**Sites with results greater than trigger value ***	**Maximum concentration detected (mg/L)**
Cadmium	160	0.0002	3	0.0002	A1	0.0003
Copper	160	0.005	13	0.0014	H2, H4, H5, H6, H7	0.013 (at H2)
Lead	160	0.004	22	0.0034	A5, H2, H4, H5, H6, H7	0.01 (at H2, H6 & H7)
Mercury	160	0.0005	1	0.0006	H7	0.0008
Zinc	160	0.03	44	0.008	all except A2	0.745 (at H2)

***** Where trigger values are less than the laboratory detection limit there may be some samples with concentrations that are greater than the trigger value that are not able to be reported.

A1 – Wairarapa Stream
A2 – Waimairi Stream
A3 – Avon River at railway line
A4 – Avon River at Gloucester St
A5 – Avon River at Gayhurst Rd
A6 – Avon River at Pages Rd
A7 – Avon River at Bridge St

H1 – Cashmere Stream
H2 – Heathcote River at Wigram Rd
H3 – Heathcote River at Templetons Rd
H4 – Heathcote River at Bowenvale
H5 – Heathcote River at Opawa Rd
H6 – Heathcote River at Tunnel Rd
H7 – Heathcote River at Ferrymead

Conclusion

The quality of the water within the Avon and Heathcote Rivers is affected by the quality of the water that flows from the springs in their headwaters, the quality of the stormwater that flows from the land during rainfall and, in the lower tidal reaches, the quality of water in the estuary.

The water that flows from the springs at the headwaters of the rivers is high in nitrate-nitrite nitrogen. This is due to high nitrate concentrations in groundwater in the shallow aquifers in the Christchurch-West Melton area. The water quality at upper catchment sites was otherwise relatively good, with low concentrations of dissolved reactive phosphorus, ammonia-nitrogen and total suspended solids, and high dissolved oxygen. The exception to this was the Heathcote River at Wigram Road site, which was frequently dry and affected by runoff from the surrounding agricultural land use rather than by groundwater spring flow.

Sites further downstream were increasingly influenced by urban land use and stormwater quality. This was shown by higher concentrations of ammonia-nitrogen, total suspended solids and heavy metals. Other factors that may have affected water quality as the rivers flowed through the urban area include point source discharges from industrial sites, sewage overflows and waterfowl.

The quality of water in the estuary is currently strongly influenced by the wastewater discharge, with high ammonia-nitrogen and dissolved reactive phosphorus concentrations and reduced dissolved oxygen concentrations (Bolton-Ritchie 2008[5]). The water quality results for the two downstream sites on each river that receive estuarine water during high tide showed the effects of this. The water quality in the estuary is expected to change when wastewater is no longer discharged into the estuary and routine monitoring in the future will provide information on how this will affect the lower parts of the rivers.

Recommendations

It is recommended that the Wigram Road site on the Heathcote River be removed from this routine monitoring programme as it is frequently dry and not reflective of spring flows in the upper Heathcote River. The site could be replaced by a site between Templetons Road and Bowenvale, either upstream or downstream of the confluence with Cashmere Stream.

It is also recommended that dissolved oxygen measurements be reported as percent saturation as well as concentration, as this will be provide for more meaningful interpretation in terms of effects on the aquatic ecosystem.

[5] Bolton-Ritchie, L. 2008. Healthy Estuary and Rivers of the City: Water quality of the Avon-Heathcote Estuary/Ihutai – Summary report on data collected in 2007. Environment Canterbury unpublished report.

Christchurch
58 Kilmore Street, PO Box 345, Christchurch

General enquiries: 03 365 3828
Fax: 03 365 3194

Customer services: 03 353 9007
or: 0800 EC INFO (0800 324 636)

Timaru
75 Church Street, PO Box 550, Timaru

General enquiries: 03 688 9069

Fax: 03 688 9067

www.ecan.govt.nz