Hulls Creek – water quality and ecology

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Executive summary

Hulls Creek is a small tributary of the Hutt River identified in Greater Wellington's Regional Policy Statement (RPS) as requiring enhancement and restoration of poor water quality. The RPS intended that the health of Hulls Creek be monitored for anticipated improvements following the removal of a sewage discharge in 1993.

This report brings together water quality and ecological information available for Hulls Creek and its tributaries, with the view to assessing the current status of its water quality and aquatic ecosystems. The information drawn on includes a water quality investigation carried out by Greater Wellington over 1998/99, Silverstream Landfill consent monitoring, and the key findings of recent one-off urban stream ecology and sediment quality investigations. In addition, the results of a follow-up water quality investigation undertaken over the 2006/07 summer are considered.

Water quality and ecological results from these studies indicate that Hulls Creek is a moderately degraded waterway. The key water quality and aquatic ecosystem issues include:

- High turbidity and faecal bacteria levels due to pastoral landuse, stock access and streamworks/developments in the upper reaches, and runoff from the Silverstream Landfill in the lower reaches;
- Elevated concentrations of some heavy metals in the lower reaches of the Pinehaven Stream and mid reaches of Hulls Creek as a result of contaminated runoff from urban areas; and
- Degraded aquatic habitat due to extensive channel modification and lack of riparian shade, particularly in the upper reaches.

Despite these issues, comparison with Greater Wellington's Rivers State of the Environment (RSoE) monitoring data suggests that Hulls Creek is not any more degraded than other urban streams in the Wellington region.

Accordingly it is recommended that:

1. Future steps to improve aquatic ecosystem health in Hulls Creek focus on:
    - continuing riparian restoration and removal of barriers to fish passage in the lower catchment;
    - restricting stock access and improving riparian habitat in the upper catchment reaches;
    - improving sediment retention/removal in the Silverstream Landfill stormwater sediment retention ponds and ensuring all future developments in the catchment have appropriate sediment control measures in place; and
    - reducing contaminated urban runoff where practicable.
2. Current and future development plans are carefully assessed to ensure they do not unnecessarily limit potential for aquatic ecosystem rehabilitation in the Hulls Creek catchment.

Contents

1. Introduction

Hulls Creek is a small tributary of the Hutt River than runs through the suburbs of Trentham, Silverstream and Pinehaven in Upper Hutt (Figure 1.1). Hulls Creek is identified in Greater Wellington Regional Council's Regional Policy Statement (RPS) as having impaired water quality that is in need of enhancement and restoration (Wellington Regional Council 1995). Though not officially documented, it is likely that the main reason for the inclusion of Hulls Creek in the RPS was that, up until 1993, it received treated sewage from the Trentham Military Camp. The RPS states that Hulls Creek needs to be monitored for improvements expected following remedial works, presumably referring to when sewage from the Trentham Military Camp was redirected to the main sewer.

This report brings together water quality and ecological information available for Hulls Creek and its tributaries, with the view to assessing the current status of water quality and aquatic ecosystems in Hulls Creek. The information drawn on includes a water quality investigation carried out by Greater Wellington over 1998/99, Silverstream Landfill consent monitoring, and the key findings of recent one-off urban stream ecology and sediment quality investigations. In addition, the results of a follow-up water quality investigation undertaken over the 2006/07 summer are considered.

Figure 1.1: Hulls Creek at Freyberg Road, Silverstream

2. Hulls Creek – an overview

2.1 Catchment characteristics

The Hulls Creek catchment is made up of low lying hills in the Blue Mountains, Pinehaven, and Trentham/Wallaceville areas and low gradient areas around Heretaunga and Silverstream (Figure 2.1).

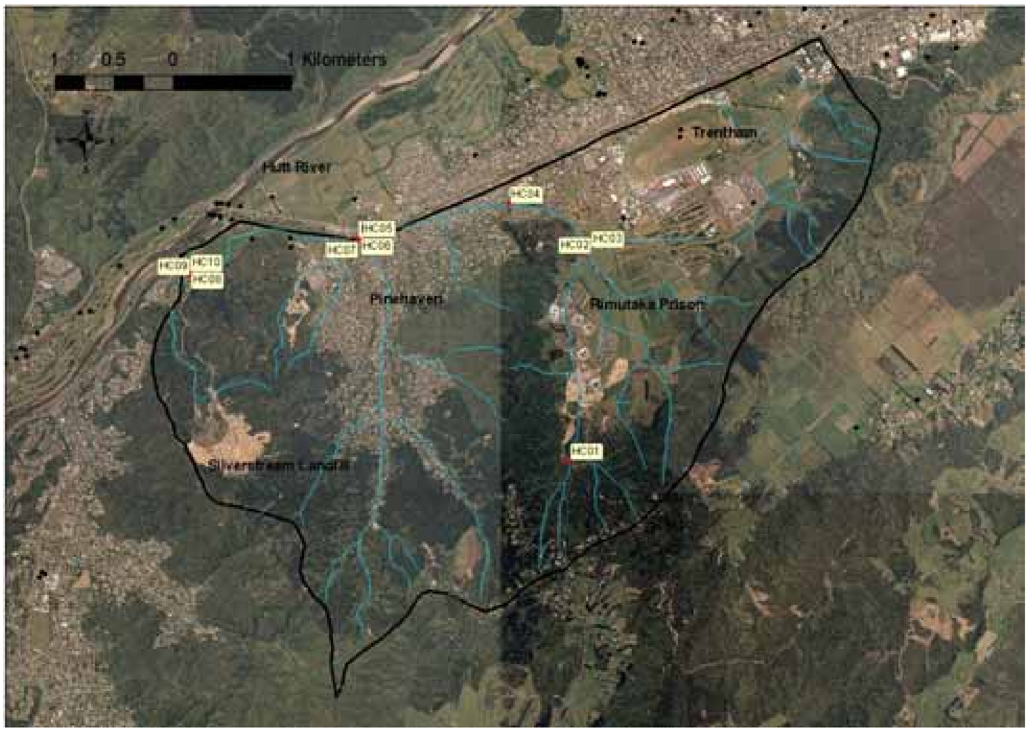

Figure 2.1: Map of the Hulls Creek catchment showing the 2006/07 water sampling sites

The dominant land cover classes in the Hulls Creek catchment are scrub, urban and indigenous forest (Table 2.1). In its upper catchment, Hulls Creek receives runoff from scrub and indigenous forest as well as the Rimutaka Prison farm. Just below the prison farm a tributary draining the northern catchment, which includes the Trentham Racecourse, a golf course, the old General Motors factory and areas of pastoral farming, enters the stream. The mid catchment is drained by the Pinehaven Stream which is dominated by plantation forestry and scrub in its headwaters and urban residential areas in its middle and lower reaches. The lower catchment is drained by Tip Stream which includes the Silverstream Landfill in its headwaters and indigenous forest and scrub in its lower reaches.

Pastoral and urban landuse in the upper and middle reaches of the Hulls Creek catchment has resulted in significant channel modification in many places. Much of the northern tributary and part of the main Hulls Creek channel between the northern tributary confluence and the former Central Institute for Technology (CIT) site have been been integrated into Upper Hutt City Council's stormwater network and are often referred to as the Heretaunga Drain. These reaches have been straightened and are concrete lined over much of their length (Figure 2.2). In urban areas some parts of Hulls Creek and its tributaries have been piped entirely. For example, a 300m reach of Pinehaven Stream has been piped immediately upstream of its confluence with Hulls Creek.

Table 2.1: Landcover in the Hulls Creek catchment

Landcover class	Area (ha)	Proportion of catchment (%)
Scrub	417	25
Urban	366	22
Indigenous forest	299	18
Urban open space	201	12
Planted forest	185	11
Pastoral	152	9
Landfill	27	2
Bare ground	12	1
Total	1658	

Source: Land Cover Database, Version 2 – MfE, 2001

Figure 2.2: Examples of channel modification in Hulls Creek at the former Central Institute of Technology (CIT) site (left), the Trentham Camp golf course (middle) and in the northern tributary downstream of the former General Motors site (right)

2.2 Water quality investigation, 1998/99

Berry (1999) measured faecal coliforms and turbidity at nine sites in Hulls Creek, one site in Tip Stream and two sites in the Hutt River on eight occasions over November and December 1998. This study identified high faecal coliform counts at all sites on Hulls Creek as well as a significant increase in faecal coliform counts in the Hutt River immediately below the Hulls Creek confluence. The main sources of this faecal contamination were identified as:

- Livestock inputs from the Rimutaka Prison farm and other pastoral farming areas in the upper catchment. Stock can access much of the creek and its tributaries in this area.

- Faecal material from cats, dogs, possums, rats and birds in both rural and urban areas.
- Possible stormwater/sewer cross-connection. Berry's (1999) study compared stream faecal coliform levels during periods of peak sewage flow to those at normal sewage flows to assess the potential for sewer cross connections. The results were not conclusive but suggested that cross connections could be a source of faecal contamination.

Turbidity levels followed a similar pattern. Apart from a control site in the upper catchment, high turbidity (>5 NTU)[1] was recorded at all sites on Hulls Creek and Tip Stream. Turbidity was particularly high around the Rimutaka Prison Farm and in the tributary running through the Rifle Range. The high turbidity was attributed to the low gradient of the area and soil and bank erosion due to cattle activity.

A significant increase in turbidity also occurred in the Hutt River below the Hulls Creek confluence.

2.3 Other water quality and ecological information

2.3.1 Silverstream Landfill consent monitoring

Under the conditions of its resource consents for Silverstream Landfill, Hutt City Council is required to monitor water quality in Tip Stream downstream of the point where the landfill's stormwater sediment retention pond discharges. This monitoring, undertaken at monthly intervals since 1992, shows that discharges from the ponds results in high levels of faecal coliforms and some metals in Tip Stream (Table 2.2).

Table 2.2: Summary of monthly monitoring in Tip Stream below the Silverstream Landfill stormwater sediment retention ponds (using only complete data sets from April 1998 to April 2007)

	Temp. (°C)	pH	Cond. (µS/cm)	DO (mg/L)	Total Aluminium (mg/L)	Ammonia-N (mg/L)	Faecal Coliforms (cfu/100mL)	Total Iron (mg/L)	Nitrate N (mg/L)	Total Zinc (mg/L)
Min	6.1	6.3	136	2.12	0.01	0.0025	10	0.06	0.005	0.0005
Median	12.7	7.1	225	9.45	0.16	0.03	290	0.73	0.12	0.036
Max	19.5	8.55	327	11.7	5.42	1.1	12,000	4.4	1.98	0.68
Consent condition exceedances (%)	n/a	3	0	0	1	0	22	25	0	0
ANZECC (2000)* exceedances (%)	n/a		n/a	n/a	52	0	n/a	n/a	9	50
No. of samples	108	108	108	108	108	108	108	108	108	108

* the 80% protection ANZECC (2000) guidelines are used for metals

Source: Data from Tonkin & Taylor

[1] 5 NTU was the guideline of the time (MfE, 1994)

Faecal coliform counts of up to 12,000 cfu/100mL have been recorded and are frequently above the 1,000 cfu/100mL guideline specified in the consent conditions. Iron concentrations of up to 4.4 mg/L have been recorded and exceed the 1 mg/L consent guideline approximately one quarter of the time.

Aluminium and zinc concentrations are also periodically elevated in Tip Stream. Though consent guidelines for these parameters have rarely been exceeded to date, concentrations frequently exceed the ANZECC (2000) 80% protection thresholds[2] (see Appendix 3 for guidelines). Total aluminium and total zinc concentrations also exceeded the ANZECC 80% protection thresholds on 51% and 50% of sampling occasions respectively. However, it is important to note that total metal measurements will not accurately reflect the bio-available metal fraction; this is generally better represented by the dissolved metal fraction.

Copper, suspended solids and turbidity are not measured as part of the monthly consent monitoring programme. Other parameters are measured on a yearly basis (see Appendix 1).

There have been several instances of non-compliant discharges from the Silverstream Landfill stormwater sediment retention ponds to Tip Stream. One such incident, on 27 January 2006, resulted in large amounts of sediment entering Tip Stream, Hulls Creek and the Hutt River (Table 2.3, Figure 2.3). High concentrations of aluminium, copper and iron were also associated with this particular discharge. It is likely that these metals were bound to sediment particles in the stormwater sediment retention pond given the circumstances of the discharge event.

Table 2.3: Water quality sampling results following an unauthorised sediment discharge from the Silverstream Landfill stormwater sediment retention ponds on 27 January 2006

Contaminant (mg/L)	Discharge from new sediment pond	Tip Stream	Hull Ck upstream of confluence	Hulls Ck downstream of confluence	Hutt R upstream of Hulls Creek confluence	Hutt R downstream of Hulls Ck confluence
Suspended solids	963	657	1.5*	162	Not measured	72
Total aluminium	51.9	48.2	0.162	16.6	0.035*	7.47
Total chromium	0.031	0.027	0.003	0.012	<0.001*	0.007
Total copper	0.028	0.023	0.005	0.011	<0.0005*	0.006
Total iron	48.8	35.9	0.7	10.4	<0.1*	4.2
Total manganese	0.993	0.452	0.017	0.139	0.0018*	0.068*
Total zinc	0.117	0.097	0.029	Not measured	0.002*	0.027

* Figures are for dissolved metals rather than total metals

2 ANZECC (2000) provides trigger values for freshwater for four different protection levels, 99%, 95%, 90% and 80%. Protection level signifies the percentage of species expected to be protected. In most cases the 95% protection level trigger value should apply to ecosystems that have been classified as slightly-moderately disturbed (modified). For ecosystems classified as highly modified it may be appropriate to apply the 90% or even 80% trigger level.

Figure 2.3: Turbid water at the confluence of Tip Stream with Hulls Creek (left) and in Hulls Creek downstream of Tip Stream (right) following an unauthorised discharge from the Silverstream Landfill stormwater sediment retention ponds, 27 January 2006

2.3.2 Sediment quality sampling

In 2005 a site at Field Street near the bottom of the Hulls Creek catchment was included in a region-wide sediment quality sampling investigation of 22 urban streams. A single composite sample of surface sediment was collected and analysed for a wide range of metals and organic compounds (Appendix 2) and the results compared against the ANZECC (2000) Interim Sediment Quality Guidelines (ISQG).

The majority of contaminants measured were well below the ISQG low trigger values. However, concentrations of zinc, dieldrin, 4’4 DDE and total DDT exceeded the ISQG low trigger value and concentrations of the organo-chlorine pesticide lindane exceeded the ISQG high trigger value (Croucher & Milne 2005).

2.3.3 Urban stream ecology study

Invertebrate and habitat data was collected from Hulls Creek and Pinehaven Stream in March/April 2004 as part of a study of urban stream ecology in the Wellington region (Kingett Mitchell 2005). Sampling was carried out at a site in the upper reaches of Hulls Creek beside the Trentham Military Camp and a site in the lower reaches near Field Street. Sampling was also carried out at a site above urban influence in the Pinehaven Stream.

In contrast to the upper Pinehaven Stream site, where channel shading was estimated to be 64%, both sites on Hulls Creek had little or no channel shading (Figure 2.4). There was 100% periphyton cover at all three sites and macrophytes covered 72% of the channel at the upper Hulls Creek site.

Figure 2.4: Sites in the Hulls Creek catchment assessed as part of Kingett Mitchell's (2005) urban stream study – upper Hulls Creek (top left), lower Hulls Creek (bottom left), and upper Pinehaven Stream (right)

Indicators of macroinvertebrate health used included the Macroinvertebrate Community Index (MCI), Quantitative Macroinvertebrate Community Index (QMCI) and number of Ephemeroptera, Plectoptera and Trichoptera (EPT) taxa[3]. MCI and QMCI scores indicated possible severe pollution at the upper Hulls Creek site and probably moderate pollution at the lower Hulls Creek site (Table 2.4). The upper Hulls Creek site was dominated by the snail *Potamopyrgus antipodarum* and oligochaete worms while the lower site was dominated by orthoclad midges and oligochaete worms. EPT taxa were rare at both sites indicating that water quality or habitat was unsuitable for these sensitive macroinvertebrates.

In comparison, the invertebrate community in the upper Pinehaven Stream was characterised by a high number of pollution sensitive EPT taxa. EPT taxa comprised 96% of the total individuals collected at this site. MCI and QMCI scores were also high indicating excellent water and habitat quality at this site (Table 2.4).

[3] MCI is an index of sensitivity to organic pollution based on the presence or absence of macroinvertebrate taxa. QMCI is similar to the MCI but incorporates the abundance of the macroinvertebrate taxa present. EPT taxa is a measure of pollution sensitive ephemeroptera (mayfly), plecoptera (stonefly) and trichoptera (caddisfly) taxa present, expressed as a percentage of total taxa richness.

Table 2.4: Invertebrate sampling results from Hulls Creek and Pinehaven Stream taken as part of Kingett Mitchell's (2005) study of urban stream ecology in the Wellington region

	Hulls Creek upper*	Hulls Creek lower**	Upper Pinehaven Stream***
Total taxa	25	20	26
MCI	77	85	133
QMCI	2.1	3.3	7.6
EPT taxa	4	6	15
% EPT individuals	0.2	0.7	95.9

* Kingett Mitchell site name Upper Silverstream, located around Gallipoli Road (between 2006/07 sampling sites at Freyberg Rd and CIT).

**Kingett Mitchell site name Lower Silverstream, located just downstream of Field Street

*** Kingett Mitchell site name Pinehaven Stream, located in an area of scrub/forest just above the urban extent.

2.3.4 Fish data

New Zealand Freshwater Fish Database records show that longfin eels (*Anguilla dieffenbachii*), redfin bullies (*Gobiomorphus huttoni*) and inanga (*Galaxias maculatus*) were caught in Hulls Creek at the confluence with the Hutt River in 2004. There was also a 2004 record for longfin eels in the mid reaches of the Pinehaven Stream.

As part of a Massey University study on the effects of barriers to fish passage, electrofishing surveys were carried out in the lower reaches of Hulls Creek above and below a weir located downstream of Eastern Hutt Road in April 2006 and 2007. On both occasions redfin bullies, common bullies (*Gobiomorphus cotidianus*) and shortfin eels (*Anguilla australis*) were found both above and below the weir. However, in April 2007 bluegill bullies (*Gobiomorphus hubbsi*) and trout (*Salmo trutta*) were found below the weir but not above. It is not clear whether these species were absent above the weir due to passage issues or due to lack of suitable habitat. However, it is likely that the weir was limiting the number of individuals found upstream and consequently the distribution of fish in the Hulls Creek catchment as a whole (Nicki Atkinson, Massey University, pers comm.).

In conjunction with the Silverstream Care Group, Greater Wellington constructed a fish pass over this weir in August 2007 (Figure 2.5). Fish monitoring will be carried out to assess any changes in the Hulls Creek fish community that the fish pass may bring about.

Another barrier to fish passage in the Hulls Creek catchment is the drop of approximately half a metre at the confluence of the Pinehaven Stream with Hulls Creek. This barrier, combined with the piping of approximately 300m of the Pinehaven Stream upstream of the confluence, is likely to be limiting fish access to high quality habitat in the upper reaches of the catchment.

Figure 2.5: Fish pass constructed at the weir downstream of Eastern Hutt Road (left) and a possible barrier to fish passage at the confluence of the Pinehaven Stream with Hulls Creek (right)

3. 2006/07 water quality investigation

In order to follow up on the investigation carried out in 1999 and to assess the current status of water quality in Hulls Creek, Greater Wellington staff carried out water quality sampling at selected sites throughout the Hulls Creek catchment during the summer of 2006/07. Sampling was limited to three occasions over this period and so the results only provide a 'snapshot' of water quality and do not necessarily reflect water quality conditions all year round.

3.1 Sites and methods

Water sampling was conducted at ten sites in the Hulls Creek catchment on three occasions over the 2006/07 summer; 19 December, 31 January and 13 March. The majority of the sites were the same as those sampled by Berry (1999), thereby enabling a direct comparison of the results with those of the earlier water quality investigation (Figure 2.1, Appendix 3). Invertebrates were also sampled on one occasion at one site in the lower reaches.

3.1.1 Sampling methods

Grab (spot) sampling was conducted at all sites, with buckets and rope used to sample the three sites adjacent to the Silverstream Railway Station (HC05, HC06 and HC07); direct access to the creek was not possible at these sites. Water samples were stored on ice upon collection and transported to the Greater Wellington's contracted laboratories for analysis within 24 hours of collection[4]. Field measurements (dissolved oxygen, temperature, pH and conductivity) were taken using approved meters calibrated on the morning of sampling. A stream gauging was also undertaken at the bottom of the catchment (approximately 50 m downstream of site HC10), to enable calculation of stream flow at the time of sampling.

One macroinvertebrate sample was collected from riffle habitat at site HC10 on 19 December 2006. Collection and sample processing were undertaken in accordance with Protocols C1 and P2 of the Ministry for the Environment's Protocol for Sampling Macroinvertebrates in Wadeable Streams (Stark et al. 2001).

3.1.2 Sample analysis

Water samples were tested for a range of physico-chemical and microbiological variables. These included dissolved oxygen, temperature, conductivity, pH, turbidity, total suspended solids, *Escherichia coli (E. coli*), total organic carbon (TOC), ammoniacal nitrogen, nitrite-nitrate nitrogen, dissolved reactive phosphorus and dissolved metals.

Not all variables were tested on all occasions as initial sampling showed that the concentrations of some parameters were below detection limits. Extra tests were also performed on some samples from the lower catchment reaches (sites HC08, HC09 and HC10). For example, water samples from site HC10 were

[4] Samples for dissolved nutrient analysis were filtered in the field where possible.

also analysed for total nutrients and metals to enable calculation of the total contaminant loads discharged to the Hutt River. In addition, horizontal black disc (water clarity) measurements were made upstream and downstream of the Tip Stream confluence to assess the visual impact of the 'milky' Tip Stream waters (observed on all sampling occasions, refer Section 3.2) on Hulls Creek.

3.2 Results

Water sampling results are summarised here (the raw results are presented in Appendix 5), both in relation to previous sampling results (Berry 1999), and compliance with national water quality guidelines. Most of the guidelines used here (refer Appendix 4) are the Australian and New Zealand Environment and Conservation Council (ANZECC) and Agriculture and Resource Management Council of Australia and New Zealand (ARMCANZ) "default trigger values" for lowland aquatic ecosystems (herewith denoted as ANZECC 2000). These trigger values are intended to be compared against the *median* value from independent samples at a site. They are not legal standards and exceedances do not necessarily mean an adverse environmental effect would result. Rather an exceedance is an 'early warning' mechanism to alert resource managers of a potential problem or emerging change that may warrant site-specific investigation or remedial action (ANZECC 2000).

Non-detect values were taken as being half the detection limit (i.e., a result reported as <0.1 mg/L was taken to be 0.05 mg/L).

3.2.1 Water temperature, dissolved oxygen and turbidity

Spot temperature measurements in Hulls Creek ranged between 14.7°C and 26.3°C. The median temperature over all sites was 17.7 °C. Highest temperatures were recorded in the upper reaches of Hulls Creek particularly in the tributary draining the northern catchment (HC03) and the main channel around Freyberg Road and the former site of the Central Institute for Technology (CIT) (HC02 and HC04). All measurements taken at these sites were greater than 20°C; the temperature threshold above which sensitive invertebrate species such as mayflies are likely to be affected (Quinn & Hickey 1990).

Spot measurements of dissolved oxygen ranged between 84% and 136% saturation. The median saturation across all sites was 101%. Both the highest and lowest dissolved oxygen saturation was recorded in the upper catchment around Freyberg Road and the former CIT site.

Turbidity levels exceeded the ANZECC (2000) default trigger value of 5.6 NTU on 22 of 30 sampling points. Turbidity levels were highest in Tip Stream with a maximum of 174 NTU recorded in January. The median turbidity recorded across all sites was 8.04 NTU. Comparison with measurements taken in 1999 suggests little change in turbidity levels in Hulls Creek in the last eight years (Figure 3.1).

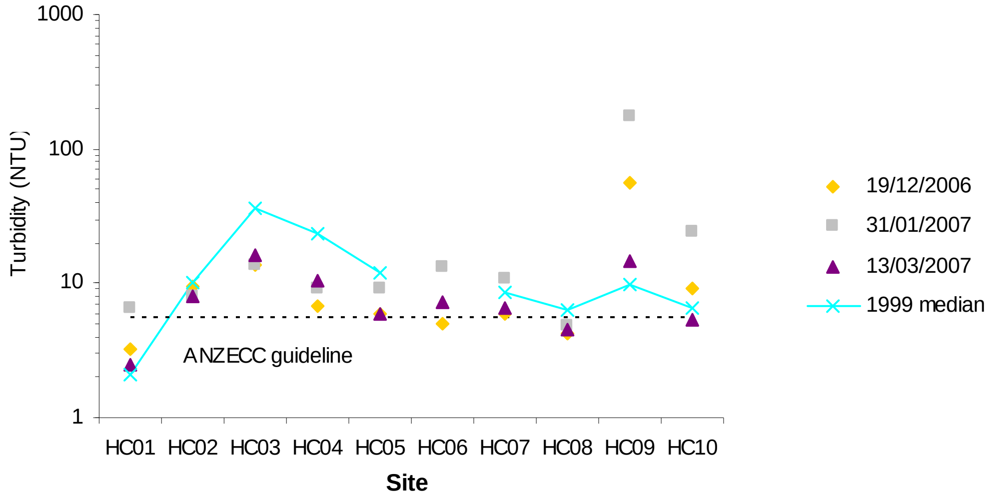

Figure 3.1: Turbidity measurements from water sampling in Hulls Creek on three occasions over 2006/07 and median results from eight sampling occasions at nine sites over 1998/99 (from Berry 1999). Note the logarithmic scale on the y-axis.

3.2.2 Microbiological water quality

E. coli counts in Hulls Creek ranged between 290 cfu/100mL and 26,000 cfu/100mL. The median *E. coli* count from all sites was 1,400 cfu/100mL. All but five of the 30 samples taken from Hulls Creek were above the action mode of the MfE/MoH (2003) recreational water quality guidelines (550 cfu/100mL), indicating that the creek is unsafe for contact recreation (Figure 3.2). In general the highest *E. coli* counts were found in the upper catchment.

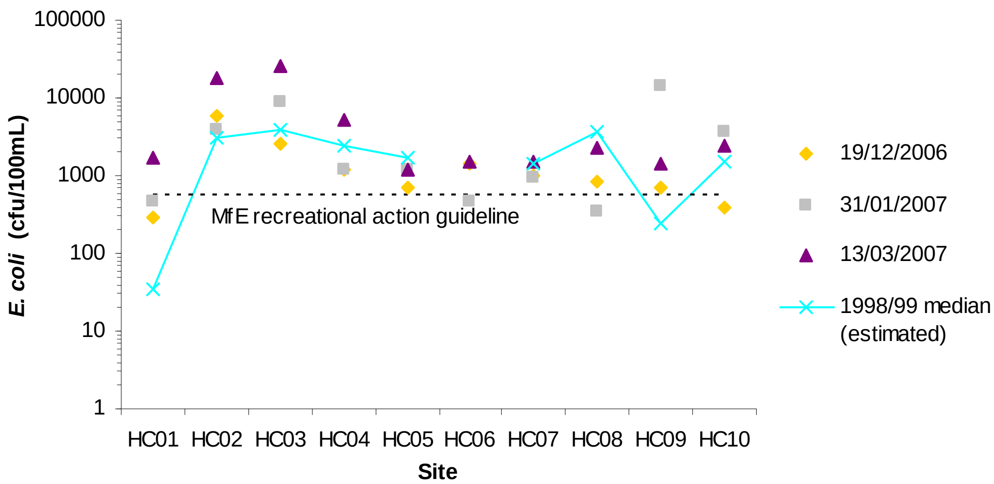

Figure 3.2: *E. coli* counts in Hulls Creek measured on three occasions in 2006/07 and median results from eight sampling occasions at nine sites in 1998/99 (from Berry 1999). Median *E. coli* counts from 1998/99 were estimated by applying the USEPA ratio to faecal coliform data. Note the logarithmic scale on the y-axis.

E. coli data collected for this study cannot be directly compared to 1999 faecal coliform data. However, using the USEPA relationship between these two indicators (the USEPA estimates that out of 200 faecal coliforms 126 will be *E. coli* (http://www.mfe.govt.nz/issues/water/water-quality-faqs.htmL#question4)) to estimate *E. coli* levels from 1999 faecal coliform data it appears that there has been little change faecal bacteria levels since 1999 (Figure 3.2).

3.2.3 Nutrients, ammonia and total organic carbon

Bio-available nitrogen concentrations measured as total oxidisable nitrogen (TON) ranged between 0.005 mg/L and 0.66 mg/L. Median TON was 0.087 mg/L. Only two samples, both taken from Tip Stream, exceeded the ANZECC (2000) default trigger level for TON (0.444 mg/L).

Bio-available phosphorus concentrations, measured as dissolved reactive phosphorus (DRP) ranged between 0.005 mg/L and 0.062 mg/L. Median DRP was 0.024 mg/L. DRP concentrations exceeded the ANZECC trigger value (0.01 mg/L) for 23 out of the 30 sampling points and were highest in the upper catchment.

Ammoniacal nitrogen concentrations ranged between 0.005 mg/L and 0.014 mg/L, with a median concentration across all sites of 0.01 mg/L. Ammoniacal nitrogen concentrations exceeded the ANZECC trigger value for physical and chemical stressors (0.021 mg/L) for 10 of the 30 sampling points. However, no measurements exceeded ANZECC (2000) 80% or 95% protection thresholds developed for toxicants[5].

Over all sites sampled, total organic carbon (TOC) concentrations ranged between 2.9 and 12.4 mg/L. The median TOC concentration was 6.75 mg/L, with the highest concentrations recorded in the mid reaches.

3.2.4 Metals

Dissolved copper concentrations ranged between 0.00025 mg/L and 0.008 mg/L (Figure 3.3), with a median concentration of 0.0013 mg/L. The ANZECC (2000) 95% protection threshold was exceeded on nine out of 30 sampling occasions, with the 80% threshold exceeded on five occasions. The highest dissolved copper concentrations were recorded at the three sites in the Pinehaven area (i.e., in the lower reaches of Pinehaven Stream and immediately upstream and downstream of the confluence with Hulls Creek). All three measurements taken from Hulls Creek below the Pinehaven Stream confluence were well above the ANZECC (2000) 80% protection threshold.

Dissolved zinc concentrations ranged between 0.0005 mg/L and 0.041 mg/L with a median concentration across all sites of 0.005 mg/L (Figure 3.4). Concentrations of dissolved zinc exceeded the 95% threshold on eight of 30 sampling occasions. Three of these measurements also exceeded the 80%

[5] ANZECC (2000) default trigger values for physical and chemical stressors are a set of numbers based on concentrations measured in slightly disturbed (modified) upland and lowland rivers in New Zealand ANZECC (2000) trigger values developed for toxicants are a set of numbers based on ecotoxicity tests on a range of species.

protection threshold. Dissolved zinc concentrations were highest in the lower Pinehaven Stream and immediately downstream of its confluence with Hulls Creek.

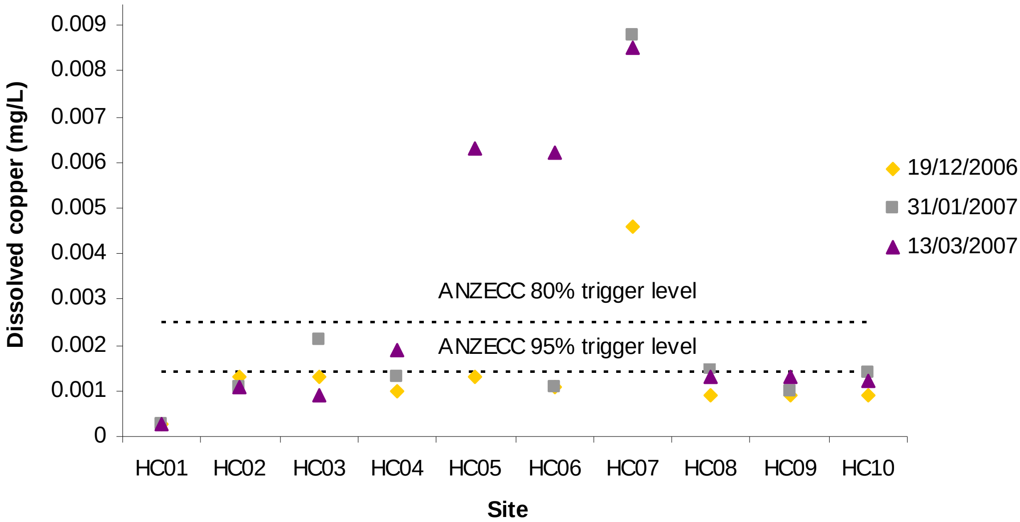

Figure 3.3: Dissolved copper concentrations recorded on three sampling occasions between December 2006 and February 2007 inclusive

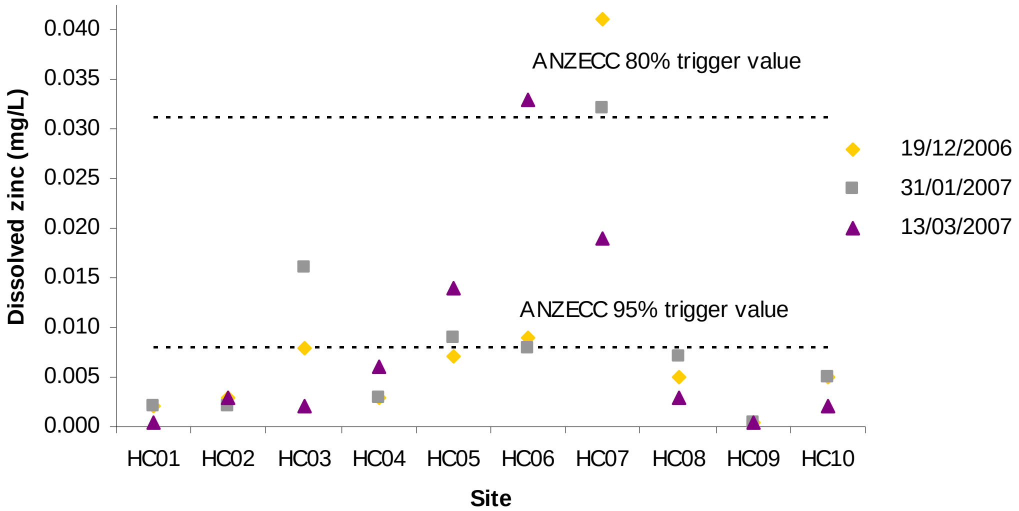

Figure 3.4: Dissolved zinc concentrations recorded on three sampling occasions between December 2006 and February 2007 inclusive

Dissolved nickel and lead concentrations were above detection limits on most sampling occasions but no results exceeded the ANZECC (2000) 80% or 95% protection thresholds (Appendix 4).

3.2.5 Contaminant loading to the Hutt River

The total annual load of selected contaminants to the Hutt River from Hulls Creek is estimated in Table 3.1 based on spot water quality measurements taken at the bottom of Hulls Creek (downstream of site HC10) on the three sampling occasions over 2006/07 and the estimated mean annual flow from Woods et al (2006). The proportion of the total contaminant load in the Hutt River is also estimated, using Greater Wellington's water quality and flow monitoring data collected from the Hutt River opposite Manor Park Golf Club. Based on mean annual flow estimations Hulls Creek contributes approximately 1.1% of the Hutt River flow at Manor Park Golf Club.

Table 3.1: Estimated annual load of nutrients, sediment and selected metals in Hulls Creek and the estimated proportion these make up of the total load in the Hutt River near the Hulls Creek confluence

Contaminant	Estimated load to the Hutt River (tonnes/yr)	% of Hutt River load*
Total nitrogen	3.04	0.96
Total phosphorus	0.38	7.00
Total organic carbon	51.2	2.88
Total suspended solids	63.6	No data
Total copper	0.015	No data
Total nickel	0.005	No data
Total lead	0.011	No data
Total zinc	0.065	No data

* Total load at Greater Wellington's closest RSoE monitoring site, Hutt River opposite Manor Park Golf Club (approximately 600m downstream of the Hulls Creek confluence), was calculated using median water quality values from Milne and Perrie (2005) as well as the mean annual flow value calculated for the site.

The data in Table 3.1 suggests that Hulls Creek typically contributes less than 10 % of the contaminant load to the Hutt River. However, it is likely that the contaminant loads have been underestimated as they are based on three sampling occasions during a period of relatively low stream flow. Loads from runoff associated with storm events have not been taken into account.

3.2.6 Macroinvertebrates

Macroinvertebrate sampling was carried out in Hulls Creek downstream of Tip Stream (site HC10) on 19 December 2006. The invertebrate community at this site was dominated by pollution tolerant taxa such as the snail *Potamoprygus antipodarum* and orthoclad midge larvae (Appendix 6). Six pollution sensitive EPT taxa were present but out of the total number of individuals collected only 7% were EPT taxa. Although the MCI score on this occasion was 100, indicating fair to good ecological condition, the QMCI was considerably lower reflecting the high abundance of pollution tolerant taxa.

Table 3.2: Invertebrate sampling results from Hulls Creek (downstream of Tip Stream confluence) on 19 December 2006

	Hulls Creek d/s Tip Stream
Total taxa	24
MCI	100
QMCI	3.71
EPT taxa	6
% EPT	7

4. Discussion

Water quality and aquatic ecology information collected in the Hulls Creek catchment in the last decade indicates that Hulls Creek is a moderately degraded waterway.

Data collected during 2006/07 suggest that fluctuations in water temperature and dissolved oxygen concentrations may be having an adverse effect on aquatic ecosystems in Hulls Creek. These fluctuations are most pronounced in the upper reaches of Hulls Creek around Freyberg Road and in the northern tributary where flows are low and there is little riparian cover or shade.

Microbiological water testing undertaken in 1998/99 (Berry 1999) and 2006/07 shows that indicator bacteria levels in Hulls Creek can get very high and are generally well above recreational water quality guidelines. Turbidity is also high, particularly in the upper catchment and in Tip Stream (Figure 4.1). High concentrations of dissolved zinc and copper also occur in the mid reaches of Hulls Creek around the Pinehaven area.

Assessment of invertebrate communities in Hulls Creek suggests moderate to severe degradation in the upper reaches of Hulls Creek and moderate degradation in the middle and lower reaches. Limited fish information suggests that fish diversity is relatively low.

Figure 4.1: Heavy siltation in a branch of the northern Hulls Creek tributary (left) and turbid water entering Hulls Creek below Tip Stream (right)

There are a number of activities and land uses that are likely to be contributing to the current degradation of water quality and aquatic ecosystem health in Hulls Creek:

- Pastoral landuse and stock access to stream channels in the upper catchment around the Rimutaka Prison farm and parts of the northern tributary are likely to be a key contributor to high turbidity and faecal bacteria levels in the upper reaches of Hulls Creek. In addition, stock access in these reaches contributes to sedimentation and reduction of instream habitat diversity.

- The lack of riparian shade in the upper reaches of Hulls Creek makes these reaches particularly susceptible to wide fluctuations in water temperature and dissolved oxygen concentrations.

- Contaminated runoff from urban areas around Pinehaven is likely to be the main source of zinc and copper in the lower reaches of the Pinehaven Stream and mid reaches of Hulls Creek.

- Runoff from the Silverstream Landfill stormwater sediment retention ponds periodically contributes significant amounts of suspended sediment and faecal bacteria to Tip Stream and the lower reaches of Hulls Creek. Greater Wellington is working with the Hutt City Council to improve the quality of the discharge from the Silverstream Landfill; plans are currently underway to construct a wetland to treat the outflow from the settling ponds prior to discharging to Tip Stream.

- Several instances of unauthorised stream works have been recorded in the Heretaunga Drain and Alexander Road areas. These unauthorised works resulted in uncontrolled sediment discharges to Hulls Creek and its tributaries and were stopped by Greater Wellington pollution control staff (Nic Conland, Greater Wellington, pers. comm.). Greater Wellington aims to ensure that all future developments have appropriate erosion and sediment control measures in place for the duration of any stream works or earthworks.

- A high proportion of stream reaches in urban areas of the Hulls Creek catchment is heavily modified through straightening, concrete lining and in some cases piping (refer to Figure 2.2, Section 2.1). This modification has resulted in significant degradation of invertebrate and fish habitat in these reaches.

4.1 Comparison with other urban streams

Hulls Creek water quality and macroinvertebrate data was compared against data collected from six urban stream sites monitored over 1997-2003 as part of Greater Wellington's Rivers State of the Environment (RSoE) programme (as reported in Milne and Perrie 2005). This comparison showed that although water quality is degraded in Hulls Creek, median levels of turbidity, faecal coliforms and dissolved reactive phosphorus in Hulls Creek were similar to those in other urban streams.

In terms of aquatic ecosystem health, it appears that invertebrate communities in Hulls Creek may be less degraded than some other urban streams in the Wellington region. The median MCI value reported by Milne and Perrie (2005) for the six urban RSoE monitoring sites was 74. In contrast, MCI scores for Hulls Creek based on sampling undertaken in 2004 and 2006 ranged from 77 to 100.

4.2 Community action and future challenges for Hulls Creek

The Silverstream Care Group, a Forest and Bird led group with financial assistance from Greater Wellington and the Ministry for the Environment's Sustainable Management Fund, is currently undertaking restoration work in the lower Hulls Creek catchment. So far this work has involved willow removal, riparian planting (Figure 4.2), weed control and rubbish removal from 700m of Hulls Creek in the lower catchment (Richard Romijn, Greater Wellington, pers. comm.). The care group has also recently constructed a fish pass at the weir located downstream of Eastern Hutt Road (refer Figure 2.5, Section 2.3.4). The riparian rehabilitation work has resulted in significant improvement in riparian and instream habitat in the lower reaches of Hulls Creek and together with removal of fish barriers may result in improved fish diversity in these reaches. This work may also improve the likelihood of fish reaching high quality habitats found in some upper catchment reaches.

Figure 4.2: A reach of lower Hulls Creek where riparian rehabilitation work has been undertaken by the Silverstream Care Group

Future pressures on the Hulls Creek catchment include several proposals for industrial park development. Two such developments in the upper reaches of the northern tributary and one in the the lower catchment (adjacent to the reach currently being restored by the care group) propose to pipe and realign significant lengths of stream. This is a concern because, although these reaches are already highly modified, they still provide important ecosystem functions such as nutrient and contaminant removal, sediment retention and flood attenuation. In addition, these reaches provide an important corridor for fish to high quality habitat in the catchment headwaters.

Though Hulls Creek is a moderately degraded ecosystem, efforts of the Silverstream Care Group show that there is a lot of potential to improve aquatic habitat in the catchment through riparian rehabilitation and removal of barriers to fish passage. Future developments need to be assessed in a way that ensures this potential isn't limited by unnecessary channel modification and piping.

5. Conclusions and recommendations

Investigations of water quality and ecology carried out in the last decade suggest that Hulls Creek is a moderately degraded ecosystem. There are a wide range of land uses and activities in the Hulls Creek catchment that contribute to this degradation: pastoral landuse; stock access to stream banks; and runoff from urban areas, streamworks/developments in the upper catchment, and the Silverstream Landfill’s stormwater sediment retention ponds. However, comparison with relevant state of the environment monitoring data suggests that Hulls Creek is not any more degraded than other urban streams in the region.

Accordingly it is recommended that:

1. Future steps to improve aquatic ecosystem health in Hulls Creek focus on:

    - Continuing riparian rehabilitation and removal of barriers to fish passage in the lower catchment;

    - Restricting stock access and improving riparian habitat in the upper reaches of Hulls Creek around the Rimutaka Prison Farm and the northern tributary;

    - Improving sediment retention/removal in the Silverstream Landfill stormwater sediment retention ponds and ensuring all future developments in the catchment involving earthworks or works in the streambed have appropriate erosion and sediment control measures in place; and

    - Reducing contaminated urban runoff where practicable, through the promotion of sustainable urban design practices such as reduced impervious cover and improved stormwater treatment.

2. Current and future development in the Hulls Creek catchment is carefully regulated to ensure no further degradation of instream values. Current plans to pipe significant lengths of stream in the catchment need to be assessed carefully to ensure that they do not unnecessarily limit the potential for future aquatic ecosystem rehabilitation in the Hulls Creek catchment.

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Appendix 1: Silverstream Landfill consent monitoring results

ANNUAL ANALYSIS RESULTS - Tip Stream downstream of Silverstream Landfill (Site SW4)

Determinand	Unit	Guidelines	21/09/06	29/11/05	23/11/04	15/11/03	19/11/02	26/11/01	29/11/00	09/11/99	11/11/98	03/11/97
Temperature	(^{o}C)	n/a	12.8	14.3	13.8	**	10.4	12.7	14.4	12.1	12	
Total Aluminium	(mg/L)	5.0	0.912	0.041	0.047	0.048	1.2	0.150	0.064	0.066	0.28	0.19
Ammonia-N	(mg/L)	1.8	<0.01	0.011	<0.01	0.01	0.72	0.022	<0.01	0.04	0.1	**12**
Total Arsenic	(mg/L)	0.1	<0.001	<0.001	0.001	0.001	0.002	0.006	<0.005	0.002	<0.002	<0.1
Bicarbonate Alkalinity ($CaCO_3$)	(mg/L)	n/a	37	48	37	38	28	31	40	42	35	40
BOD	(mg/L)	n/a	1	<1	<1	<1	11	4	1	<1.0	<2	4
Total Boron	(mg/L)	5.0	0.07	0.05	<0.03	0.04	0.11	0.172	0.082	0.092	0.077	<0.05
Total Cadmium	(mg/L)	0.01	<0.0002	<0.0002	<0.0002	<0.0003	<0.0003	<0.001	<0.001	<0.001	<0.001	<0.002
Calcium	(mg/L)	n/a	10.1	12.4	8.4	9.7	9.3	10.5	10	8.5	8.1	7.3
Carbonate Alkalinity ($CaCO_3$)	(mg/L)	n/a	<2	<2	<2	<2	<2	<2	<2	<2		<3
Chloride	(mg/L)	700	38.5	38.5	39.39	39.1	30	34.4	45	29	39	38
Total Chromium	(mg/L)	1.0	<0.001	<0.001	<0.001	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.01
COD	(mg/L)	n/a	<15	<15	<15	<15	48	12	21	11	11	12
Conductivity	(μS/cm)	1500	171	241	225	232	196	194	199	195	214	240
Total Copper	(mg/L)	0.2	0.0022	0.0009	0.0016	0.001	0.004	0.014	0.015	0.002	0.002	<0.005
Dissolved Oxygen	(mg/L)	n/a	10.21	9.45	9.56	9.05	9.7		9.4		9.4	9
Faecal Coliforms	(/100ml)	1000	240	28	200	110	**8700**	530	390	127	200	<10
Total Iron	(mg/L)	1.0	**4.4**	0.696	0.416	0.424	**1.28**	**4.5**	0.325	0.770	0.54	0.52
Total Lead	(mg/L)	0.2	0.006	0.0007	<0.0005	0.0013	0.0199	<0.005	<0.005	0.004	0.006	<0.01
Total Magnesium	(mg/L)	n/a	4.72	4.54	3.71	4.03	3.28	4	4.03	3.500	3.9	3.3
Total Manganese	(mg/L)	2.0	0.124	0.0645	0.035	0.032	0.104	0.030	0.042	0.097	0.047	0.07
Total Mercury	(mg/L)	0.002	<0.0005	<0.0005	<0.0005	<0.0002	<0.0002	<0.0002	<0.002	*<0.004*	<0.001	<0.001
Total Nickel	(mg/L)	0.2	0.0013	0.0011	0.002	<0.001	0.002	<0.005	<0.005	0.0017	<0.002	<0.005
Nitrate-N	(mg/L)	30	0.41	<0.01	0.09	0.17	0.426	1.67	<0.2	<0.2	<0.2	<0.01
pH		6.5-9.0	6.83	7	6.8	7	6.9	7.4	7.1	7.1	6.9	7.1
Phenol	(mg/L)	n/a	0.16	0.08	<0.02	0.04	0.07	0.02	<0.01	<0.1		
Potassium	(mg/L)	n/a	2.44	2.35	2.36	2.49	3.14	2.66	2.5	2.1	2.6	2.4
Sodium	(mg/L)	300	18.9	23	22.4	26.4	22.9	27	26	19	22	27
Sulphate	(mg/L)	1000	9.36	7.08	6.54	9.8	14.5	10.8	9.5	9	13.6	6.4
Total Coliforms	(/100ml)	n/a	320	170	1300	110	23000	2500	550	390	10000	2000
Zinc	(mg/L)	2.0	0.009	0.008	0.239	0.018	0.056	0.316	0.018	0.042	0.011	0.004
TPHs*	(mg/L)	n/a	nd	nd	nd	nd	nd	nd	nd		nd	nd
VOC*	(μg/L)	n/a	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
SVOC*	(μg/L)	n/a	nd	nd	nd	nd		nd	nd	nd	nd	nd

** Temperature probe not operating   nd = not detected (ie below detection limits)   ns = not sampled   Bold values exceed the guideline level

Appendix 2: Hulls Creek sediment sampling results, 2005

Sample location	Hulls Creek at Field St
Easting	2678509
Northing	6004626
Sampling date	May 2005
Units	mg/kg dry wt

Exceeds ANZECC (2000) ISQG low trigger value

Exceeds (ANZECC (2000) ISQG high trigger value

Total Recoverable Silver	0.1	Total Chlordane ((cis+trans)*100/42)	ND
Total Recoverable Arsenic	7.1	cis-Chlordane	ND
Total Recoverable Cadmium	0.16	trans-Chlordane	ND
Total Recoverable Chromium	13.4	Methoxychlor	ND
Total Recoverable Copper	27.4	Acenaphthene	ND
Total Recoverable Mercury	0.09	Acenaphthylene	ND
Total Recoverable Nickel	10.4	Anthracene	ND
Total Recoverable Lead	43.7	Fluorene	ND
Total Recoverable Antimony	0.34	Naphthalene	ND
Total Recoverable Zinc	249	Phenanthrene	0.018
Total Organic Carbon (%)	1.8	Total LMW PAH	0.018
Hexachlorobenzene	ND	Benzo[a]anthracene	0.019
Alpha-BHC	ND	Benzo[a]pyrene (BAP)	0.021
Beta-BHC	ND	Dibenzo[a,h]anthracene	0.006
Gamma-BHC (Lindane)	0.0017	Chrysene	0.027
Delta-BHC	ND	Fluoranthene	0.038
Heptachlor	ND	Pyrene	0.039
Heptachlor epoxide	ND	Benzo[b]fluoranthene	0.039
Aldrin	ND	Benzo[k]fluoranthene	0.013
Dieldrin	0.0011	Benzo[g,h,i]perylene	0.023
Endrin	ND	Indeno(1,2,3-c,d)pyrene	0.018
Endrin Aldehyde	ND	Total HMW PAH	0.244
Endosulfan I	ND		
Endosulfan II	ND		
Endosulfan sulphate	ND		
2,4'-DDE	ND		
4,4'-DDE	0.0028		
Total DDE	0.0028		
2,4'-DDD	ND		
4,4'-DDD	0.0011		
Total DDD	0.0011		
2,4'-DDT	0.0022		
4,4'-DDT	0.0067		
Total DDT	0.0089		

ND = below detection limit

Appendix 3: 2006/07 water quality investigation sites

Site no.	Site name	Easting	Northing	Equivalent site in Berry 1999
HC01	Hulls Ck u/s Rimutaka Prison	2680577	6002774	Site 1 - control
HC02	Hulls Ck u/s Freyberg Rd	2680692	6004511	Site 2 - Rimutaka Prison
HC03	Hulls Ck trib u/s Freyberg Rd	2680757	6004559	Site 3 - Rifle Range
HC04	Hulls Ck d/s CIT	2680072	6004936	Site 4 - Upstream STP
HC05	Hulls Ck u/s Pinehaven Stream	2678827	6004648	Site 6 - Upstream Pinehaven Stream
HC06	Pinehaven Stream	2678810	6004640	None
HC07	Hulls Ck d/s Pinehaven Stream	2678791	6004643	Site 7 - Downstream Pinehaven Stream
HC08	Hulls Ck u/s Tip Stream	2677377	6004330	Site 8 - Upstream Tip Stream
HC09	Tip Stream	2677361	6004330	Site 9 - Tip Stream
HC10	Hulls Ck d/s Tip Stream	2677372	6004359	Site 10 - Downstream Tip Stream

Appendix 4: Water quality guidelines

General water quality guidelines

Variable	Guideline value	Reference
Water temperature (°C)	<20	See Quinn & Hickey (1990)
Dissolved oxygen (% saturation)	≥80	RMA 1991 Third Schedule
Turbidity (NTU)	≤5.6	ANZECC & ARMCANZ (2000)
Nitrite-nitrate Nitrogen (mg/L)	≤0.444	ANZECC & ARMCANZ (2000)
Ammoniacal Nitrogen (mg/L)	≤0.021	ANZECC & ARMCANZ (2000)
Total Nitrogen (mg/L)	≤0.614	ANZECC & ARMCANZ (2000)
Dissolved Reactive Phosphorus (mg/L)	≤0.010	ANZECC & ARMCANZ (2000)
Total Phosphorus (mg/L)	≤0.033	ANZECC & ARMCANZ (2000)
E. coli (cfu/100 mL)	≤550	MfE/MoH (2003)

See Milne and Perrie (2005) for comment on some of these guidelines.

ANZECC (2000) Trigger values for Toxicants

Chemical	Level of protection (% species)	
	95%	80%
Aluminium (mg/L)	0.055	0.150
Copper (mg/L)	0.0014	0.0025
Cadmium (mg/L)	0.0002	0.0008
Chromium (CrVI) (mg/L)	0.001	0.040
Arsenic (AsV) (mg/L)	0.013	0.140
Lead (mg/L)	0.0034	0.0094
Nickel (mg/L)	0.011	0.017
Zinc (mg/L)	0.008	0.031
Ammonia (mg/L)	0.9	2.3

Appendix 5: 2006/07 water quality investigation results

Site No.	Temperature (°C)			Conductivity (µs/cm)			Dissolved Oxygen (% sat)			Dissolved Oxygen (mg/L)		
	19/12/2006	31/01/2007	13/03/2007	19/12/2006	31/01/2007	13/03/2007	19/12/2006	31/01/2007	13/03/2007	19/12/2006	31/01/2007	13/03/2007
HC01	15.7	16.4	17.7	197	196	216	98	95.5	101.4	9.75	9.35	9.66
HC02	20.7	20.9	20.4	210	214	206	106	105.5	83.5	9.5	9.42	7.52
HC03	26.3	25.9	23.6	204	201	210	85.5	95.1	111.1	6.9	7.75	9.32
HC04	20.2	20.4	20.1	209	205	206	126.3	135.7	123.8	11.45	12.25	11.2
HC05	18.8	17.3	19.0	213	208	168	103	104	91.5	9.6	9.95	8.57
HC06	15.2	15.9	17.7	208	205	190	101	99.7	98.4	10.13	9.85	9.35
HC07	16.6	17.2	18.8	209	207	177	102.4	105.5	90.5	9.98	10.1	8.4
HC08	15.2	16.9	18.2	207	202	225	121.3	108.5	92.7	12.19	10.55	8.74
HC09	15.5	16.5	17.4	234	217	284	99.1	95.5	93.6	9.86	9.35	8.96
HC10	14.7	16.7	18.1	213	205	227	110	105	92.5	11.2	10.2	8.73

Site No.	pH			*E. coli* (cfu/100mL)			Turbidity (NTU)		
	19/12/2006	31/01/2007	13/03/2007	19/12/2006	31/01/2007	13/03/2007	19/12/2006	31/01/2007	13/03/2007
HC01	7.2	7.3	8.2	290	470	1700	3.19	6.58	2.48
HC02	7.1	7.4	7.7	5800	3800	18000	9.55	8.09	7.99
HC03	6.8	6.6	7.9	2600	8800	26000	13.8	13.7	16.4
HC04	7.7	8.5	8.5	1200	1200	5100	6.87	9.23	10.4
HC05	7.4	7.7	7.8	690	1200	1200	5.99	9.04	5.98
HC06	7.4	7.5	8.2	1400	460	1500	4.99	13.1	7.15
HC07	7.3	7.6	8.1	1000	960	1500	5.83	10.7	6.53
HC08	7.7	7.4	7.6	840	340	2300	4.24	4.8	4.51
HC09	7.4	7.4	8.1	700	14000	1400	55.8	174	14.7
HC10	7.4	7.3	8.0	390	3600	2400	9.03	24.3	5.35

Site No.	Total Ammoniacal-N (mg/L)			Nitrate-N + Nitrite-N (mg/L)			Dissolved Reactive P (mg/L)			Total OrganicCarbon (mg/L)		
	19/12/2006	31/01/2007	13/03/2007	19/12/2006	31/01/2007	13/03/2007	19/12/2006	31/01/2007	13/03/2007	19/12/2006	31/01/2007	13/03/2007
HC01	< 0.01	< 0.01	< 0.01	0.093	0.056	0.064	0.006	0.008	0.008	3.6	6.2	4.2
HC02	0.03	0.02	0.06	0.099	0.088	0.105	0.027	0.026	0.036	6.8	7.7	7.3
HC03	0.03	0.07	0.14	0.007	0.005	0.038	0.048	0.062	0.057	7.2	12.4	8.1
HC04	< 0.01	< 0.01	< 0.01	0.081	0.033	0.044	0.029	0.026	0.019	6.5	8	9.2
HC05	< 0.01	0.01	0.07	0.132	0.108	0.19	0.031	0.033	0.035	6.4	7.2	11
HC06	0.03	0.02	0.04	0.068	0.086	0.136	0.013	0.015	0.005	2.9	4.8	9.8
HC07	0.03	0.01	0.13	0.114	0.105	0.207	0.026	0.025	0.016	5.8	6.7	10.4
HC08	< 0.01	< 0.01	< 0.01	0.074	0.021	0.011	0.018	0.019	0.024	5.3	6.4	5.6
HC09	< 0.01	< 0.01	0.01	0.546	0.431	0.66	< 0.004	0.006	< 0.004	5.8	7.5	7.3
HC10	< 0.01	0.01	0.01	0.117	0.059	0.071	0.015	0.013	0.023	5	6.8	5.9

Site No.	Dissolved Copper (mg/L)			Dissolved Nickel (mg/L)			Dissolved Lead (mg/L)			Dissolved Zinc (mg/L)		
	19/12/2006	31/01/2007	13/03/2007	19/12/2006	31/01/2007	13/03/2007	19/12/2006	31/01/2007	13/03/2007	19/12/2006	31/01/2007	13/03/2007
HC01	<0.0005	<0.0005	<0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0001	0.0001	< 0.0001	0.002	0.002	<0.001
HC02	0.0013	0.0011	0.0011	0.001	0.0007	0.0006	0.0006	0.0004	0.0004	0.003	0.002	0.003
HC03	0.0013	0.0021	0.0009	0.0007	0.0009	< 0.0005	0.0012	0.0024	0.001	0.008	0.016	0.002
HC04	0.001	0.0013	0.0019	0.0008	0.0007	< 0.0005	0.0005	0.0006	0.0005	0.003	0.003	0.006
HC05	0.0013	0.0019	0.0063	0.0007	0.0009	0.0009	0.0005	0.0007	0.0009	0.007	0.009	0.014
HC06	0.0011	0.0011	0.0062	0.0005	< 0.0005	0.0011	0.0002	0.0003	0.0008	0.009	0.008	0.033
HC07	0.0046	0.0088	0.0085	0.0011	0.0025	0.0013	0.0008	0.0017	0.0011	0.041	0.032	0.019
HC08	0.0009	0.0015	0.0013	< 0.0005	0.0006	< 0.0005	0.0003	0.0005	0.0004	0.005	0.007	0.003
HC09	0.0009	0.001	0.0013	0.0006	0.0005	0.0006	0.0002	0.0001	0.0005	<0.001	<0.001	<0.001
HC10	0.0009	0.0014	0.0012	0.0005	0.0006	< 0.0005	0.0003	0.0005	0.0004	0.005	0.005	0.002

Other metals sampling,19/12/2006

Site No.	Dissolved Arsenic (mg/L)	Dissolved Cadmium (mg/L)	Dissolved Chromium (mg/L)
HC01	< 0.001	< 0.00005	< 0.0005
HC02	< 0.001	< 0.00005	< 0.0005
HC03	0.001	< 0.00005	< 0.0005
HC04	< 0.001	< 0.00005	< 0.0005
HC05	< 0.001	< 0.00005	< 0.0005
HC06	< 0.001	< 0.00005	< 0.0005
HC07	< 0.001	0.00005	< 0.0005
HC08	< 0.001	< 0.00005	< 0.0005
HC09	< 0.001	< 0.00005	< 0.0005
HC10	< 0.001	< 0.00005	< 0.0005

Other parameters measured at sites HC09 and HC10

	19/12/2006		31/01/2007		13/03/2007	
	HC09	HC10	HC09	HC10	HC09	HC10
Total Suspended Solids (mg/L)		5	65	12	7	5
Dissolved Arsenic (mg/L)			< 0.001	< 0.001	< 0.001	< 0.001
Total Recoverable Arsenic (mg/L)	0.002		0.003	< 0.001	0.001	0.001
Dissolved Cadmium (mg/L)			< 0.00005	< 0.00005	< 0.00005	< 0.00005
Total Recoverable Cadmium (mg/L)	0.00006		< 0.00005	< 0.00005	< 0.00005	< 0.00005
Dissolved Chromium (mg/L)			< 0.0005	< 0.0005	< 0.0005	< 0.0005
Total Recoverable Chromium (mg/L)	0.0021		0.0023	0.0006	0.0006	< 0.0005
Total Recoverable Copper (mg/L)	0.0018		0.003	0.0019	0.0015	0.0015
Total Recoverable Nickel (mg/L)	0.0014		0.0023	0.0009	0.0009	< 0.0005
Total Recoverable Lead (mg/L)	0.0039		0.0069	0.0016	0.0022	0.001
Total Recoverable Zinc (mg/L)	0.009		0.017	0.01	0.005	0.005
Total Kjeldahl Nitrogen (mg/L)		0.3		0.4		0.2
Total Phosphorus (mg/L)		0.034		0.054		0.043
Total Nitrogen (mg/L)		0.4				0.3

Appendix 6: Macroinvertebrate sampling results

Macroinvertebrate sampling results from 19/12/06

Taxa	Total No. individuals
Aoteapsyche spp.	1
Aphrophila sp.	4
Archichauliodes diversus	11
Austrosimulium spp.	4
Collembola	4
Costachorema spp.	1
Deleatidium spp.	8
Diamesinae	4
Hydrobiosis parumbripennis	1
Hydrobiosis spp.	8
Hydrobiosis umbripennis	26
Mischoderus sp.	4
Muscidae	4
Oligochaetes	34
Orthocladiinae	116
Oxyethira spp.	4
Paracalliope spp.	11
Potamopyrgus antipodarum	469
Psilochorema spp.	1
Spaniocerca sp.	8
Tanypodinae	4
Tanytarsini spp.	26
Xanthocnemis zealandica	4
Zelandoperla spp.	1
Antipodochlora braueri	1