Mill Stream Water Quality, 2008-09

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MARLBOROUGH DISTRICT COUNCIL

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Executive Summary

The water quality of Mill Stream has been the subject of debate for several years, however very little data was available on it, making it difficult to define the state of the water quality and thus determine the degree of degradation perceived by the local community. A monitoring programme was established to determine the state of water quality in the stream. Monitoring sites were established along the length of the stream and its tributaries and sampled on a monthly basis for a year. The results establish a baseline which defines the current state of water quality.

Mill Stream is a highly prized waterway in the Marlborough region as it is the longest spring fed stream in the region. The Wairau Awatere Resource Management Plan states that the system of streams are managed for aquatic ecosystems, fish spawning and contact recreation purposes. Results show that Mill Stream has poor water quality for 6 of the 10 parameters analysed for, in particular suspended solids, turbidity, *E. coli* and nitrate. Nutrient (nitrate and phosphorus) concentrations are high which promote algal blooms and dense macrophyte growth in the stream which lead to ‘choking’ of the waterways.

It is recommended that the stream and its tributaries are fenced in their entirety in the middle and lower reaches to prevent stock access to the stream and to prevent further erosion of the stream banks; this will help to reduce the amount of suspended solids entering the system and thereby improve clarity. Riparian planting of the stream margins is also recommended as this will further stabilise the banks.

Contents

1. Introduction

Mill Stream is the commonly accepted name for the stream that enters the Wairau River just behind the Wairau Valley township. Mill Stream holds a unique position amongst Marlborough's surface waters in being the longest spring fed stream in the region. It is highly prized as a source of freshwater for both domestic and agricultural use. The Wairau Awatere Resource Management Plan classifies this system of streams as being managed for aquatic ecosystems, fish spawning and contact recreation. These waterways are recognised by DOC and Fish and Game as a valuable habitat and spawning area.

The hydrology of the stream is complex with several small ephemeral hill streams e.g. Excell Stream and Huddleston Stream, feeding into it, in addition flow is received from groundwater in the form of springs bubbling up from the stream bed. Groundwater is seen to 'bubble' up from the stream bed at various locations along its length. Studies suggest that the groundwater forming part of the base flow of Mill Stream is principally derived from the catchment of Boundary Creek (MDC, 2007).

In recent years the water quality of the stream has come under scrutiny with many complaints around the perceived deterioration of the water quality and consequently problems with the ability of some landowners to use the water.

The water quality of Mill Stream has long been an issue for debate but very little data is available on it. Some data is available on groundwater quality in the region. The water quality of the shallow groundwater closely resembles the water quality of the stream (MDC data prior to 2008). Due to the paucity of data surrounding the water quality of Mill Stream a monitoring programme was established in 2008 where 15 sites were sampled on a monthly basis along Mill Stream and its tributaries.

2. Objectives of the Survey

The objectives of the survey were:

1. To provide baseline water quality for Mill Stream by defining the current state of water quality

2. To assess seasonal changes in water quality for Mill Stream

3. To determine the state of water quality in Mill Stream by assessing against relevant water quality guidelines and classification in the Wairau Awatere Resource Management Plan

4. To identify areas of degraded water quality

5. To establish ongoing monitoring for Mill Stream

3. Catchment Description

3.1. Physical Setting

The physical characteristics of a stream at a catchment scale are largely determined by geology, source of flow, climate and land use. Mill Stream is located on the south bank of the Mid Wairau Valley (figure 1). It has a cool dry climate with an average rainfall of 1050mm per year. The rain fed tributaries (Excell Stream and Huddleston) rise at approximately 600m asl. The main stem of Mill Stream starts at an elevation of approximately 200m asl where springs first appear just south of the Wairau fault at SH63 (figure 2). Groundwater is forced up from the ground by this fault. From this point it is thought the stream low flows are principally fed by upwelling from groundwater.

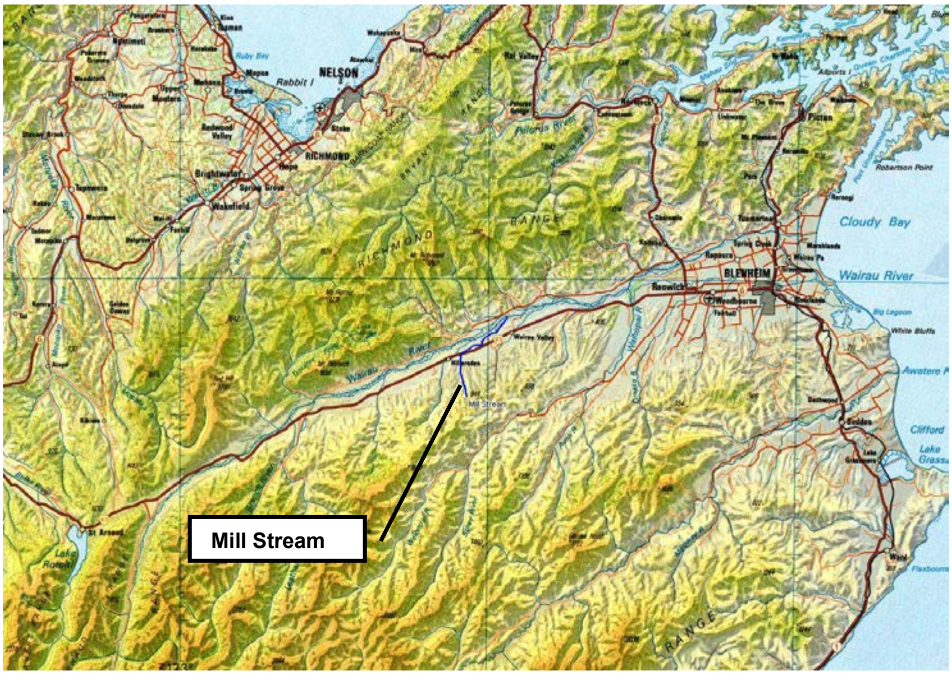


Figure 1: Location of Mill Stream in Marlborough.

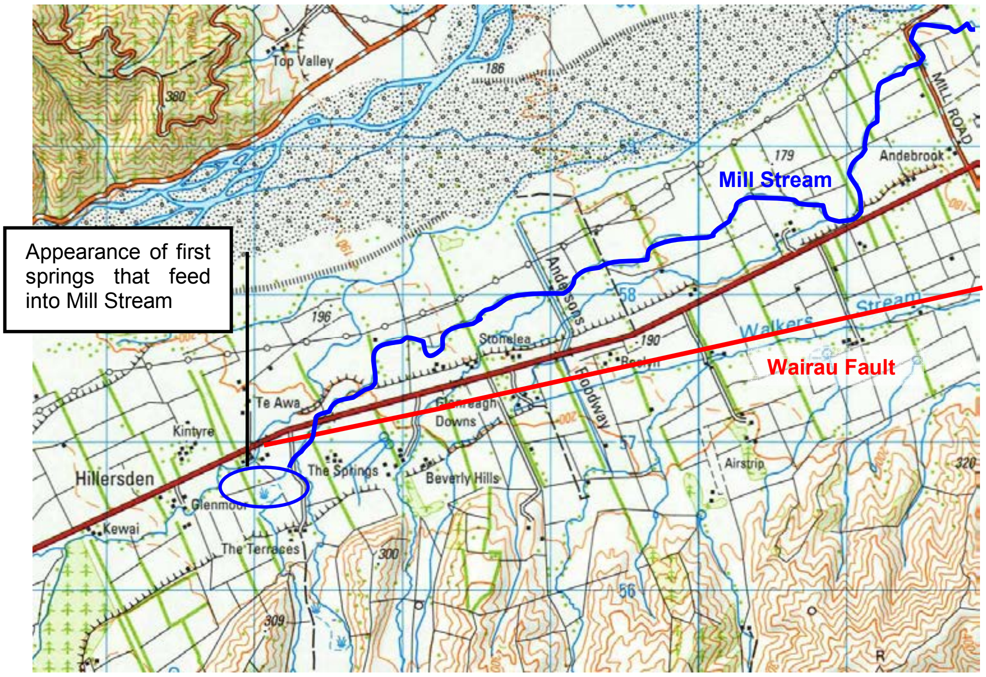


Figure 2: Location of the Wairau fault in relation to the springs feeding into Mill Stream.

Mill Stream is approximately 10 km in length. Excell and Huddleston Streams have hill country catchments of approximately 10 km^2 and 7 km^2 respectively.

3.2. Geological Setting

The underlying geology of Mill Stream and the surrounding area is comprised of hard sedimentary rock. Well sorted gravels dominate the lower reaches with clay bound gravels and minor fan deposits dominating the upper reaches (figure 3).

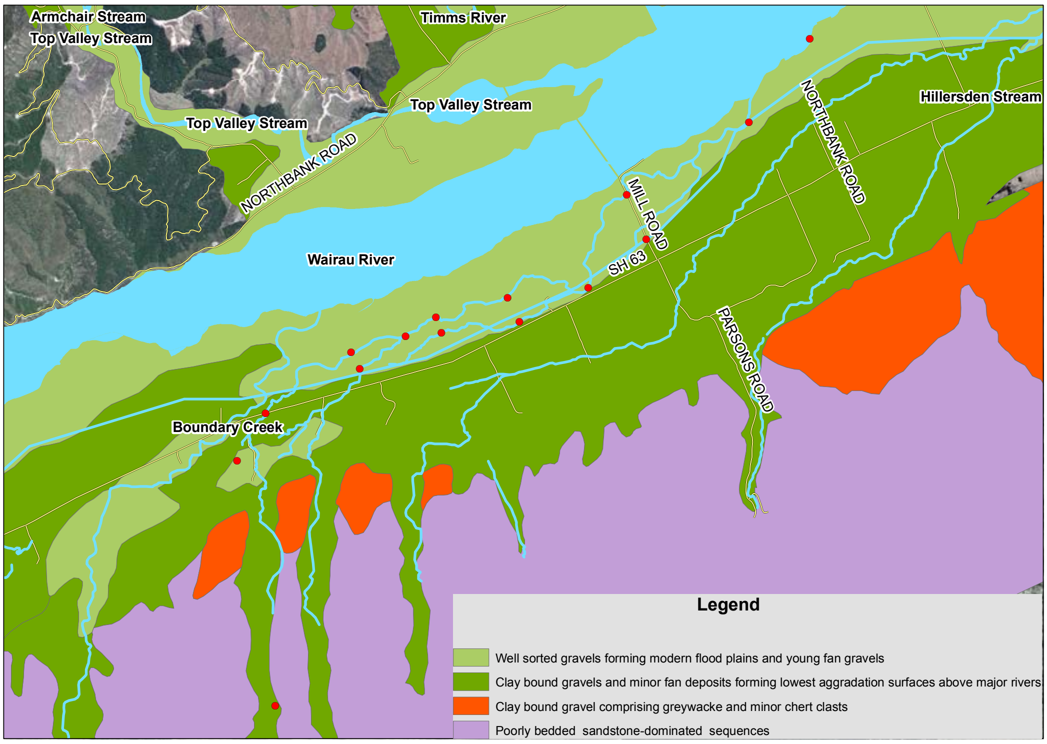


Figure 3: Underlying geology of Mill Stream, with the sites sampled during this survey marked as red points.

3.3. Hydrological Setting

The hydrology of Mill Stream is complex and as yet only moderately understood. A number of ephemeral hill streams (including Excell Stream and Huddleston Stream) feed into it but most of its summer base flow is derived from upwelling of groundwater. Groundwater convergences, where groundwater is forced to the surface by the underlying geology occurs throughout the length of the stream but is most visibly seen at Mill Road (figure 4), where the site MST-26 is located. Marlborough District Council carried out a study to help determine the source and age of the groundwater in the aquifers west of the Wairau Valley township (MDC, 2007). The report showed that the shallow groundwater is likely to be derived from the Southbank hill streams with a lesser association with the Wairau River. It is likely that groundwater feeding into Mill Stream is predominately derived from the Boundary Creek catchment and catchments further west along the valley possibly from as far west as Wye River. Groundwater flow is generally from west to east.

A permanent flow site is located at MST-21 on the lower reaches of Mill Stream; rainfall is measured at a nearby site. Rainfall and flow have been measured since 2007 and 2003 respectively. Daily rainfall totals and flow for the sampling period are shown in figure 5.

Figure 4: Groundwater convergence at Mill Road feeding into a south tributary of Mill Stream. Site MST-26 is located at the road culvert on the middle right of the photo.

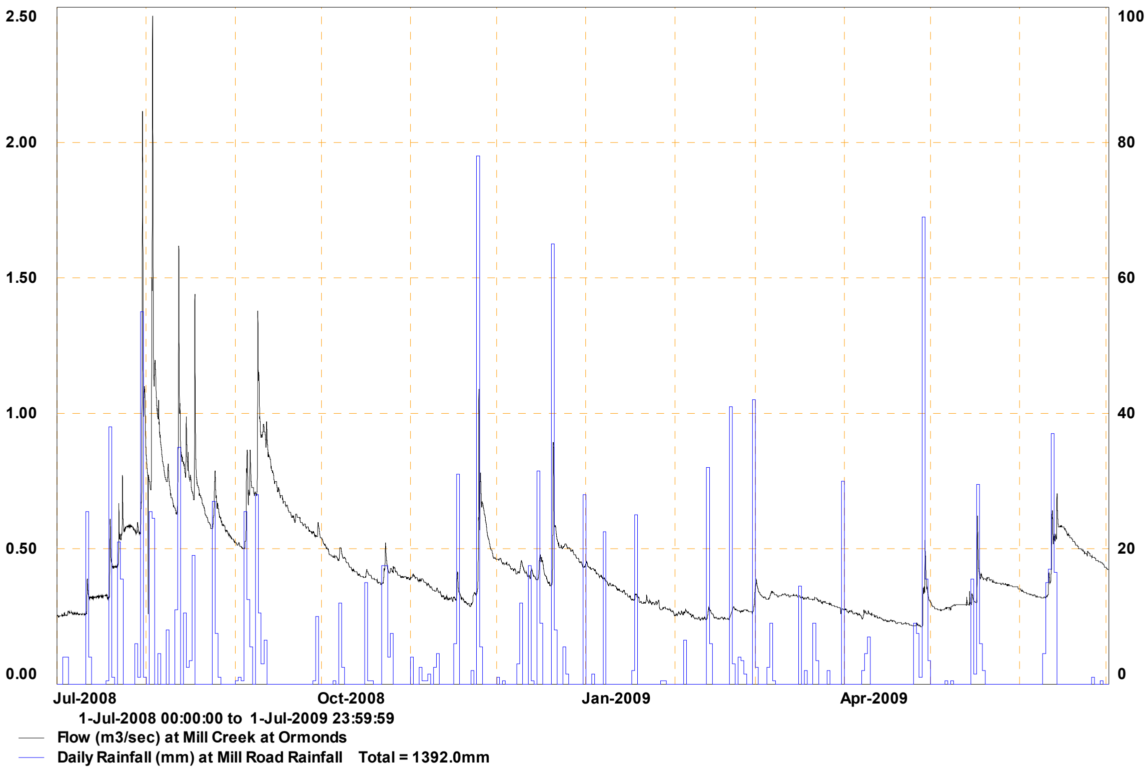


Figure 5: Mill Stream flow (m3/s) measured at MST-21 and daily rainfall (mm) for the sampling period September 2008 to June 2009.

3.4. Land Use

Exotic forestry occurs in the Southbank Hills whilst the middle and lower reaches are dominated by low intensity sheep, beef and deer farming (photos 1 -4). Vineyards occur further west up the Valley as far as Wye River. A freshwater fish farm is located in the lower reaches of the stream (downstream of site MST-21).




Photos 1– 4: Sheep, deer and beef farming on land surrounding Mill Stream.

4. Site Descriptions

Fifteen sites along Mill Steam and its tributaries were sampled on a monthly basis from September 2008 to June 2009 (Appendix 1). Sites were located in the upper, middle and lower reaches in order to give a good representation of water quality along the length of the stream. It is acknowledged that whilst the number of sites and their locations will give a good indication of how water quality changes along the length of the stream it is not an exhaustive list. All sites were sampled on the same day between 8.00 am and 2.30pm approx. Table 1 lists the names and locations of the sites. Photos of the sites are shown in Appendix 2.

Table 1: List of sites and their locations sampled during this study.

Site ID	Site Name	Location	Easting	Northing
MST-27	Excell Stream u/s	Excell stream upstream in forestry section at ford	2547569	5953891
MST-28	Excell Stream	Excell stream at pump well u/s cattle crossing	2547145	5956623
MST-20	Excell Stream	Excell Stream at SH63 bridge	2547461	5957151
MST-16	Excell Stream	Excell Stream at bridge on deer farm	2548413	5957831
MST-29	Mill Stream	Mill Stream at Anderson floodway	2549020	5958011
MST-30	Mill Stream	Mill Stream at Campbell White boundary	2549360	5958220
MST-31	Mill Stream	Mill Stream at Redwood Topp boundary	2550157	5958438
MST-7	Mill Stream	Mill Stream on Cowdreys at big tree	2551056	5958551
MST-6	Mill Stream	Mill Stream at Mill Road bridge	2551483	5959583
MST-21	Mill Stream	At MDC logger site	2552848	5960399
MST-25	Mill Stream	At MDC municipal water supply	2553523	5961326
MST-26	Mill Stream south tributary	Southern Tributary at Mill Road	2551701	5959089
HDS-1	Huddleston upper	Huddleston at footbridge	2548511	5957648
HDS-2	Huddleston mid	Huddleston at Campbell White boundary at road	2549420	5958050
HDS-3	Huddleston lower	Huddleston at Redwood Topp boundary	2550290	5958170

5. Sampling Procedure

Water samples were taken every month and stored in containers supplied by Environmental Laboratory Services Ltd. (ELS). These samples were sealed in the field and stored in chilli bins with ice packs; the ice packs were replaced with fresh ice-packs prior to being courier overnight to ELS. In addition, dissolved oxygen and temperature were measured in the field using a YSI hand held field meter. The meter was calibrated each month prior to being used in the field. Each month a photograph was taken at each of the sites in order to build a record over the year of how conditions at the site changed from month to month.

ELS carried out the following analyses for each sample: pH, suspended solids, specific conductivity, turbidity, faecal coliforms, *E. coli*, nitrite nitrate nitrogen, nitrate nitrogen, ammonia and dissolved reactive phosphorus. Stream flows and rainfall were recorded at Marlborough District Councils telemeted site at MST-21. Flows and rainfall have been measured at this site since April 2003 and January 2007 respectively.

Monthly sampling has continued at MST-21 and is now part of the State of the Environment monitoring programme. MST-21 was chosen as an SoE site because of its location towards the bottom of the catchment and more specifically because flow and rainfall is being continuously monitored at the site.

6. Results

The results for the water quality parameters measured during this investigation are assessed spatially, temporally and in relation to various relevant water quality guidelines. The following parameters are assessed:

- pH
- Suspended Solids
- Specific Conductivity
- Turbidity
- E. coli
- Nitrate Nitrogen
- Ammonia Nitrogen
- Dissolved Reactive Phosphorus
- Dissolved Oxygen
- Temperature

6.1. pH

The pH of the stream varies considerably along the length of the stream; however the mean values are generally within the ANZECC guideline range for aquatic life (figure 6). The lowest pH was observed at MST-28 and MST-26 where the range was slightly below the ANZECC guidelines for aquatic life protection. These two sites are situated in areas of groundwater convergence where the stream water is forced to the surface and thus the chemistry of the water will closely reflect that of the shallow groundwater. This effect is also seen at MST-7 where groundwater is visibly seen bubbling up from the surface. Groundwater from the Wairau Valley aquifer and upper aquifer has a low pH reflecting its young age, it is estimated that the mean residence time is less than two years (MDC, 2007).

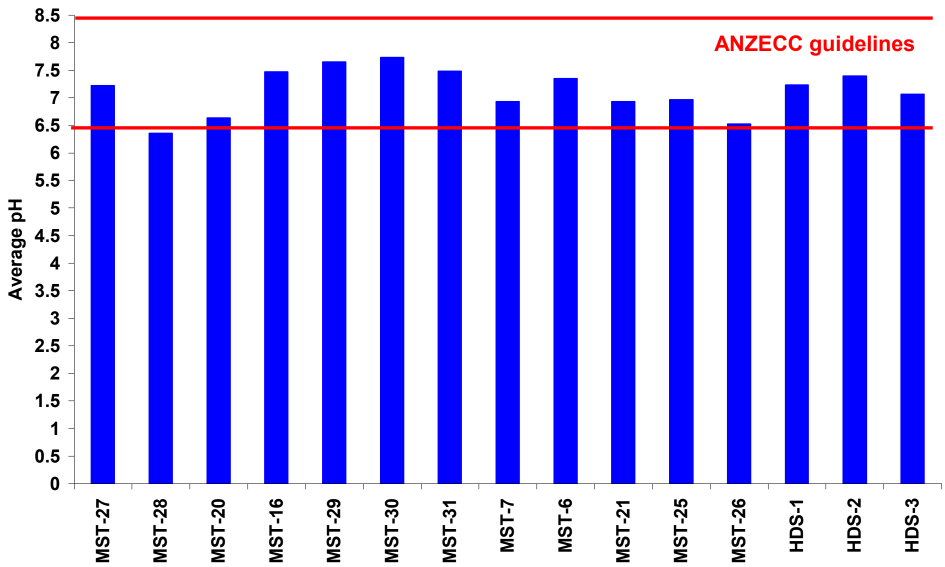


Figure 6: Mean pH recorded at each site over the sampling period.

pH shows a seasonal variation with lower pH's being observed in summer than in winter (figure 7). This is most likely due to flows in the stream being dominated by groundwater flow in the summer. Winter flows in Mill Stream are likely to be more influenced by surface water flows from the Southbank Hills tributaries.

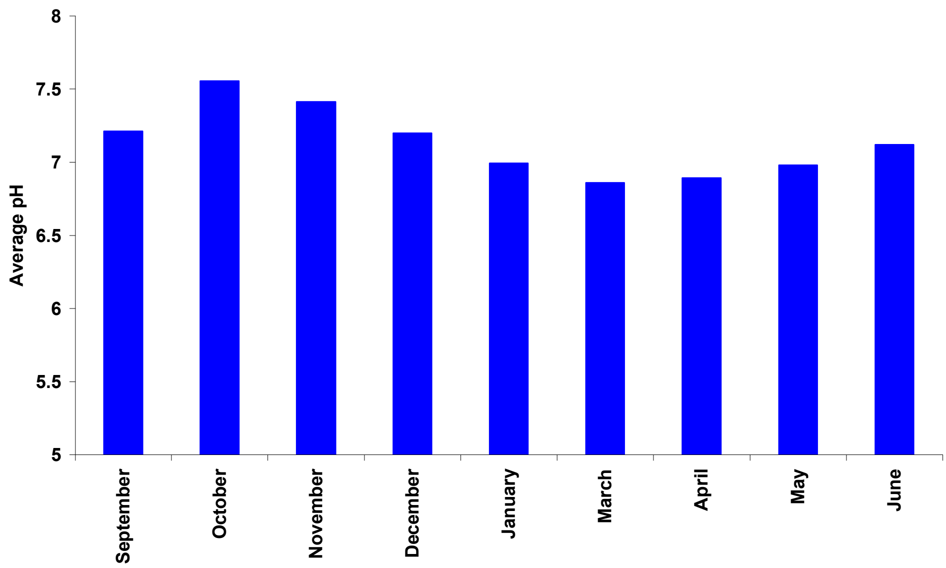


Figure 7: Mean pH recorded each month during the survey.

6.2. Suspended Solids

There is a very distinctive longitudinal variation of suspended solids concentrations from upstream to downstream (figure 8). The highest concentrations are seen in the middle reaches (MST-16 to MST-7 and HDS-1 to HDS-2), however silt and mud were observed to cover the rocky substrate from MST-28 to MST-25. Due to the natural character of the stream (low lying and slow flowing) it will take longer to flush out sediment generated within the system. The low elevation character of the stream means that where suspended solids are generated (from for example stream bank erosion) they will be slowly washed downstream or deposited nearby. Extensive macrophyte growth along the stream will also retard the transport of suspended solids downstream. The streams are fenced in parts along their length, however, due to the susceptible nature of the stream, the stream and its tributaries would need to be entirely fenced along the middle and lower reaches in order to prevent erosion of its banks and clogging of the streambed with silt and mud. HDS-2 has the highest mean suspended solids concentrations.

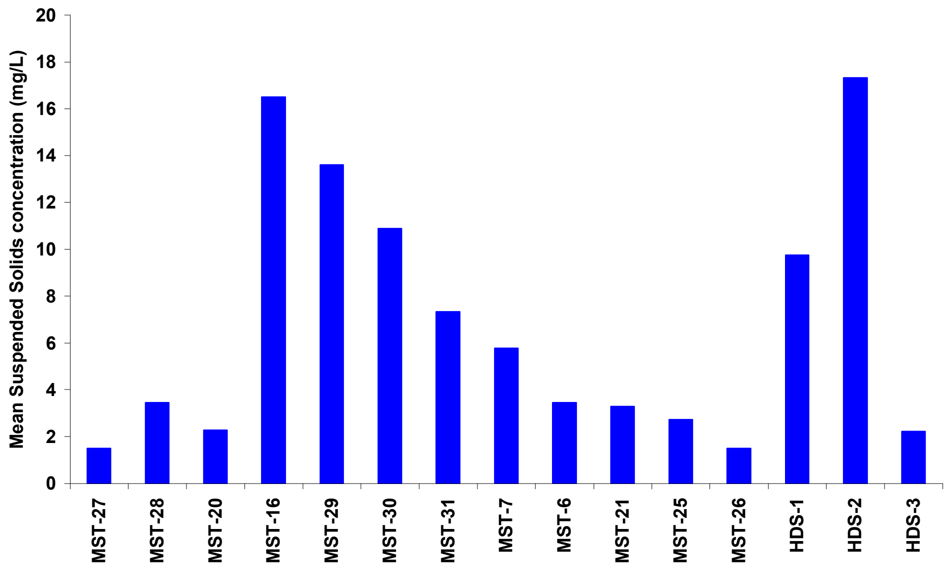


Figure 8: Mean suspended solids concentrations recorded at each site over the sampling period.

There is also a distinct seasonal variation in suspended solids concentration with highest concentrations occurring in winter (figure 9). This is the time of greatest rainfall and where stream banks are unstable and/or unprotected this will also be the time when they are most susceptible to erosion. The velocity of the water will have a major influence on the distribution of fine sediments in the streambed.

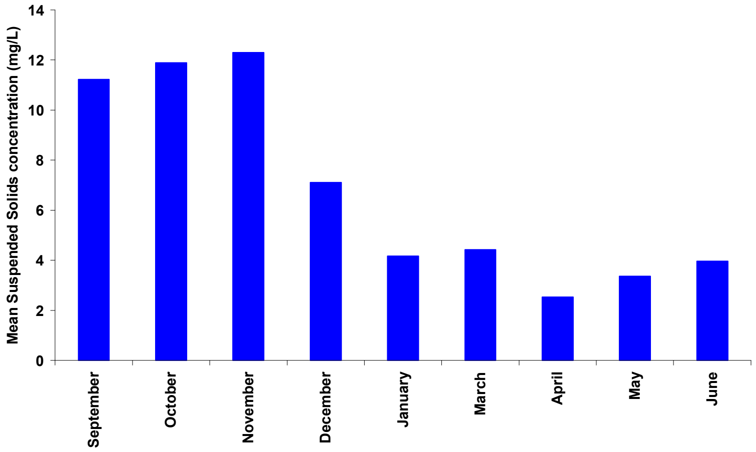


Figure 9: Mean suspended solids concentration recorded each month during the survey.

There are no guidelines for suspended solids in New Zealand. The Freshwater Fish Directive of the European Union sets a standard of 25mg/L suspended solids as maximum value, except in exceptional circumstances such as floods and droughts, whilst the Canadian guidelines state that the change in suspended solids concentration should not exceed 10mg/L (CCREM, 1991). The above guidelines are primarily based on adverse effects to sensitive aquatic life. Suspended solids concentrations regularly exceed the European and Canadian guidelines particularly in the middle reaches of Mill Stream.

6.3. Specific Conductivity

Conductivity is primarily a function of the underlying geology but the addition of contaminants may also raise the conductivity of streams and rivers. Conductivity varies with temperature, therefore specific conductivity (which is conductivity measured at 25°C) is measured to ensure comparisons between sites and over time. The higher conductivity values from MST-20 to MST-31 and HDS-1 to HDS-3 (the middle reaches of the streams) could be as a result of contaminants entering the streams at these locations (figure 10). Figure 3 shows that there is a difference in the geology just north of the Wairau fault, which may also account for the differences in conductivity.

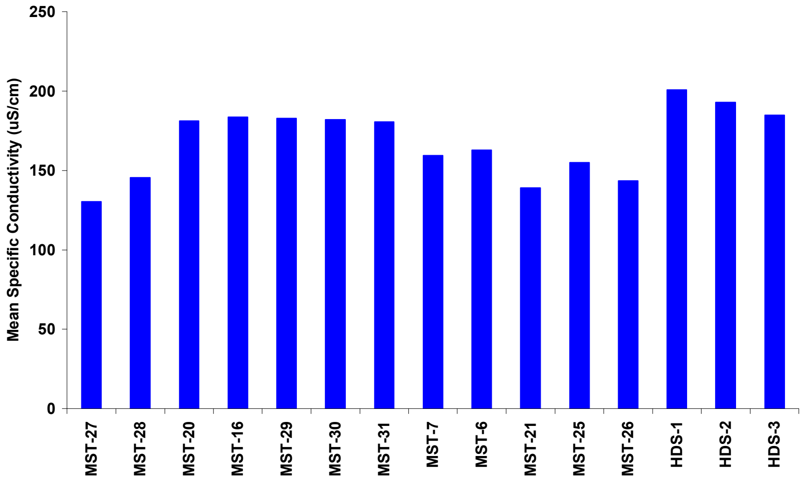


Figure 10: Mean conductivity recorded at each site over the sampling period.

Conductivity is slightly elevated during the winter, possibly as a result of rainfall washing contaminants into the stream or contaminants percolating through the ground into the groundwater, however the difference is only slight (figure 11).

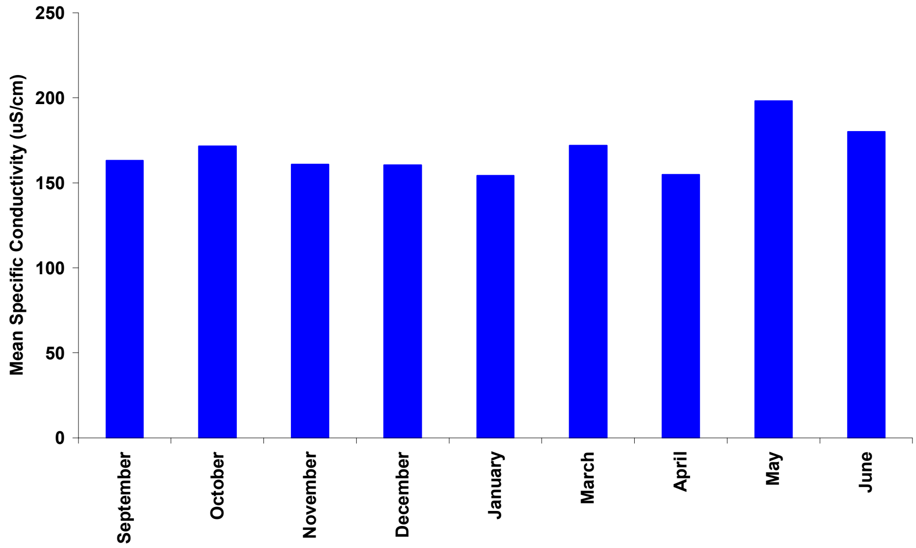


Figure 11: Mean conductivity recorded each month during the survey.

No guidelines exist for conductivity as values will be different for every river. Freshwater needs to become highly saline (up to 1500µS/cm) in order for adverse effects on aquatic biota to occur (Hart *et al*, 1990, 1991). Conductivity is not expected to change much over time and therefore it is a useful parameter to measure in order to monitor long term changes in water quality.

6.4. Turbidity

Turbidity is a measure of light reflectance in water and is a useful measure of water clarity. Turbidity is often highly correlated with suspended solids. Figure 12 shows the mean turbidity levels measured for each site, the values are highly correlated with the suspended solids concentrations as seen in figure 8.

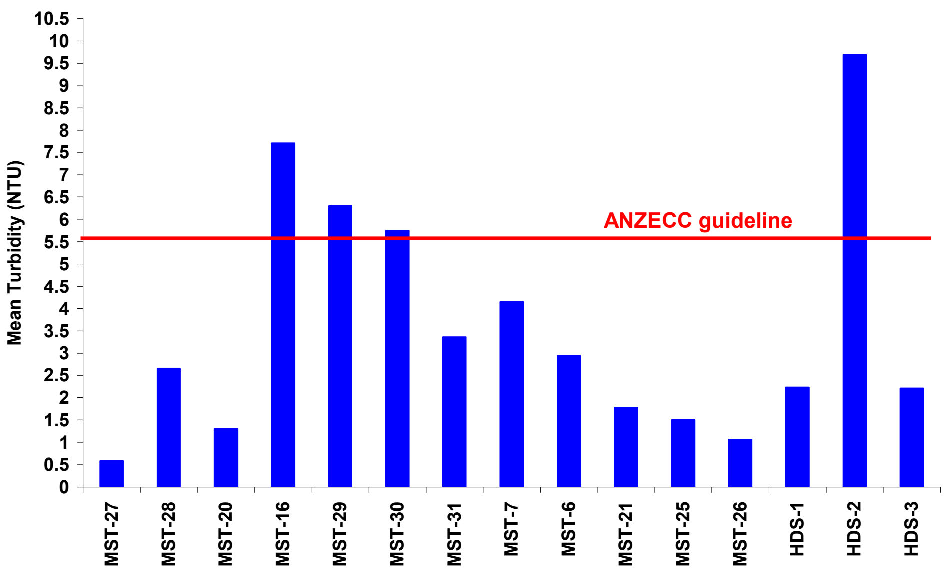


Figure 12: Mean turbidity recorded at each site over the sampling period.

The highest turbidity measurements are from MST-16 to MST-30 and at HDS-2. The ANZECC guidelines give a guideline level for turbidity for lowland rivers of 5.6 NTU. Four of the sites fail these guidelines all year round (figure 12).

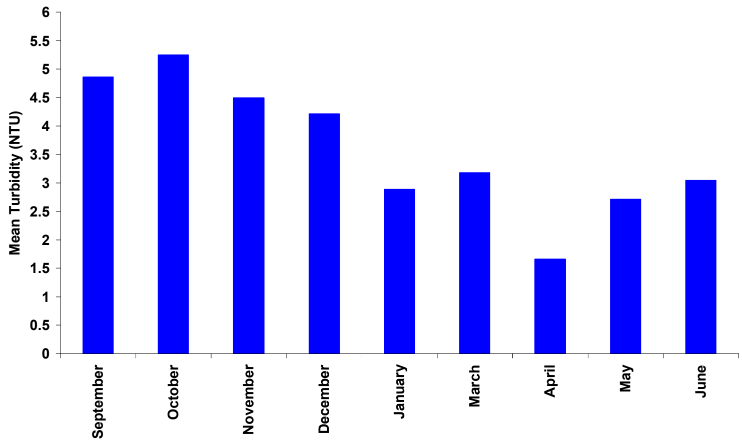


Figure 13: Mean turbidity recorded each month during the survey.

The seasonal pattern for turbidity is similar to that seen for suspended solids, with higher winter/spring levels (figure 13).

6.5. E. coli

The primary source of *E. coli* in the stream is from stock (sheep, beef and deer) being grazed in the fields. *E. coli* will enter the waterway in two ways, surface water runoff from fields and directly when stock enter waterways and defecate directly into the water. Fencing a waterway will prevent the latter, whilst having a riparian margin strip of at least several metres will help to retard the transport of contaminants from surface water runoff. There is a distinct spatial variation in *E. coli* numbers along the length of the stream with the middle reaches from MST-28 to MST-7 and MST-26 and HDS-2 having the highest numbers (figure 14).

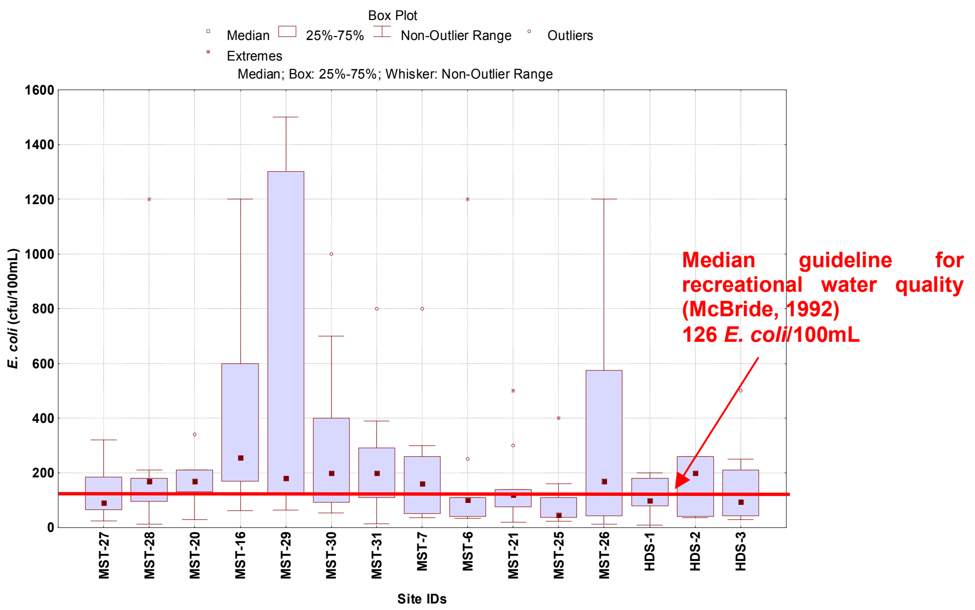


Figure 14: Summary statistics for *E. coli* at each site sampled during the survey. The plot shows the median *E. coli* number (red square), upper and lower quartile numbers (blue box) and the 95%ile (non-outlier) range. The plot does not include all outliers and extremes as this would have skewed the plot.

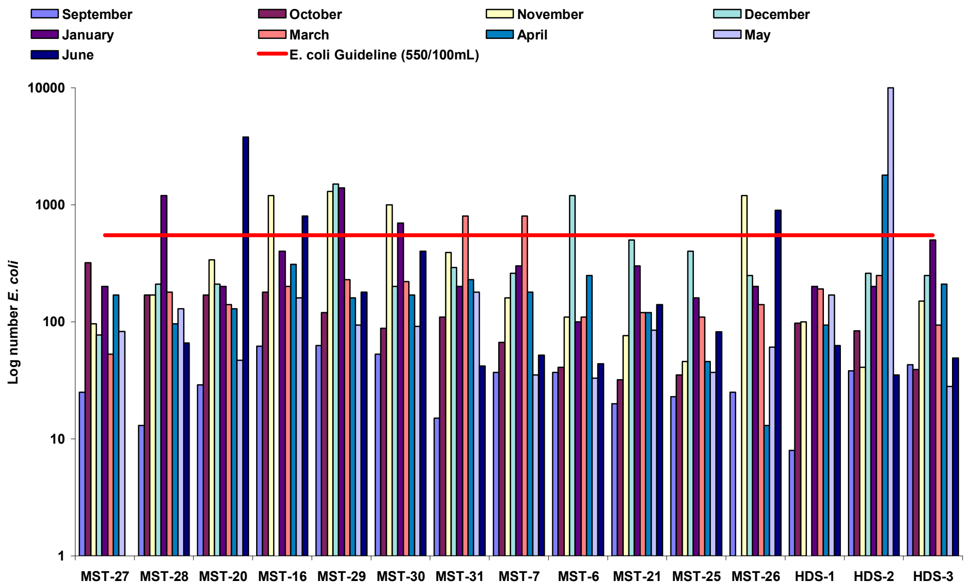


Figure 15: *E. coli* numbers for each site during the sampling period in relation to MfE's contact recreation guideline for *E. coli* (550 *E. coli*/100mL).

Guidelines for bacterial contamination of waterways usually relate to contract recreational values and stock drinking water as the presence of *E. coli* alone does not have a detrimental effect on the aquatic ecology of waterways. These guidelines are as follows:

- ANZECC (2000) stock drinking water guideline (median) 100 *E. coli*/100mL
- Ministry for the Environment contact recreational guideline 550 *E. coli*/100mL
- Median guideline for recreational water quality (McBride, 1992) 126 *E. coli*/100mL

Under the Wairau Awatere Resource Management Plan, Mill Stream is managed for contact recreation purposes, for this reason the Ministry for the Environments guideline of 550 *E. coli*/100mL (from a single sample) applies. A median guideline of 126 *E. coli*/100mL gives an indication of how likely a stream is to comply with the contact recreation guideline of 550 *E. coli*/100mL over a sampling period.

Figure 15 shows that MfE's contact recreation guideline was exceeded a total of 16 times during the sampling period. Exceedances occurred from MST-28 to MST-6 and at MST-26 and HDS-2 (figure 15). Figure 14 shows that the median bacteria numbers at these sites are also above the median guideline for contact recreation as described above. Increases in *E. coli* numbers are often associated with rainfall events as contaminants are washed from the land into waterways. Four of the exceedances occurred in dry weather these occurred at MST-20, MST-16, MST-26 and HDS-2.

The ANZECC guideline for stock drinking water is less than that for contact recreation (100 *E. coli*/100mL as a median value). 10 if the 14 sites sampled exceeded this guideline.

There is a distinct seasonal variation in the median *E. coli* numbers, with the highest numbers occurring during the summer months (figure 16) when the lowest rainfall was recorded (table 2) and the lowest occurring in the winter and spring months.

Table 2: Monthly rainfall totals recorded at MDC's telemetered hydrology site.

	September	October	November	December	January	March	April	May	June
Monthly rainfall total (mm)	104	77.5	138.5	183	52	75.5	119	55.5	91.5

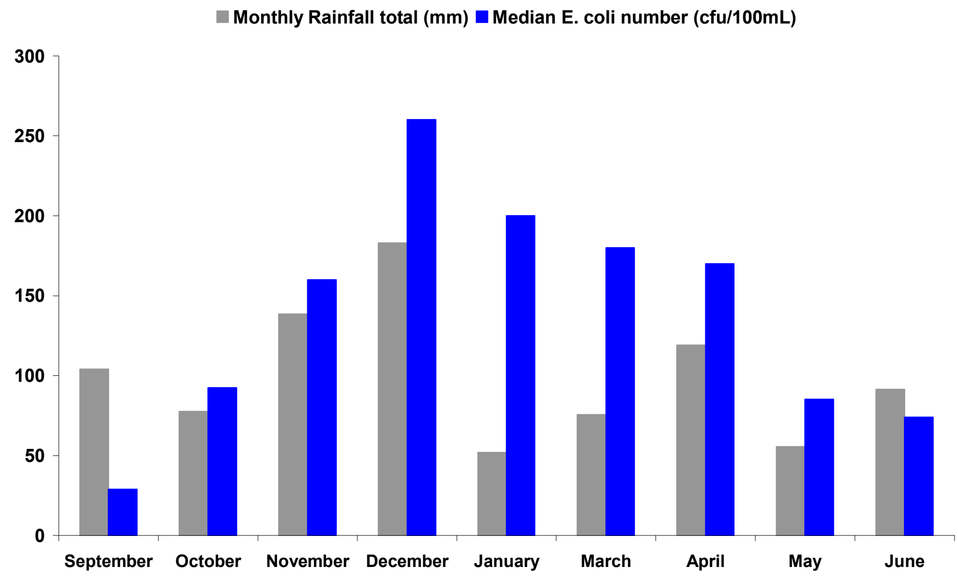


Figure 16: Monthly variation in *E. coli* numbers.

6.6. Nitrate Nitrogen

Nitrate concentrations show an interesting spatial pattern (figures 17 and 18). The upstream site MST-27 has a negligible concentration and is typical of that seen in upland rain fed streams in Marlborough. Nitrate concentrations increase sharply at MST-28, where the highest average nitrate concentrations are recorded; this is also where groundwater starts to have a major influence on the hydrology of the stream. MST-20, located just downstream of MST-28 has lower nitrate concentrations with similar concentrations being observed along the length of Mill Stream until MST-7. A small increase in nitrate concentration occurs at MST-21 and persists until the outlet at MST-26. This increase may be due to the increased volumes of groundwater entering the stream in these lower sections.

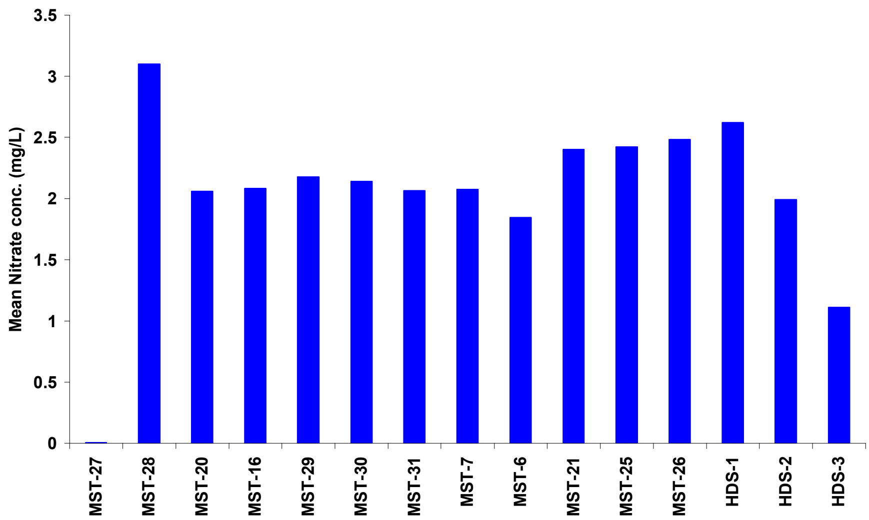


Figure 17: Mean nitrate concentrations recorded at each site over the sampling period.

These results suggest that groundwater has a major influence on the nitrate concentrations of Mill Stream, it is uncertain where the groundwater flow originates from but it is likely that the water catchment of Boundary Creek has a major influence on groundwater volumes and consequently the water quality of Mill Stream (McCarthy, 2008). In addition land practices from as far west as Wye River may also influence the groundwater quality in this area.

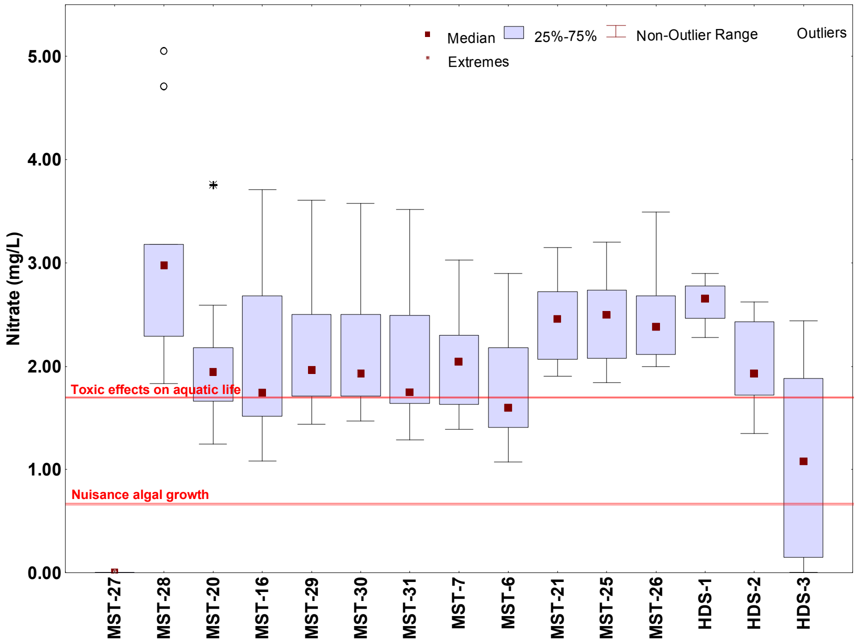


Figure 18: Summary statistics for nitrate concentrations for each site monitored during the investigation.

Figure 18 shows the summary statistics for each of the sites monitored. All sites with the exception of MST-27 and HDS-3 have similar distribution patterns. MST-27 is not influenced by groundwater in the Wairau Valley and can be characterised as a predominately rain fed stream. HDS-3 shows similarities between a rain fed system and a spring fed system having the broadest range of nitrate concentrations showing perhaps that it is equally influenced by surface water runoff (i.e. rain fed) and groundwater flow (i.e. spring fed).

The mean nitrate concentration for the sites is between 2 and 2.5mg/L. A mean annual nitrate concentration of 2mg/L is high in relation to others rivers and streams in Marlborough. Figure 19 compares the nitrate concentrations for the 34 state of the environment river monitoring sites. Doctors Creek, the Kaituna River and the Taylor River have the next highest nitrate concentrations, all of which are predominately low lying catchments dominated by pasture and/or crops. Spring Creek and Murphys Creek are two other spring fed streams situated in the Wairau Valley, both of which have significantly lower nitrate concentrations than that seen for Mill Stream.

All except two of the sites monitored in Mill Stream are above the ANZECC guideline for lowland streams for the prevention of nuisance algal growth (0.667mg/L) for 100% of the time (figure 18), in addition these sites are also above the nitrate concentration considered to be toxic to aquatic life (1.7mg/L) (Hickey and Martin, 2009). Increased nutrients will result in nuisance algal blooms as frequently observed in Mill Stream and in addition the amount of suspended sediment being generated within the system and being deposited on the stream bed will encourage nuisance macrophyte growth resulting in the 'choking' of the stream, again, as frequently observed in Mill Stream.

The Wairau Awatere Resource Management Plan classifies Mill Stream as fish spawning habitat. The continual exceedance of the nitrate toxicity threshold will mean that fish and other aquatic life will be adversely affected.

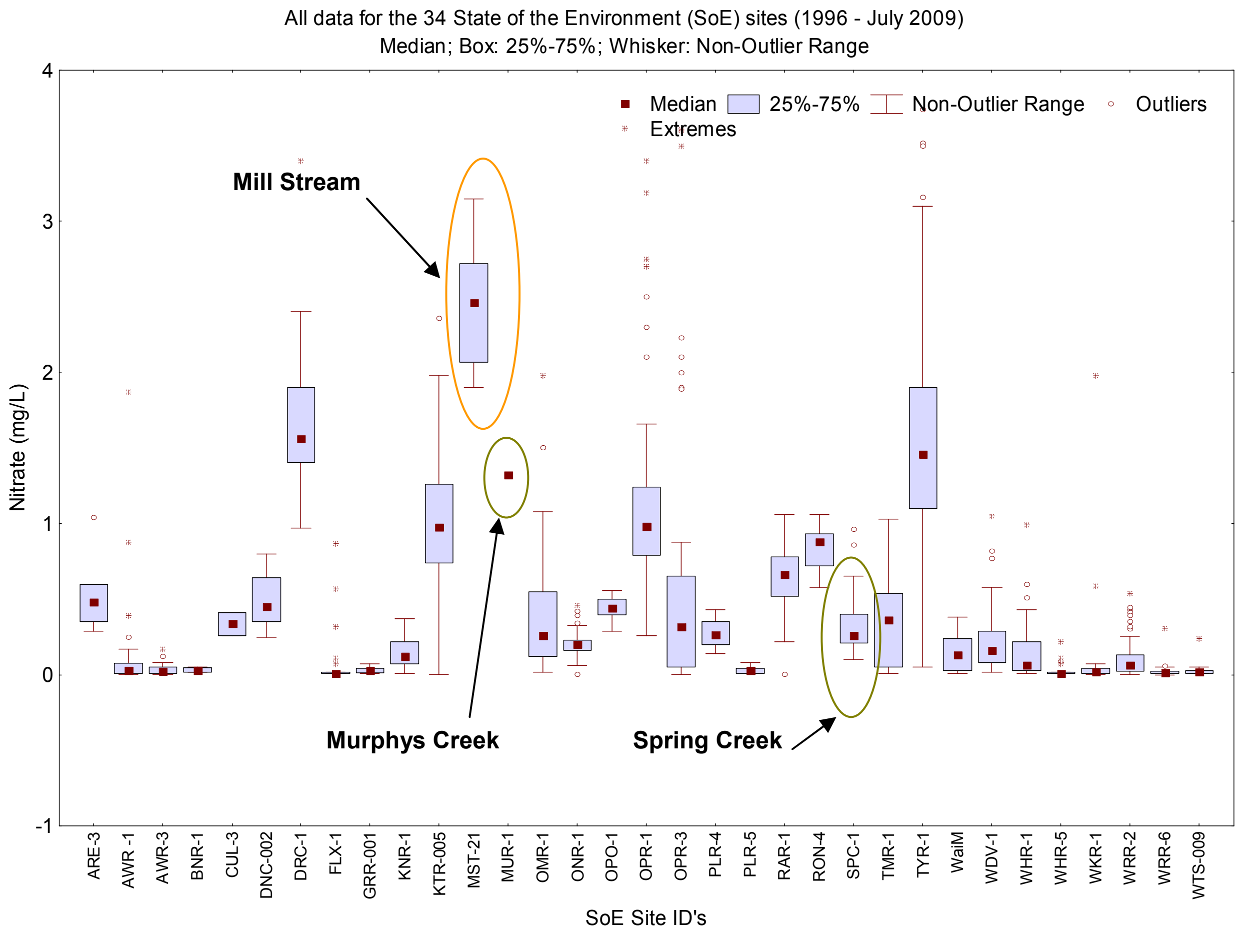


Figure 19: Comparison of nitrate concentrations for the river sites monitored in the Marlborough region. The site locations and site names are shown in Appendix 3.

Nitrate concentrations show a very distinctive temporal pattern, with increased concentrations recorded in winter and spring and lowest concentrations recorded in summer and autumn. This is a pattern often seen in rivers and streams in New Zealand. Figure 20 shows the mean concentrations for all sites combined for the sampling period.

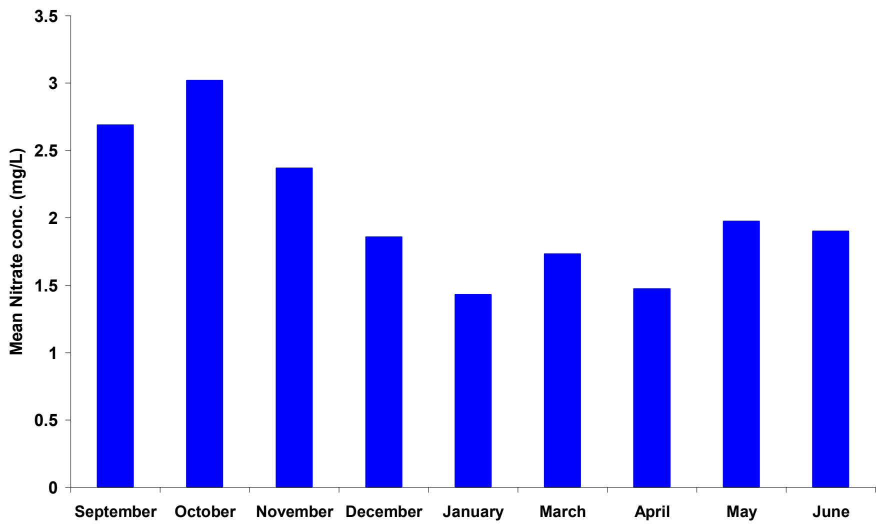


Figure 20: Mean nitrate concentrations recorded each month during the survey.

6.7. Ammonia Nitrogen

Figure 21 shows the spatial pattern of mean ammonia concentrations measured at each site. Mean ammonia levels are elevated at MST-28, MST-16 and HDS-2, especially when compared with other rivers and streams in Marlborough, where 97% of monitored sites have lower ammonia concentrations to those measured at MST-28, MST-16 and HDS-2 (figure 22). All other sites monitored along Mill Stream show similar results to those monitored at 97% of SoE sites.

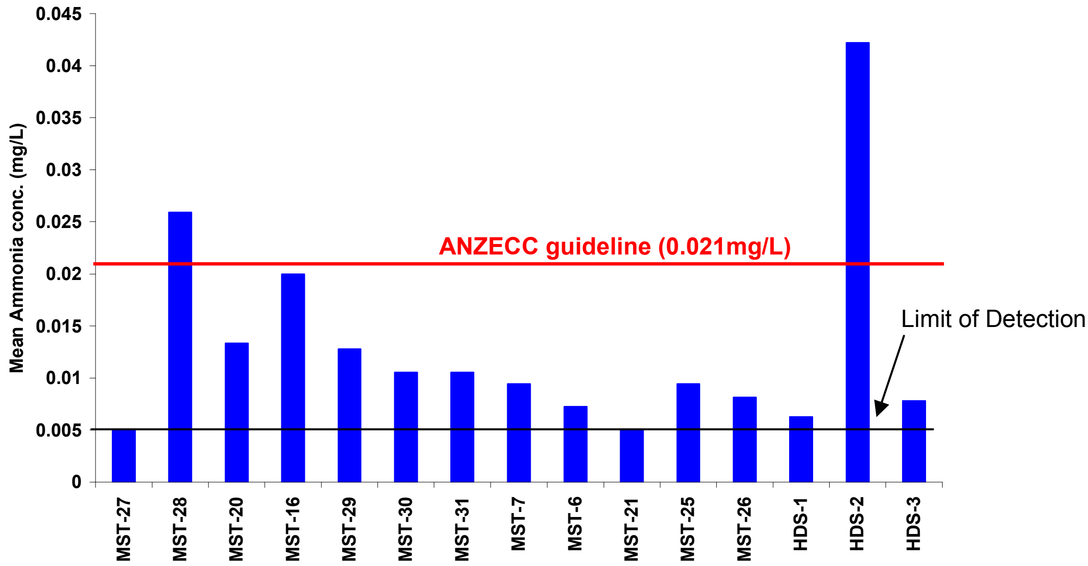


Figure 21: Mean ammonia concentrations recorded at each site over the sampling period.

The lowest ammonia levels were recorded at MST-27 and MST-21 where all samples were below the limit of detection (figure 21). Ammonia levels are elevated in the middle reaches of the stream and also downstream of the fish farm. It is likely that stock access to the stream and discharge from the fishfarm is responsible for these elevated levels; however ammonia concentrations are only a concern at MST-28, MST-16 and HDS-2 where concentrations are particularly high, regularly exceed the ANZECC guidelines and are likely to cause stress to aquatic life. HDS-2 has particularly poor water quality with regard to ammonia concentrations.

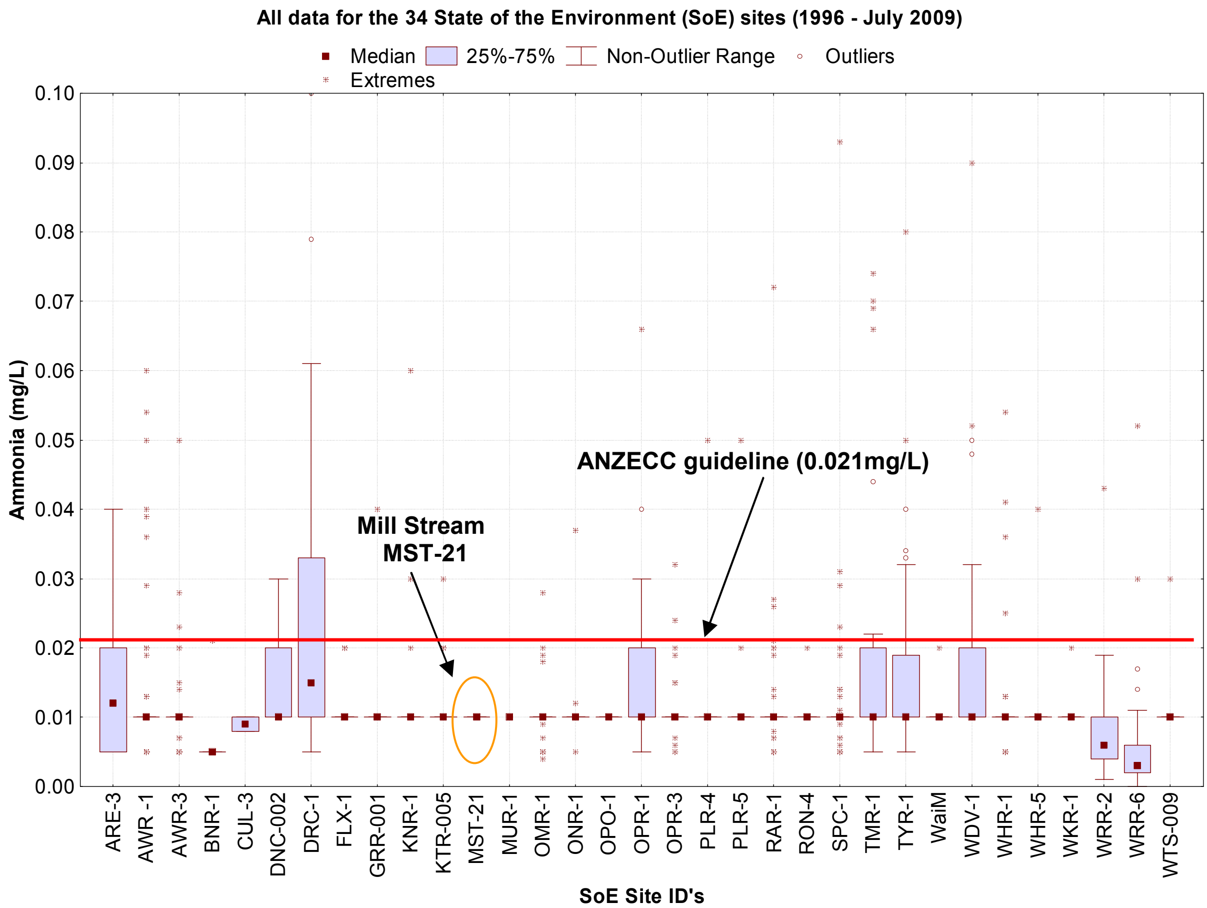


Figure 22: Comparison of ammonia concentrations for the river sites monitored in the Marlborough region for State of the Environment (SoE) reporting. The site locations and site names are shown in Appendix 3.

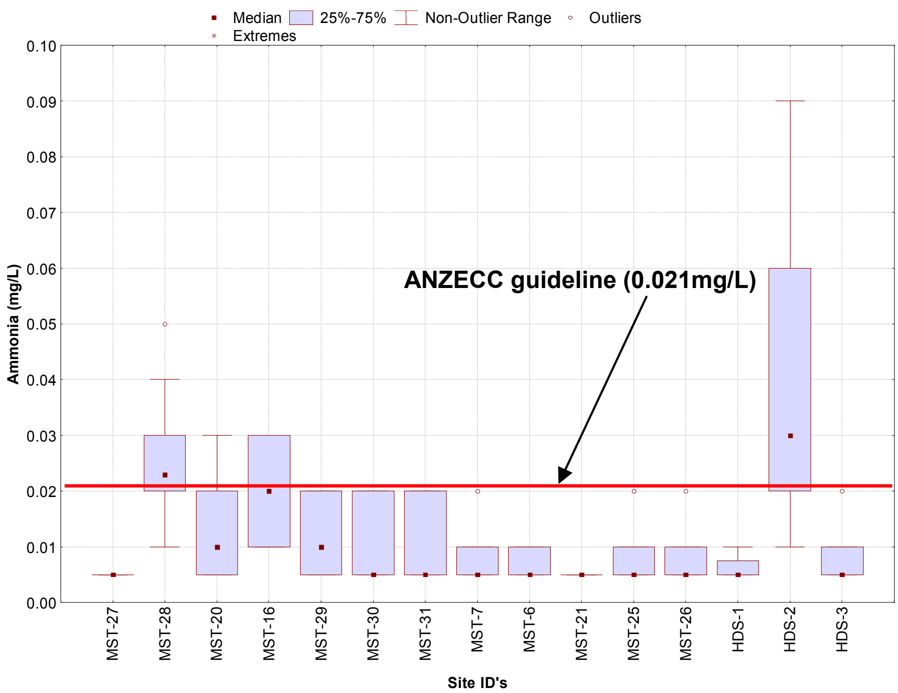


Figure 23: Summary statistics for ammonia concentrations measured along Mill Stream and its tributaries.

Ammonia levels are slightly more elevated in winter (figure 24); this is a similar pattern to that observed at many rivers and streams in New Zealand. However, the seasonal variation in ammonia concentrations is not as marked as that seen for nitrate.

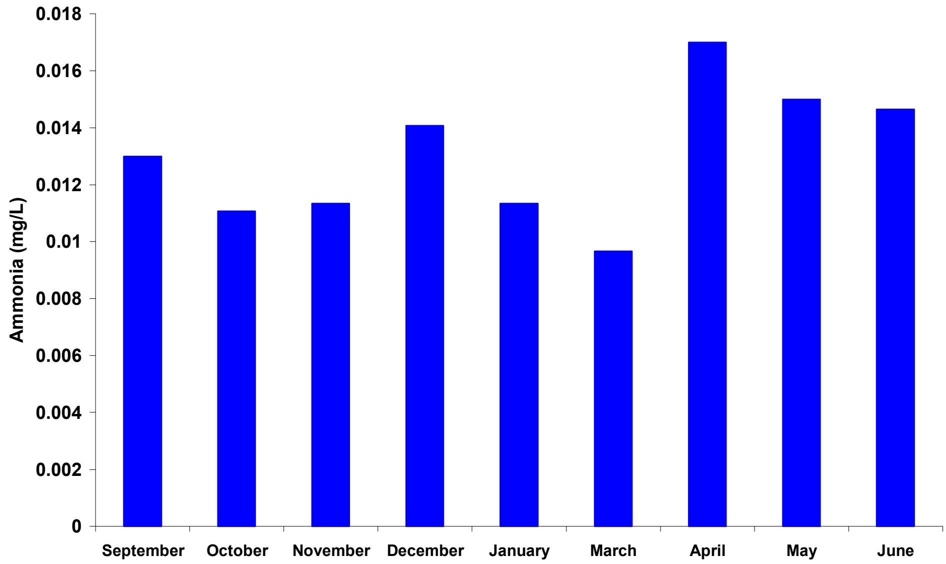


Figure 24: Mean ammonia concentrations recorded each month during the survey

6.8. Dissolved Reactive Phosphorus

DRP shows a very different spatial pattern to that observed for nitrate, whereby the highest concentrations are at the top of the catchment at MST-27 and MST-28. MST-27 had negligible concentrations of nitrate. It is likely that top dressing of phosphorus in the hill country and the natural geology of the catchment is responsible for DRP concentrations.

There is a small but discernible decrease in DRP from the upper to the lower catchment; with a dramatic decrease in DRP at HDS-3 (figure 25), possibly as a result of a settlement pond installed upstream. Suspended solids, turbidity and nitrate levels all have reduced in levels/concentration at HDS-3, possibly due to the presence of the pond. Discussions with the land owner confirm that the pond is regularly desludged.

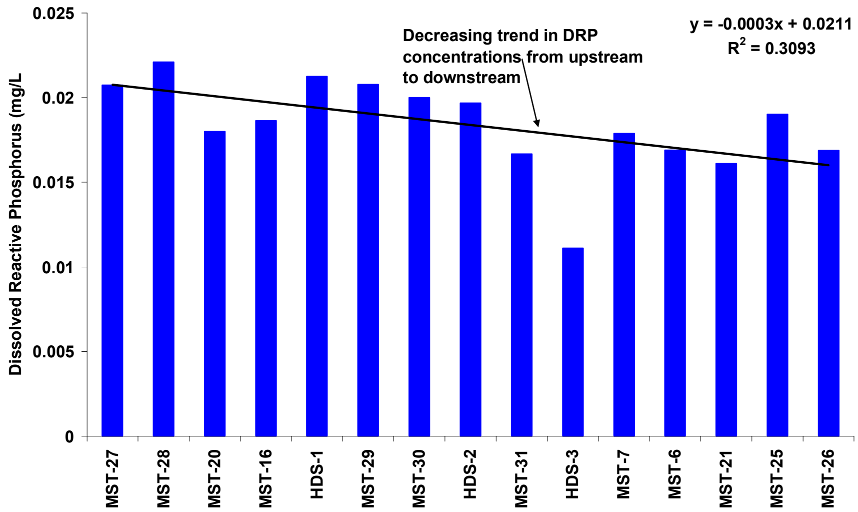


Figure 25: Mean DRP concentrations recorded at each site over the sampling period.

DRP can enter waterways through subsurface or overland flow. Increasing concentrations coinciding with increased flow/rainfall can be indicative of diffuse sources of DRP whilst decreasing concentrations with increasing flow can be indicative of point sources of DRP. Appendix 4 compares DRP concentrations with rainfall at each of the sampling sites for each sampling occasion. DRP concentrations at MST-27, MST-31 and HDS-1 show a strong correlation with rainfall suggesting diffuse inputs of DRP, whilst DRP concentrations at MST-28, MST-20 and MST-16 show a negative correlation with rainfall suggesting point sources of DRP. DRP concentrations at the remainder sites do not show strong positive or negative correlation with rainfall and it is considered that both overland and subsurface flow contribute equally to DRP concentrations.

Dissolved Reactive Phosphorus (DRP) concentrations are higher in spring (figure 26), typically the wettest part of the year. On average the DRP levels are twice the ANZECC guideline level for lowland streams. In general the DRP concentrations are slightly above those recorded at the 34 SoE sites.

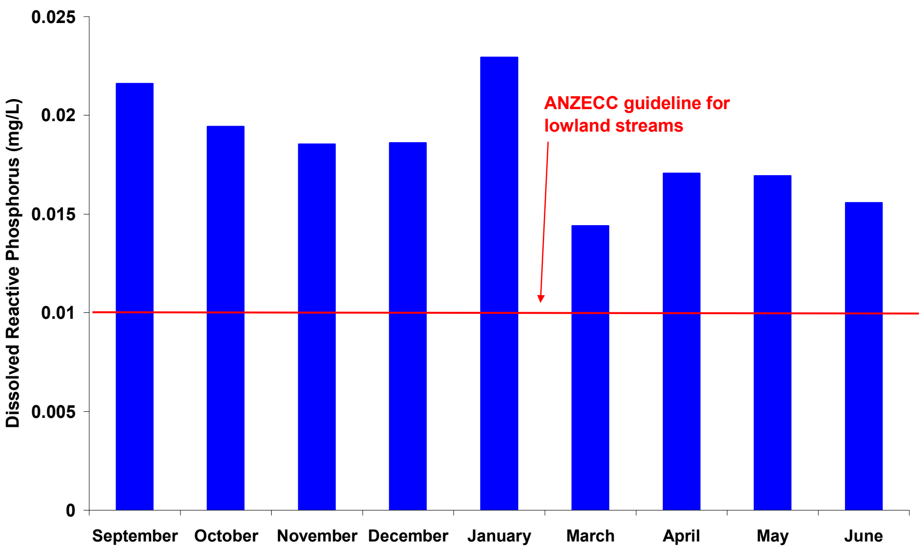


Figure 26: Mean DRP concentrations recorded each month during the survey.

6.9. Dissolved Oxygen

Dissolved oxygen levels are low at MST-28, MST-20, MST-26 and HDS-3 (figure 27). It is likely that the low oxygen levels at MST-28 and MST-26 are a result of oxygen deficient groundwaters upwelling to the surface. The low oxygen concentration at MST-20 is likely due to the low oxygen levels observed upstream at MST-28. Low oxygen levels at HDS-3 could be a result of low oxygenated waters leaving the pond upstream of the site. During warm dry weather oxygen levels in ponds are known to decrease, this can impact on the water quality of rivers and streams for hundreds of metres downstream from where they discharge (Maxted and McCready, 2005).

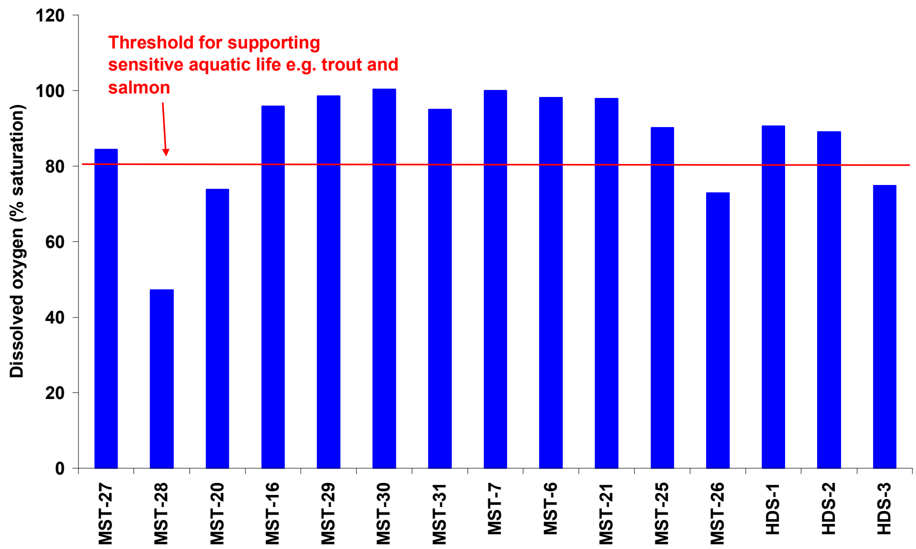


Figure 27: Mean dissolved oxygen saturation recorded at each site over the sampling period.

Spot measurements have shown that low dissolved oxygen levels are a problem at MST-28, MST-20, MST-26 and HDS-3 and are likely to be a problem at MST-6 and HDS-2. Continuous monitoring of dissolved oxygen at selected sites for a month during the summer period would further elucidate the extent of the problem.

Dissolved oxygen concentrations are lower during the summer months with mean concentrations dipping below 80% saturation, the level at which aquatic life, in particular salmonid species of fish can begin to suffer. Dissolved oxygen exhibits a diurnal variation with lowest concentrations occurring just before dawn and highest concentration occurring in the early afternoon. As only spot measurements were taken at each site it was not possible to assess these diurnal variations and therefore the worst case scenarios may not have been recorded for some sites. However as sampling was carried out at the approximately the same time of day for each site the temporal trend as show in figure 28 can be interpreted as being reasonably accurate. This temporal trend shows that dissolved oxygen levels in the summer months can be low enough to stress aquatic life.

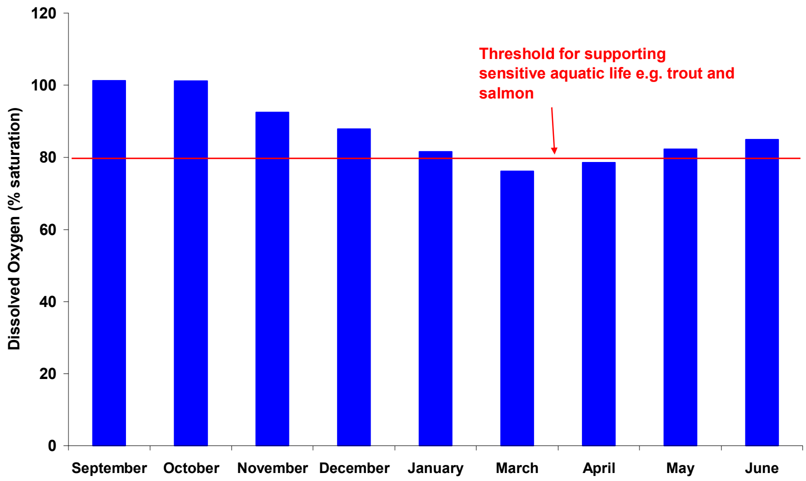


Figure 28: Mean dissolved oxygen saturation recorded each month during the survey.

6.10. Temperature

The temperature measured at the sites is largely a function of the time of day at which sampling took place with sites in the upper catchment sampled early in the morning and sites lower down sampled by early afternoon. Predictably, the highest temperatures occur during the summer months and lowest temperatures during the winter months (figure 29). There were unseasonably high water temperatures recorded during September.

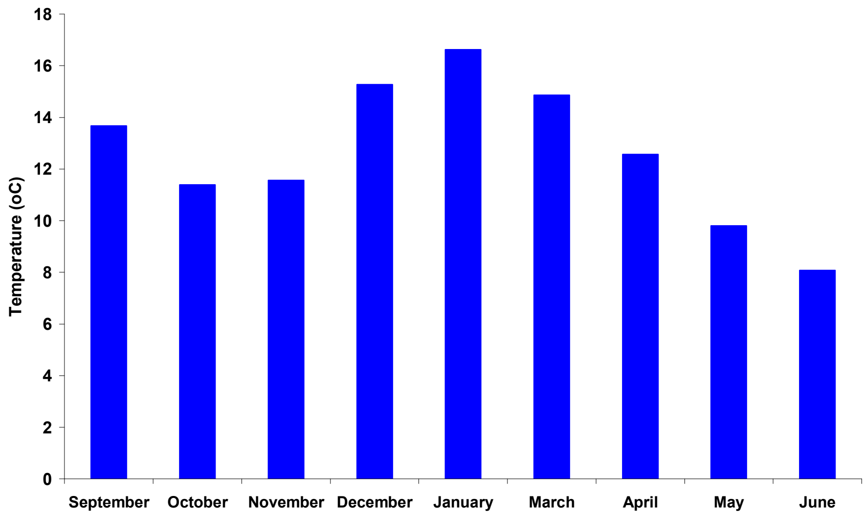


Figure 29: Average monthly water temperature.

There is considerable variation in water temperature between sites (figure 30). Some sites show a much smaller variation in temperature e.g. MST-28 and MST-26, reflecting the dominance of groundwater upwelling at these sites. Temperatures at MST-27 reflect changing air temperature during the year. Temperature at MST-27 was always recorded early in the morning at this site. An absence of riparian vegetation will result in higher stream water temperatures, in addition the presence of large amounts of suspended sediment will also result in increased water temperatures as the suspended sediment act like radiators, absorbing heat from the sun and radiating it out into the water. HDS-3 shows the largest variation in temperature, possibly as a result of the pond located upstream. Temperatures in small ponds can become elevated during summers and can affect stream water temperatures several hundred meters downstream of the discharge (Maxted and McCready, 2005). HDS-2 shows the second highest water temperatures, it also had the highest suspended solids concentration, which may be a contributing to the high water temperatures recorded at this site.

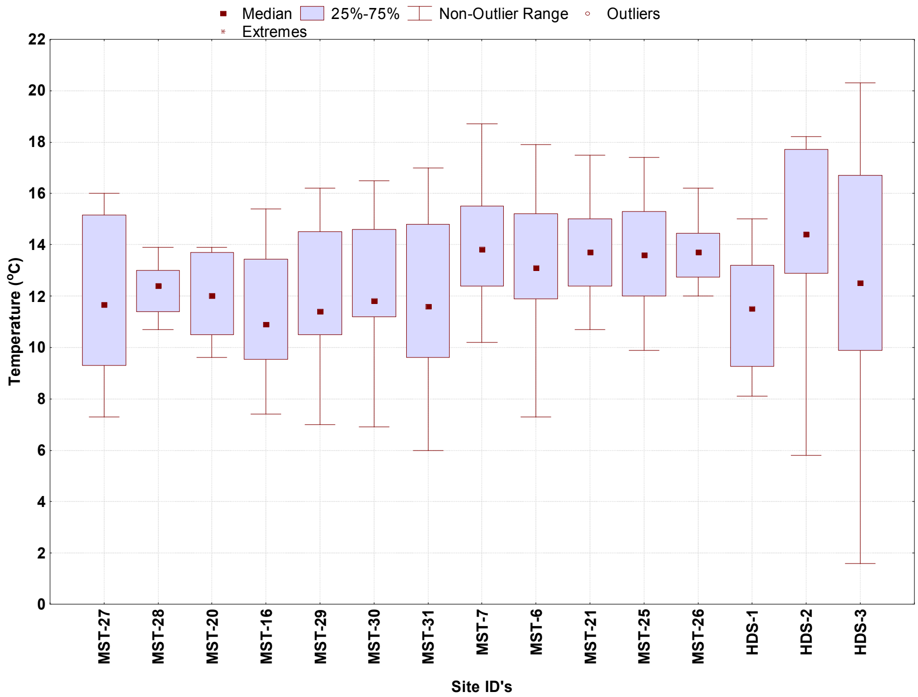


Figure 30: Summary statistics of water temperature for each site sampled during the survey.

HDS-3 also has the highest temperature recorded during the study. Notwithstanding this water temperatures are not excessive and are generally below 20°C, the temperature at which aquatic life and in particular salmonid life can begin to be stressed.

7. Discussion and Recommendations

Water quality in Mill Stream is poor in relation to 6 of the 10 water quality parameters measured. Mill Stream has particularly poor water quality in relation to suspended solids, turbidity, *E. coli* and nitrate. The hydrology of Mill Stream is complex as it is influenced by both upwelling of groundwater and rain fed tributaries arising in the Southbank Hills. In winter the rain fed tributaries from the Southbank Hills have a greater influence on water quality, whereas in the summertime stream flow is predominantly derived from the upwelling of groundwater. Seasonal variation exists for pH, suspended solids, turbidity, *E. coli*, nitrate, dissolved oxygen and temperature.

Nuisance algal and macrophyte growth is a complex combination of excessive nutrients (principally nitrates and phosphorus) and, in the case of macrophyte growth, suspended sediment. Good on farm nutrient management practices should help to reduce the amount of nutrients entering groundwaters and surface waters. Phosphorus levels are high at all sites including the upland site at MST-27, this pattern is very different to that observed for nitrates and perhaps reflects the fact that nitrate concentrations principally reflect groundwater quality and nitrate entering the system in the lowland plains whilst phosphorus concentrations reflect diffuse surface water run-off and the rain fed stream systems. Potential point sources of phosphorus between MST-28 and MST-16 should be investigated and if possible mitigated.

The pattern of a point source of DRP influencing DRP concentrations at sites MST-28, MST-20 and MST-16 is unusual and it is difficult to ascertain where that point source might be. Where DRP is strongly correlated with rainfall (at MST-27, HDS-1 and MST-31) rainfall and overland flow are thought to strongly influence water quality. The remainder of the sites show that groundwater and rain fed surface water runoff are likely to equally influence DRP concentrations in the stream. Phosphorus concentrations are highest in the upper reaches and decrease further downstream. Top dressing of phosphorus fertiliser in the hill country may account for the elevated phosphorus levels observed.

Dissolved oxygen levels are generally good with the exception of some areas at the ‘head’ of springs where lower oxygen levels persist as a result of oxidation conditions in the shallow groundwater aquifer. Seasonal variation in dissolved oxygen concentrations shows that oxygen levels are lower in the summertime. Groundwater is likely to strongly influence water quality at MST-28 and MST-26 resulting in reduced dissolved oxygen concentrations and lower pH’s. Surface water runoff from rainfall is likely to strongly influence water quality at MST-27, MST-31 and HDS-1.

Dilution, associated with upwelling of springs as one proceeds down the catchment, largely results in improved water quality, with the exception of nitrates which remain high and even increase slightly as one proceeds downstream.

The hydrology and water quality of Mill Stream is complex and it is likely that the water quality of Mill Stream is being affected by land use practices outside of the immediate catchment; however vast improvements could be made to water quality in terms of suspended sediments, turbidity and *E. coli* by fencing all of the stream margins and the stream margins of its associated tributaries, thereby removing stock access from the waterways. This will allow the banks to stabilise sufficiently to prevent further erosion, the amount of sediment generated within the catchment could be dramatically improved, and this would in turn improve turbidity and water clarity. Preventing stock access to the water will also help reduce the *E. coli* load to the stream. Considerable damage has been done to some section of stream bank and it will take some time to stabilise these sections and prevent further erosion, riparian planting of these sections would help in this process.

A permanent state of the environment monitoring (SoE) site has been established at MST-21 (where Councils permanent flow is sited). Water samples are taken monthly and analysed by an IANZ accredited laboratory for the following suite of parameters: pH, total suspended solids, specific conductivity, turbidity, faecal coliforms, *E. coli*, Nitrite nitrate nitrogen, nitrate nitrogen, ammonia nitrogen and dissolved reactive phosphorus. In addition spot measurements of temperature and dissolved oxygen are taken each month. Macroinvertebrate samples will be taken on an annual basis at MST-21. Reporting of water quality for Mill Stream will be done in conjunction with the 33 current SoE sites through the regular annual SoE reports on surface water quality.

8. REFERENCES

ANZECC (2000) *Australian and New Zealand Guidelines for Fresh and Marine Water Quality*. Australian and New Zealand Environment and Conservation Council and Agriculture and Resource Management Council of Australia and New Zealand.

CCREM (1991) *Canadian water quality guidelines*, Canadian Council of Resource and Environment Ministers, Inland Waters Directorate, Environment Canada, Ottawa.

Hart, B.T., Edwards, R., James, K., Swadling, C., Meredith, A., McMahon, A. and Hortle, K. (1990) Effects of saline discharges on aquatic ecosystems. *Water Research* 24, 1103–17.

Hart, B.T., Edwards, R., James, K., Swadling, C., Meredith, A., McMahon, A. and Hortle, K. (1991) Biological effects of saline discharges to streams and wetlands: A review. *Hydrobiologia* 210, 105–44. USEPA 1986. *Quality criteria for water — 1986*. US Environmental Protection Agency, Washington DC.

Hickey, C. W. and Martin, M. L. (2009) *A review of nitrate toxicity to freshwater aquatic species*. Prepared for Environment Canterbury by NIWA. Report No. R09/57. ISBN 978-1-86937-997-1.

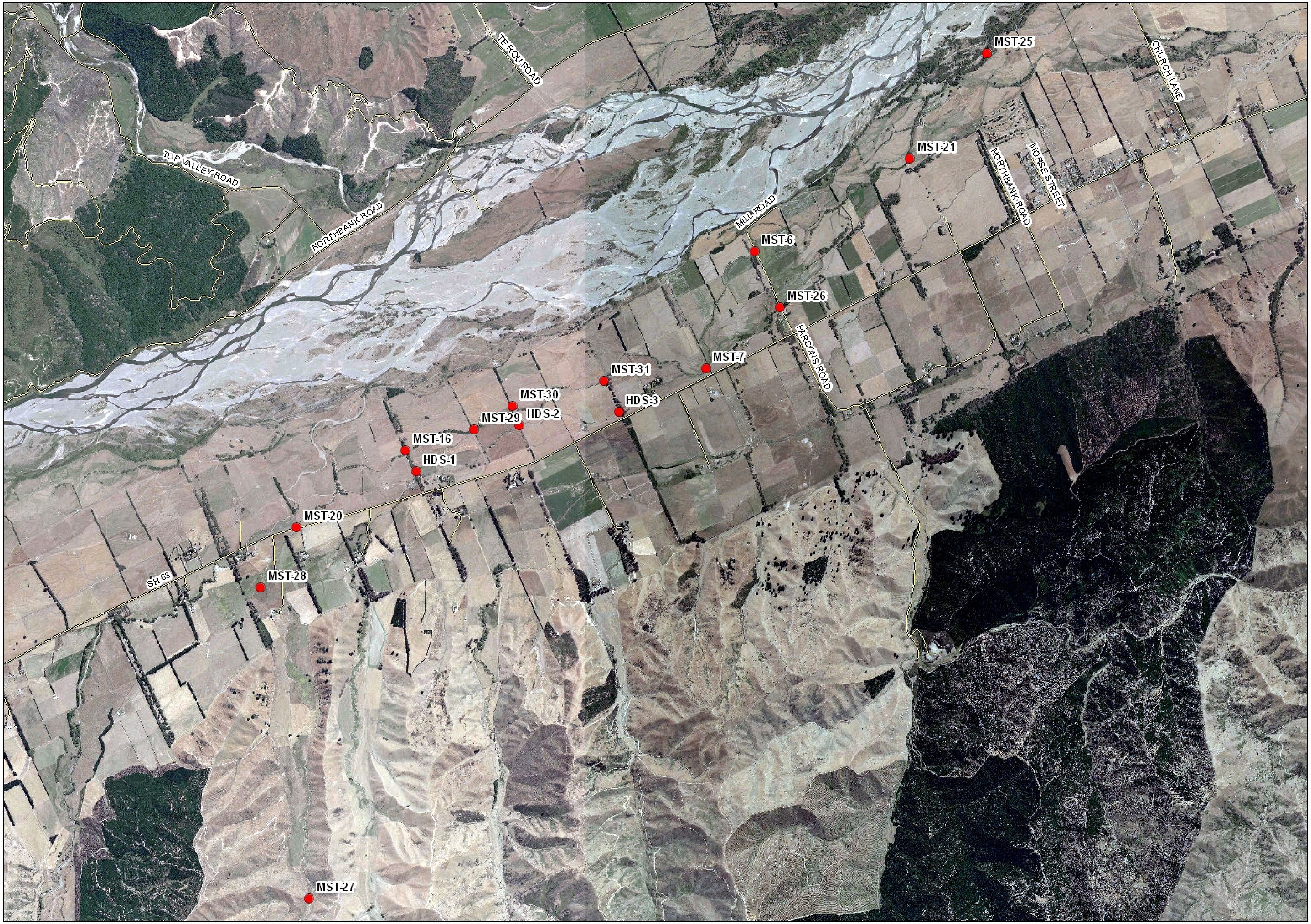
Maxted, J. R. and McCready, C. H. (2005) Effects of small ponds on stream water quality and macroinvertebrate communities. *New Zealand Journal of Marine and Freshwater Research, 2005, Vol. 39*: 1069–1084.

McCarthy, H. H. J. (2008) *The nature and origin of saline groundwater in the Wairau Valle, Marlborough, New Zealand*. MSc thesis, University of Canterbury.

MDC (2007) *Wairau Valley Exploratory Drilling and Testing Technical Report*. Groundwater Group Technical Report 2007/02. July 2007.

APPENDIX 1

Aerial photograph of Mill Stream and surrounding land showing the locations of the 15 sites sampled during the survey


MST-25
CHURCH LANE
MST-21
NORTHBANK ROAD
MORSE STREET
TE ROU ROAD
TOP VALLEY ROAD
NORTHBANK ROAD
MILL ROAD
MST-6
MST-26
PARSONS ROAD
MST-7
MST-31
HDS-3
MST-30
HDS-2
MST-29
MST-16
HDS-1
MST-20
MST-28
SH 63
MST-27

APPENDIX 2

Site Photographs

MST-27

MST-28

MST-20

MST-16

MST-29

MST-30

HDS-1

HDS-2

HDS-3

MST-31

MST-7

MST-6

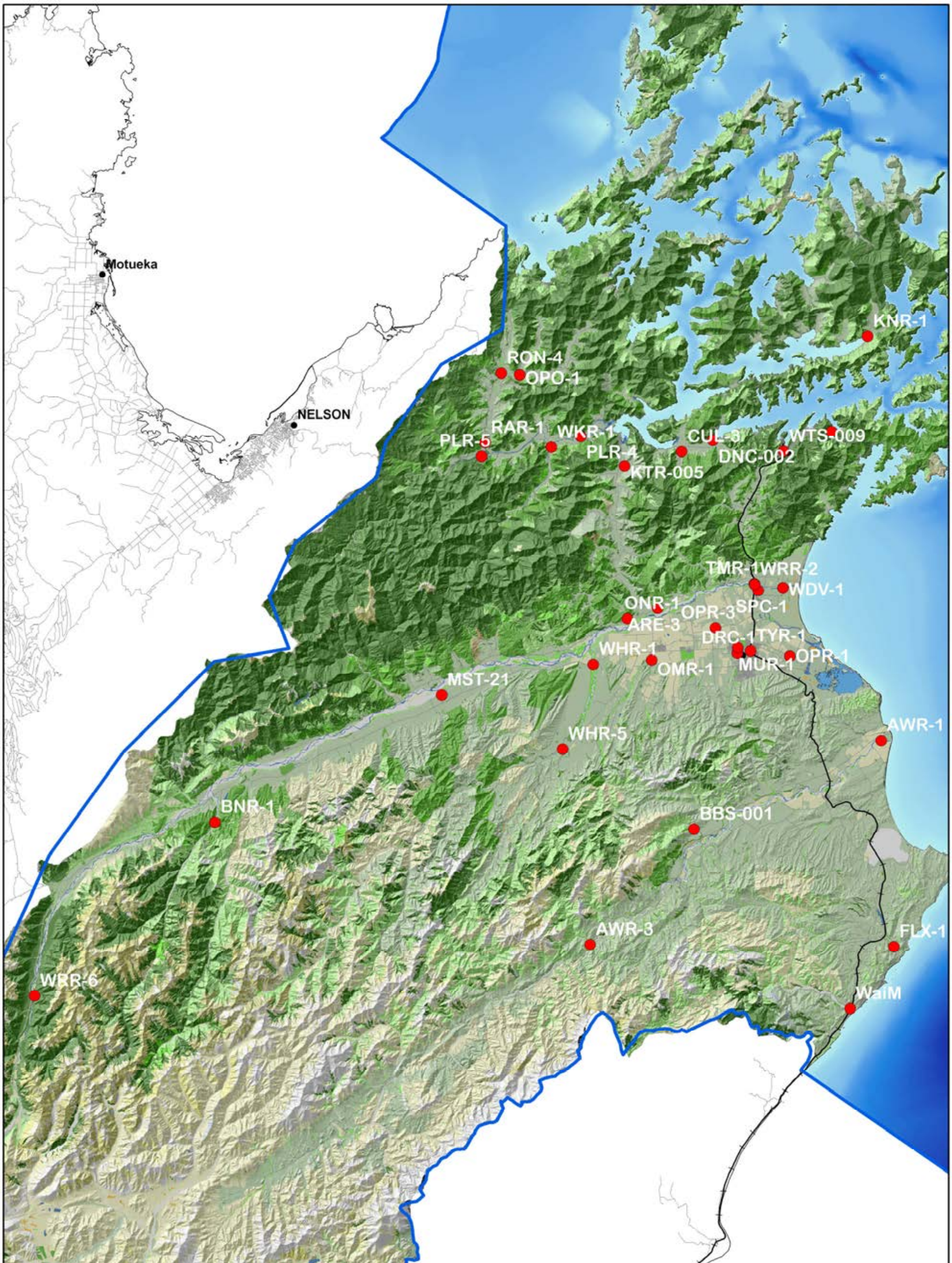
MST-26

MST-21

MST-25

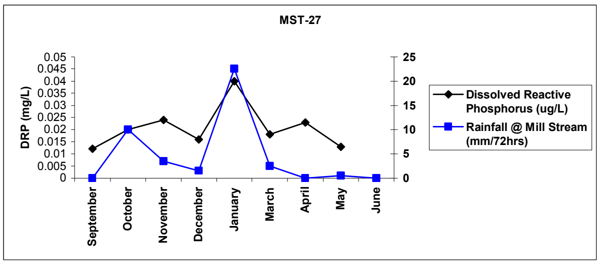
APPENDIX 3

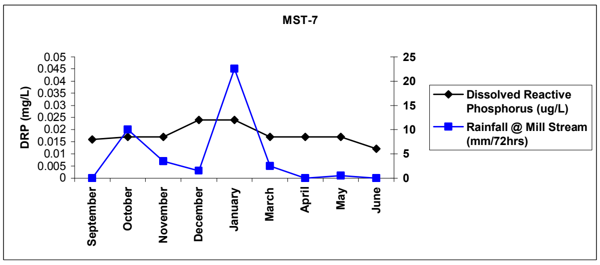
Map of Marlborough showing the locations of the 34 State of the Environment (SoE) monitoring sites

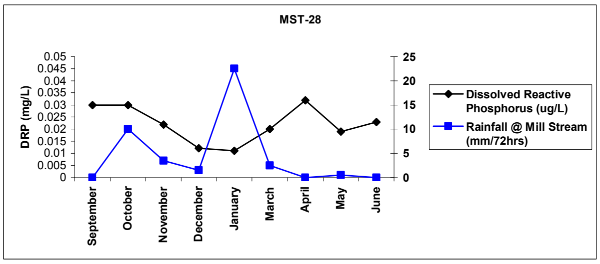

Motueka
NELSON
RON-4
OPO-1
RAR-1
WKR-1
PLR-5
PLR-4
CUL-3
DNC-002
WTS-009
KTR-005
KNR-1
TMR-1
WRR-2
WDV-1
ONR-1
ARE-3
OPR-3
SPC-1
DRC-1
TYR-1
WHR-1
OMR-1
MUR-1
OPR-1
MST-21
WHR-5
AWR-1
BNR-1
BBS-001
AWR-3
FLX-1
WRR-6
WaiM

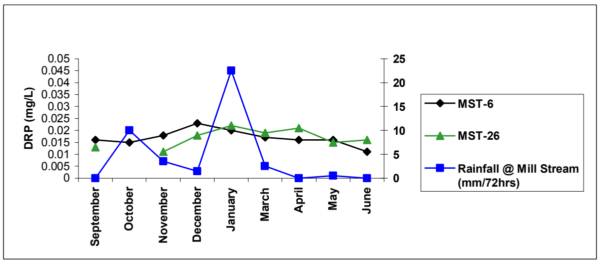
APPENDIX 4

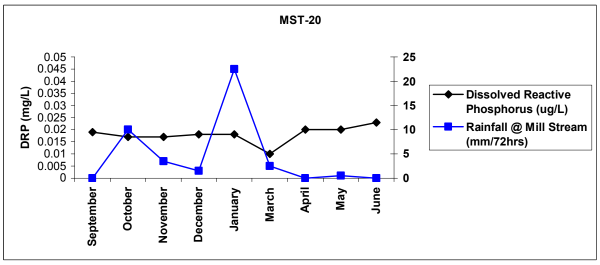
Graphs showing dissolved reactive phosphorus concentrations in relation to rainfall at each site sampled for the duration of the survey

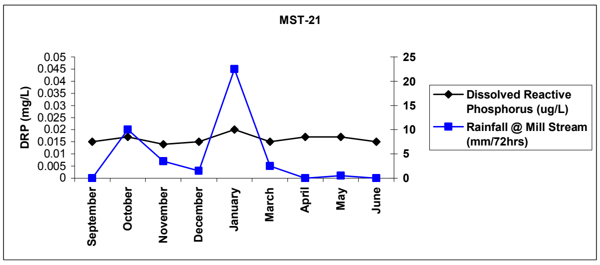

MST-27
DRP (mg/L)
Dissolved Reactive Phosphorus (ug/L)
Rainfall @ Mill Stream (mm/72hrs)
September
October
November
December
January
March
April
May
June

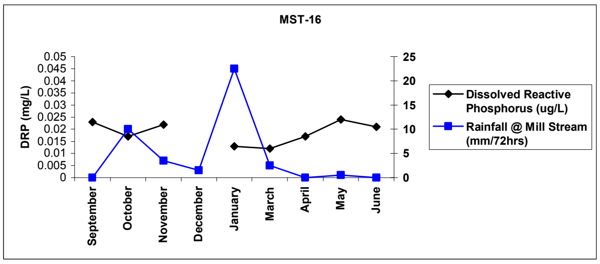

MST-7
DRP (mg/L)
Dissolved Reactive Phosphorus (ug/L)
Rainfall @ Mill Stream (mm/72hrs)
September
October
November
December
January
March
April
May
June

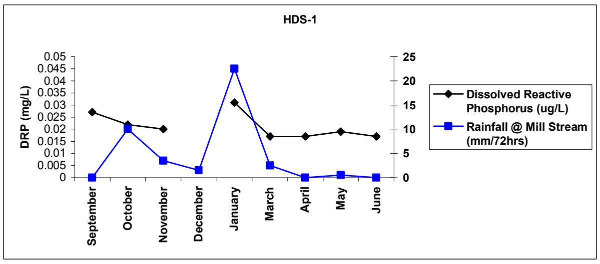

MST-28
DRP (mg/L)
Dissolved Reactive Phosphorus (ug/L)
Rainfall @ Mill Stream (mm/72hrs)
September
October
November
December
January
March
April
May
June

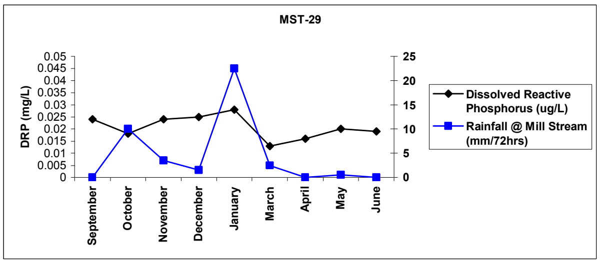

DRP (mg/L)
MST-6
MST-26
Rainfall @ Mill Stream (mm/72hrs)
September
October
November
December
January
March
April
May
June

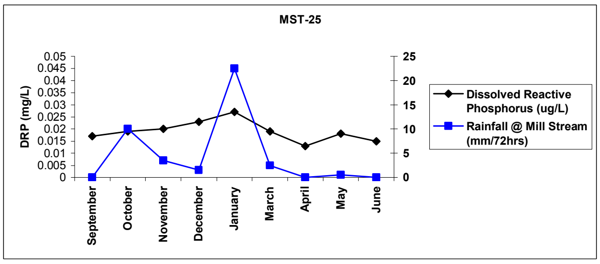

MST-20
DRP (mg/L)
Dissolved Reactive Phosphorus (ug/L)
Rainfall @ Mill Stream (mm/72hrs)
September
October
November
December
January
March
April
May
June

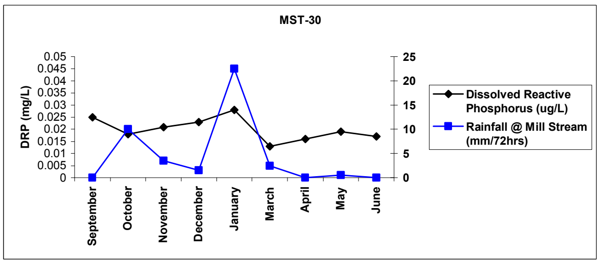

MST-21
DRP (mg/L)
Dissolved Reactive Phosphorus (ug/L)
Rainfall @ Mill Stream (mm/72hrs)
September
October
November
December
January
March
April
May
June

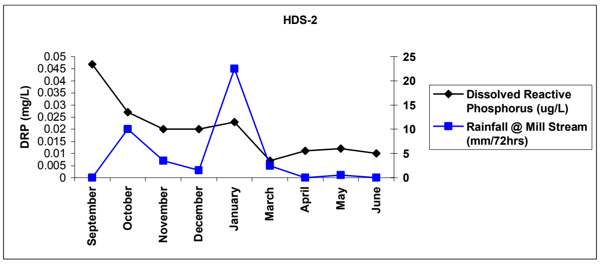

MST-16
DRP (mg/L)
Dissolved Reactive Phosphorus (ug/L)
Rainfall @ Mill Stream (mm/72hrs)
September
October
November
December
January
March
April
May
June

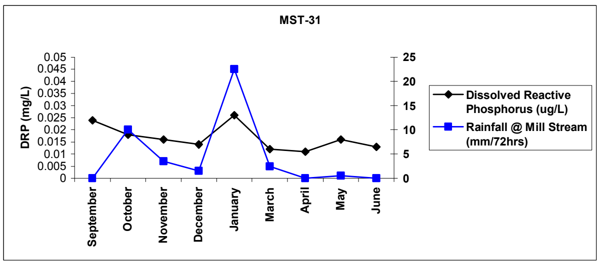

HDS-1
DRP (mg/L)
Dissolved Reactive Phosphorus (ug/L)
Rainfall @ Mill Stream (mm/72hrs)
September
October
November
December
January
March
April
May
June

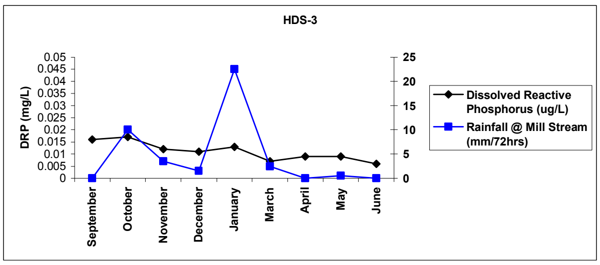

MST-29
DRP (mg/L)
Dissolved Reactive Phosphorus (ug/L)
Rainfall @ Mill Stream (mm/72hrs)
September
October
November
December
January
March
April
May
June


MST-25
DRP (mg/L)
Dissolved Reactive Phosphorus (ug/L)
Rainfall @ Mill Stream (mm/72hrs)
September
October
November
December
January
March
April
May
June


MST-30
DRP (mg/L)
Dissolved Reactive Phosphorus (ug/L)
Rainfall @ Mill Stream (mm/72hrs)
September
October
November
December
January
March
April
May
June


HDS-2
DRP (mg/L)
Dissolved Reactive Phosphorus (ug/L)
Rainfall @ Mill Stream (mm/72hrs)
September
October
November
December
January
March
April
May
June


MST-31
DRP (mg/L)
Dissolved Reactive Phosphorus (ug/L)
Rainfall @ Mill Stream (mm/72hrs)
September
October
November
December
January
March
April
May
June


HDS-3
DRP (mg/L)
Dissolved Reactive Phosphorus (ug/L)
Rainfall @ Mill Stream (mm/72hrs)
September
October
November
December
January
March
April
May
June

APPENDIX 5

Water Quality Results for all sites for the duration of the sampling period

Mill Stream Monitoring 2008/09

Less than values are halved
NS = no sample taken

Excell Stream upstream MST-27

Test Code	Auth.		September	October	November	December	January	March	April	May	June
		Sampling date	*18-Sep-08*	*2-Oct-08*	*6-Nov-08*	*4-Dec-08*	*8-Jan-09*	*5-Mar-09*	*2-Apr-09*	*7-May-09*	*4-Jun-09*
		Sample ID number	*20083669*	*20083857*	*20085005*	*20085441*	*20090062*	*20091122*	*20091625*	*20092022*	*NS*
0001	ELS	pH	7.5	7.3	7.5	7.4	7.2	6.9	6.9	7.1	
0002	ELS	Suspended Solids (mg/L)	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	
0055	ELS	Conductivity @ 25°C (µS/cm)	114	124	140	129	141	138	141	116	
0084	ELS	Turbidity (NTU)	0.9	1.01	0.45	0.63	0.35	0.54	0.3	0.49	
0089	ELS	Faecal Coliforms (cfu/100mL)	27	350	96	77	200	53	170	100	
0098	ELS	*E. coli* (cfu/100mL)	25	320	96	77	200	53	170	83	
0515	ELS	Nitrite nitrate nitrogen (mg/L)	0.006	0.012	0.0025	0.007	0.062	0.005	0.0025	0.008	
0605	ELS	Nitrate - Nitrogen (mg/L)	0.02	0.005	0.005	0.005	0.005	0.005	0.005	0.005	
0760	ELS	Ammonia Nitrogen (mg/L)	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	
2088	ELS	Dissolved Reactive Phosphorus (mg/L)	0.012	0.02	0.024	0.016	0.04	0.018	0.023	0.013	
	MDC	Conductivity @ 25°C (µS/cm)	113.8	97.7	135.5	86.1	144.5	138.3	124	129	
	MDC	Dissolved Oxygen (mg/L)	11.6	10.61	9.92	9.02	7.48	8.23	7.38	9.69	
	MDC	Dissolved Oxygen (% saturation)	100.9	86.8	89.9	89.1	75.9	82.7	68.9	81.4	
	MDC	Average Daily Flow @ Mill Stream (m^3/s)	0.666	0.508	0.372	0.443	0.374	0.315	0.267	0.281	0.332
	MDC	Rainfall @ Mill Stream (mm/72hrs)	0	10	3.5	1.5	22.5	2.5	30	0.5	
	MDC	Rainfall @ Mill Stream (mm/24hrs)	0	0	1	0.5	22.5	2.5	0	0.5	
	MDC	Temperature (°C)	10.8	7.3	11	14.8	16	15.5	12.3	7.8	

Excell Stream MST-28

Test Code	Auth.		September	October	November	December	January	March	April	May	June
		Sampling date	*18-Sep-08*	*2-Oct-08*	*6-Nov-08*	*4-Dec-08*	*8-Jan-09*	*5-Mar-09*	*2-Apr-09*	*7-May-09*	*4-Jun-09*
		Sample ID number	*20083670*	*20083858*	*20085006*	*20085442*	*20090063*	*20091123*	*20091626*	*20092023*	*20093200*
0001	ELS	pH	6.3	6.3	6.5	6.3	6.1	6.2	6.4	6.4	6.7
0002	ELS	Suspended Solids (mg/L)	1.5	1.5	1.5	3	15	1.5	1.5	1.5	4
0055	ELS	Conductivity @ 25°C (µS/cm)	163	155	139	142	141	151	138	138	143
0084	ELS	Turbidity (NTU)	1.42	0.89	0.86	1.3	14.5	1.94	0.74	1.06	1.26

0089	ELS	Faecal Coliforms (cfu/100mL)	13	170	170	210	1300	180	96	150	66
0098	ELS	*E. coli* (cfu/100mL)	13	170	170	210	1200	180	96	130	66
0515	ELS	Nitrite nitrate nitrogen (mg/L)	4.61	4.85	4	2.99	2.01	3.03	1.8	2.18	2.3
0605	ELS	Nitrate - Nitrogen (mg/L)	5.05	4.71	3.18	2.98	2.19	3.03	1.83	2.64	2.29
0760	ELS	Ammonia Nitrogen (mg/L)	0.02	0.02	0.01	0.023	0.05	0.03	0.04	0.03	0.01
2088	ELS	Dissolved Reactive Phosphorus (mg/L)	0.03	0.03	0.022	0.012	0.011	0.02	0.032	0.019	0.023
	MDC	Conductivity @ 25°C (µS/cm)	162.7	154.1	138.5	150.5	144.2	153.9	141.8	145.8	152.4
	MDC	Dissolved Oxygen (mg/L)	8.1	6.97	6.25	4.54	1.59	2.28	3.79	5.46	6.83
	MDC	Dissolved Oxygen (% saturation)	75.9	63.6	57.4	43.1	15.4	22.1	35.9	49.9	61.8
	MDC	Average Daily Flow @ Mill Stream (m^3/s)	0.666	0.508	0.372	0.443	0.374	0.315	0.267	0.281	0.332
	MDC	Rainfall @ Mill Stream (mm/72hrs)	0	10	3.5	1.5	22.5	2.5	30	0.5	0
	MDC	Rainfall @ Mill Stream (mm/24hrs)	0	0	1	0.5	22.5	2.5	0	0.5	0
	MDC	Temperature (°C)	12.4	11.3	11.5	13	13.6	13.9	12.8	11.4	10.7

Excell Stream MST-20

			September	October	November	December	January	March	April	May	June
Test Code	**Auth.**	***Sampling date***	*18-Sep-08*	*2-Oct-08*	*6-Nov-08*	*4-Dec-08*	*8-Jan-09*	*5-Mar-09*	*2-Apr-09*	*7-May-09*	*4-Jun-09*
		Sample ID number	*20083671*	*20083859*	*20085007*	*20085443*	*20090064*	*20091124*	*20091627*	*20092024*	*20093201*
0001	ELS	pH	6.7	6.8	6.8	6.8	6.4	6.3	6.5	6.6	6.8
0002	ELS	Suspended Solids (mg/L)	5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	5
0055	ELS	Conductivity @ 25°C (µS/cm)	199	189	170	181	146	221	135	222	168
0084	ELS	Turbidity (NTU)	1.73	1.05	1.58	1.69	0.95	0.57	0.69	1.41	2.02
0089	ELS	Faecal Coliforms (cfu/100mL)	29	170	350	220	200	140	130	67	3800
0098	ELS	*E. coli* (cfu/100mL)	29	170	340	210	200	140	130	47	3800
0515	ELS	Nitrite nitrate nitrogen (mg/L)	3.47	4.48	3.4	1.92	1.38	2	1.22	1.72	1.63
0605	ELS	Nitrate - Nitrogen (mg/L)	2.18	3.76	2.59	1.71	1.41	2.02	1.25	1.95	1.66
0760	ELS	Ammonia Nitrogen (mg/L)	0.005	0.005	0.005	0.01	0.005	0.01	0.03	0.02	0.03
2088	ELS	Dissolved Reactive Phosphorus (mg/L)	0.019	0.017	0.017	0.018	0.018	0.01	0.02	0.02	0.023
	MDC	Conductivity @ 25°C (µS/cm)	198.1	190.2	170.8	191.2	147.4	203.3	138.2	208.9	176.7
	MDC	Dissolved Oxygen (mg/L)	10.74	10.98	10.02	9.37	6.36	4.23	4.76	7.26	8.31
	MDC	Dissolved Oxygen (% saturation)	99.7	98.5	91.7	90.5	61.6	40.9	44.3	64.5	72.4
	MDC	Average Daily Flow @ Mill Stream (m^3/s)	0.666	0.508	0.372	0.443	0.374	0.315	0.267	0.281	0.332
	MDC	Rainfall @ Mill Stream (mm/72hrs)	0	10	3.5	1.5	22.5	2.5	30	0.5	0
	MDC	Rainfall @ Mill Stream (mm/24hrs)	0	0	1	0.5	22.5	2.5	0	0.5	0

	MDC	Temperature (^oC)	12	10.5	11.4	13.7	13.9	13.9	12.2	10.1	9.6

Excell Stream MST-16

			September	October	November	December	January	March	April	May	June
Test Code	**Auth.**	***Sampling date***	*18-Sep-08*	*2-Oct-08*	*6-Nov-08*	*4-Dec-08*	*8-Jan-09*	*5-Mar-09*	*2-Apr-09*	*7-May-09*	*4-Jun-09*
		Sample ID number	*20083673*	*20083860*	*20085008*	*NS*	*20090065*	*20091125*	*20091628*	*20092025*	*20093202*
0001	ELS	pH	7.6	7.8	7.6		7.7	7.3	7	7.5	7.3
0002	ELS	Suspended Solids (mg/L)	62	10	28		4	10	3	5	10
0055	ELS	Conductivity @ 25^oC (µS/cm)	196	190	170		144	197	134	265	173
0084	ELS	Turbidity (NTU)	20.6	2.11	10.3		1.93	8.66	2.29	3.59	12.2
0089	ELS	Faecal Coliforms (cfu/100mL)	120	180	1300		800	200	310	190	900
0098	ELS	*E. coli* (cfu/100mL)	62	180	1200		400	200	310	160	800
0515	ELS	Nitrite nitrate nitrogen (mg/L)	3.37	4.43	3.35		1.21	1.85	1.08	1.63	1.6
0605	ELS	Nitrate - Nitrogen (mg/L)	2.82	3.71	2.54		1.39	1.85	1.08	1.64	1.64
0760	ELS	Ammonia Nitrogen (mg/L)	0.03	0.01	0.03		0.01	0.01	0.02	0.02	0.03
2088	ELS	Dissolved Reactive Phosphorus (mg/L)	0.023	0.017	0.022		0.013	0.012	0.017	0.024	0.021
	MDC	Conductivity @ 25^oC (µS/cm)	197.8	190.4	171.8		148.5	203.1	137.6	208.7	177.2
	MDC	Dissolved Oxygen (mg/L)	10.98	11.29	10.55		9.97	9.86	9.56	10.94	10.93
	MDC	Dissolved Oxygen (% saturation)	103.2	100.7	94.9		99.8	96.5	86.7	94.2	91.1
	MDC	Average Daily Flow @ Mill Stream (m^3/s)	0.666	0.508	0.372	0.443	0.374	0.315	0.267	0.281	0.332
	MDC	Rainfall @ Mill Stream (mm/72hrs)	0	10	3.5	1.5	22.5	2.5	30	0.5	0
	MDC	Rainfall @ Mill Stream (mm/24hrs)	0	0	1	0.5	22.5	2.5	0	0.5	0
	MDC	Temperature (^oC)	12.5	10.3	10.7		15.4	14.4	11.1	8.8	7.4

Mill Stream MST-29

			September	October	November	December	January	March	April	May	June
Test Code	**Auth.**	***Sampling date***	*18-Sep-08*	*2-Oct-08*	*6-Nov-08*	*4-Dec-08*	*8-Jan-09*	*5-Mar-09*	*2-Apr-09*	*7-May-09*	*4-Jun-09*
		Sample ID number	*20083674*	*20083862*	*20085010*	*20085446*	*20090067*	*20091127*	*20091630*	*20092027*	*20093204*
0001	ELS	pH	7.9	7.9	8	8.2	7.8	7.3	7.1	7.4	7.3
0002	ELS	Suspended Solids (mg/L)	19	60	14	15	4	6	1.5	1.5	1.5
0055	ELS	Conductivity @ 25^oC (µS/cm)	186	188	170	178	159	198	153	236	178
0084	ELS	Turbidity (NTU)	6.64	17.8	6.6	9.36	2.42	8.36	2.4	1.6	1.52
0089	ELS	Faecal Coliforms (cfu/100mL)	63	130	1800	1700	1900	230	160	160	190
0098	ELS	*E. coli* (cfu/100mL)	63	120	1300	1500	1400	230	160	94	180

0515	ELS	Nitrite nitrate nitrogen (mg/L)	3.29	4.33	3.27	1.92	1.41	1.94	1.66	1.76	1.7
0605	ELS	Nitrate - Nitrogen (mg/L)	2.88	3.61	2.5	1.73	1.44	1.97	1.64	2.12	1.71
0760	ELS	Ammonia Nitrogen (mg/L)	0.02	0.02	0.02	0.02	0.01	0.005	0.005	0.005	0.01
2088	ELS	Dissolved Reactive Phosphorus (mg/L)	0.024	0.018	0.024	0.025	0.028	0.013	0.016	0.02	0.019
	MDC	Conductivity @ 25°C (µS/cm)	186.3	187.3	171.1	188.3	157.4	201.3	159.3	207.8	182.7
	MDC	Dissolved Oxygen (mg/L)	10.99	11.34	10.68	11.02	10.27	9.84	9.98	10.61	10.98
	MDC	Dissolved Oxygen (% saturation)	105.1	101.7	97.6	108.6	104.6	96.7	91.7	90.8	90.3
	MDC	Average Daily Flow @ Mill Stream (m^3/s)	0.666	0.508	0.372	0.443	0.374	0.315	0.267	0.281	0.332
	MDC	Rainfall @ Mill Stream (mm/72hrs)	0	10	3.5	1.5	22.5	2.5	30	0.5	0
	MDC	Rainfall @ Mill Stream (mm/24hrs)	0	0	1	0.5	22.5	2.5	0	0.5	0
	MDC	Temperature (°C)	13.3	10.5	11.4	14.9	16.2	14.5	11.4	8.5	7

Mill Stream MST-30

			September	**October**	**November**	**December**	**January**	**March**	**April**	**May**	**June**
Test Code	**Auth.**	***Sampling date***	*18-Sep-08*	*2-Oct-08*	*6-Nov-08*	*4-Dec-08*	*8-Jan-09*	*5-Mar-09*	*2-Apr-09*	*7-May-09*	*4-Jun-09*
		Sample ID number	*20083676*	*20083863*	*20085011*	*20085447*	*20090068*	*20091128*	*20091631*	*20092028*	*20093205*
0001	ELS	pH	7.9	8.1	8	8.1	7.8	7.4	7.2	7.6	7.5
0002	ELS	Suspended Solids (mg/L)	27	29	13	11	5	6	4	1.5	1.5
0055	ELS	Conductivity @ 25°C (µS/cm)	185	187	166	178	154	197	154	242	176
0084	ELS	Turbidity (NTU)	9.58	13	6.07	6.82	2.89	7.84	2.37	1.54	1.66
0089	ELS	Faecal Coliforms (cfu/100mL)	53	88	1200	230	800	220	170	150	400
0098	ELS	*E. coli* (cfu/100mL)	53	88	1000	200	700	220	170	92	400
0515	ELS	Nitrite nitrate nitrogen (mg/L)	3.22	4.32	2.52	1.84	1.39	1.87	1.62	1.69	1.64
0605	ELS	Nitrate - Nitrogen (mg/L)	2.82	3.58	2.5	1.71	1.47	1.93	1.61	1.94	1.71
0760	ELS	Ammonia Nitrogen (mg/L)	0.02	0.02	0.02	0.01	0.005	0.005	0.005	0.005	0.005
2088	ELS	Dissolved Reactive Phosphorus (mg/L)	0.025	0.018	0.021	0.023	0.028	0.013	0.016	0.019	0.017
	MDC	Conductivity @ 25°C (µS/cm)	185.4	187.2	171.3	188.2	156.6	201.4	159.1	209.2	186.4
	MDC	Dissolved Oxygen (mg/L)	10.72	11.49	10.84	10.8	10.18	10.01	10.52	11.16	11.02
	MDC	Dissolved Oxygen (% saturation)	104.1	104.7	100.3	107.2	104.2	98.4	97.1	97.2	90.6
	MDC	Average Daily Flow @ Mill Stream (m^3/s)	0.666	0.508	0.372	0.443	0.374	0.315	0.267	0.281	0.332
	MDC	Rainfall @ Mill Stream (mm/72hrs)	0	10	3.5	1.5	22.5	2.5	30	0.5	0
	MDC	Rainfall @ Mill Stream (mm/24hrs)	0	0	1	0.5	22.5	2.5	0	0.5	0
	MDC	Temperature (°C)	14	11.2	11.8	15.1	16.5	14.6	11.8	9.3	6.9

Mill Stream MST-31

Test Code	Auth.		September	October	November	December	January	March	April	May	June
		Sampling date	*18-Sep-08*	*2-Oct-08*	*6-Nov-08*	*4-Dec-08*	*8-Jan-09*	*5-Mar-09*	*2-Apr-09*	*7-May-09*	*4-Jun-09*
		Sample ID number	*20083678*	*20083865*	*20085013*	*20085449*	*20090070*	*20091130*	*20091633*	*20092030*	*20093207*
0001	ELS	pH	7.6	7.8	7.8	7.6	7.4	7.2	7.1	7.4	7.5
0002	ELS	Suspended Solids (mg/L)	11	9	22	7	6	5	3	1.5	1.5
0055	ELS	Conductivity @ 25°C (µS/cm)	182	186	170	177	152	196	156	226	180
0084	ELS	Turbidity (NTU)	4.3	3.71	9.35	3.6	2.08	3.53	1.68	1.06	0.97
0089	ELS	Faecal Coliforms (cfu/100mL)	25	110	390	290	300	800	230	220	42
0098	ELS	*E. coli* (cfu/100mL)	15	110	390	290	200	800	230	180	42
0515	ELS	Nitrite nitrate nitrogen (mg/L)	3.13	4.29	2.51	1.61	1.26	1.68	1.47	1.58	1.6
0605	ELS	Nitrate - Nitrogen (mg/L)	2.95	3.52	2.49	1.64	1.29	1.75	1.49	1.81	1.65
0760	ELS	Ammonia Nitrogen (mg/L)	0.02	0.02	0.02	0.005	0.01	0.005	0.005	0.005	0.005
2088	ELS	Dissolved Reactive Phosphorus (mg/L)	0.024	0.018	0.016	0.014	0.026	0.012	0.011	0.016	0.013
	MDC	Conductivity @ 25°C (µS/cm)	184.7	187.5	171.2	186.6	156.1	185.4	158.4	211.2	186.7
	MDC	Dissolved Oxygen (mg/L)	9.88	10.77	10.91	9.77	9.33	9.41	9.64	11.01	11.72
	MDC	Dissolved Oxygen (% saturation)	97.6	99.1	95.7	97.4	96.5	92.6	88.6	92.9	94.2
	MDC	Average Daily Flow @ Mill Stream (m^3/s)	0.666	0.508	0.372	0.443	0.374	0.315	0.267	0.281	0.332
	MDC	Rainfall @ Mill Stream (mm/72hrs)	0	10	3.5	1.5	22.5	2.5	30	0.5	0
	MDC	Rainfall @ Mill Stream (mm/24hrs)	0	0	1	0.5	22.5	2.5	0	0.5	0
	MDC	Temperature (°C)	14.7	11.6	9.6	15.2	17	14.8	11.6	8	6

Mill Stream MST-7

Test Code	Auth.		September	October	November	December	January	March	April	May	June
		Sampling date	*18-Sep-08*	*2-Oct-08*	*6-Nov-08*	*4-Dec-08*	*8-Jan-09*	*5-Mar-09*	*2-Apr-09*	*7-May-09*	*4-Jun-09*
		Sample ID number	*20083679*	*20083867*	*20085015*	*20085451*	*20090072*	*20091132*	*20091635*	*20092032*	*20093209*
0001	ELS	pH	6.9	7.2	7.1	6.7	6.7	7.2	7	6.6	7
0002	ELS	Suspended Solids (mg/L)	11	7	4	4	1.5	7	10	1.5	6
0055	ELS	Conductivity @ 25°C (µS/cm)	158	168	156	152	139	190	152	166	154
0084	ELS	Turbidity (NTU)	7.5	4.09	4.03	2.53	2.59	5.28	5.35	2.83	3.15
0089	ELS	Faecal Coliforms (cfu/100mL)	95	67	160	270	300	800	180	41	52
0098	ELS	*E. coli* (cfu/100mL)	37	67	160	260	300	800	180	35	52
0515	ELS	Nitrite nitrate nitrogen (mg/L)	3.19	3.84	2.31	1.92	1.35	1.58	1.47	1.62	1.65
0605	ELS	Nitrate - Nitrogen (mg/L)	2.97	3.03	2.3	2.21	1.39	1.64	1.46	2.05	1.63

0760	ELS	Ammonia Nitrogen (mg/L)	0.005	0.005	0.005	0.005	0.005	0.01	0.02	0.01	0.02
2088	ELS	Dissolved Reactive Phosphorus (mg/L)	0.016	0.017	0.017	0.024	0.024	0.017	0.017	0.017	0.012
	MDC	Conductivity @ 25°C (µS/cm)	160.1	168.7	159.8	167.9	145.7	187.9	157	169.8	152.9
	MDC	Dissolved Oxygen (mg/L)	11.33	11.51	10.41	10.01	10.35	9.55	10.36	9.07	9.77
	MDC	Dissolved Oxygen (% saturation)	110.9	110.7	96.4	100.6	110.5	99.6	99.7	84.8	86.4
	MDC	Average Daily Flow @ Mill Stream (m^3/s)	0.666	0.508	0.372	0.443	0.374	0.315	0.267	0.281	0.332
	MDC	Rainfall @ Mill Stream (mm/72hrs)	0	10	3.5	1.5	22.5	2.5	30	0.5	0
	MDC	Rainfall @ Mill Stream (mm/24hrs)	0	0	1	0.5	22.5	2.5	0	0.5	0
	MDC	Temperature (°C)	14.3	13.1	11.8	15.8	18.7	15.5	13.8	12.4	10.2

Mill Stream MST-6

			September	October	November	December	January	March	April	May	June
Test Code	**Auth.**	***Sampling date***	*18-Sep-08*	*2-Oct-08*	*6-Nov-08*	*4-Dec-08*	*8-Jan-09*	*5-Mar-09*	*2-Apr-09*	*7-May-09*	*4-Jun-09*
		Sample ID number	*20083681*	*20083868*	*20085016*	*20085452*	*20090073*	*20091133*	*20091636*	*20092033*	*20093210*
0001	ELS	pH	7.3	8.3	7.9	7.5	7.3	7	7	6.9	7
0002	ELS	Suspended Solids (mg/L)	7	7	3	5	3	1.5	1.5	1.5	1.5
0055	ELS	Conductivity @ 25°C (µS/cm)	158	169	157	163	142	192	153	179	153
0084	ELS	Turbidity (NTU)	5.25	4.52	2.89	3.04	2.55	2.82	2.13	1.26	1.99
0089	ELS	Faecal Coliforms (cfu/100mL)	42	41	110	1200	100	110	250	38	44
0098	ELS	*E. coli* (cfu/100mL)	37	41	110	1200	100	110	250	33	44
0515	ELS	Nitrite nitrate nitrogen (mg/L)	2.96	3.76	2.15	1.55	1.03	1.37	1.36	1.48	1.71
0605	ELS	Nitrate - Nitrogen (mg/L)	2.73	2.9	2.18	1.58	1.07	1.41	1.34	1.8	1.6
0760	ELS	Ammonia Nitrogen (mg/L)	0.005	0.005	0.005	0.01	0.005	0.01	0.005	0.01	0.01
2088	ELS	Dissolved Reactive Phosphorus (mg/L)	0.016	0.015	0.018	0.023	0.02	0.017	0.016	0.016	0.011
	MDC	Conductivity @ 25°C (µS/cm)	158.3	168.2	159.8	173.6	146	197.2	157.9	180.2	159.7
	MDC	Dissolved Oxygen (mg/L)	12.03	13.58	11.98	9.86	9.42	7.74	8.6	9.17	10.63
	MDC	Dissolved Oxygen (% saturation)	118.4	129.1	110.3	100.4	100.5	77.1	80.4	78.7	88.4
	MDC	Average Daily Flow @ Mill Stream (m^3/s)	0.666	0.508	0.372	0.443	0.374	0.315	0.267	0.281	0.332
	MDC	Rainfall @ Mill Stream (mm/72hrs)	0	10	3.5	1.5	22.5	2.5	30	0.5	0
	MDC	Rainfall @ Mill Stream (mm/24hrs)	0	0	1	0.5	22.5	2.5	0	0.5	0
	MDC	Temperature (°C)	14.6	13.1	11.9	16.3	17.9	15.2	12.3	8.8	7.3

Mill Stream MST-21

			September	October	November	December	January	March	April	May	June
Test Code	Auth.	***Sampling date***	*18-Sep-08*	*2-Oct-08*	*6-Nov-08*	*4-Dec-08*	*8-Jan-09*	*5-Mar-09*	*2-Apr-09*	*7-May-09*	*4-Jun-09*
		Sample ID number	*20083682*	*20083869*	*20085018*	*20085454*	*20090075*	*20091135*	*20091638*	*20092035*	*20093212*
0001	ELS	pH	7	7.2	7.1	7	6.8	6.7	6.8	6.8	7
0002	ELS	Suspended Solids (mg/L)	5	3	3	6	4	4	1.5	1.5	1.5
0055	ELS	Conductivity @ 25^{o}C (µS/cm)	157	157	152	155	150	16.6	153	164	148
0084	ELS	Turbidity (NTU)	2.62	1.55	2.26	2.36	1.95	1.66	0.84	1.37	1.43
0089	ELS	Faecal Coliforms (cfu/100mL)	41	32	76	600	400	120	120	100	140
0098	ELS	*E. coli* (cfu/100mL)	20	32	76	500	300	120	120	85	140
0515	ELS	Nitrite nitrate nitrogen (mg/L)	3.3	3.67	2.69	2.37	1.95	2.01	1.92	2.19	2.07
0605	ELS	Nitrate - Nitrogen (mg/L)	3.15	2.8	2.72	2.46	1.98	2.07	1.9	2.46	2.09
0760	ELS	Ammonia Nitrogen (mg/L)	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
2088	ELS	Dissolved Reactive Phosphorus (mg/L)	0.015	0.017	0.014	0.015	0.02	0.015	0.017	0.017	0.015
	MDC	Conductivity @ 25^{o}C (µS/cm)	157.4	157.3	152.1	164.4	149.4	172.1	157.3	165.5	154
	MDC	Dissolved Oxygen (mg/L)	11.2	11.42	10.66	9.74	9.3	9.1	9.65	9.65	10.5
	MDC	Dissolved Oxygen (% saturation)	107.9	108.7	99.8	97.3	97.2	90.7	94.2	90.3	94.5
	MDC	Average Daily Flow @ Mill Stream (m^3/s)	0.666	0.508	0.372	0.443	0.374	0.315	0.267	0.281	0.332
	MDC	Rainfall @ Mill Stream (mm/72hrs)	0	10	3.5	1.5	22.5	2.5	30	0.5	0
	MDC	Rainfall @ Mill Stream (mm/24hrs)	0	0	1	0.5	22.5	2.5	0	0.5	0
	MDC	Temperature (^{o}C)	13.7	13.1	12.4	15.4	17.5	15	14.1	12.4	10.7

Mill Stream MST-25

			September	October	November	December	January	March	April	May	June
Test Code	Auth.	***Sampling date***	*18-Sep-08*	*2-Oct-08*	*6-Nov-08*	*4-Dec-08*	*8-Jan-09*	*5-Mar-09*	*2-Apr-09*	*7-May-09*	*4-Jun-09*
		Sample ID number	*20083683*	*20083870*	*20085019*	*20085455*	*20090076*	*20091136*	*20091639*	*20092036*	*20093213*
0001	ELS	pH	7.1	7.3	7.1	7	6.8	6.7	6.8	6.8	7.1
0002	ELS	Suspended Solids (mg/L)	4	1.5	1.5	6	3	4	1.5	1.5	1.5
0055	ELS	Conductivity @ 25^{o}C (µS/cm)	158	158	149	157	146	169	153	159	146
0084	ELS	Turbidity (NTU)	2.24	1.09	1.32	2.32	1.91	1.39	0.92	1.19	1.12
0089	ELS	Faecal Coliforms (cfu/100mL)	33	40	46	400	160	110	48	53	82
0098	ELS	*E. coli* (cfu/100mL)	23	35	46	400	160	110	46	37	82
0515	ELS	Nitrite nitrate nitrogen (mg/L)	3.27	3.58	2.75	2.45	1.92	2.03	1.83	2.37	2.2
0605	ELS	Nitrate - Nitrogen (mg/L)	2.57	2.76	2.74	2.5	1.98	2.08	1.84	3.2	2.13
0760	ELS	Ammonia Nitrogen (mg/L)	0.005	0.01	0.005	0.02	0.02	0.01	0.005	0.005	0.005

2088	ELS	Dissolved Reactive Phosphorus (mg/L)	0.017	0.019	0.02	0.023	0.027	0.019	0.013	0.018	0.015
	MDC	Conductivity @ 25°C (µS/cm)	157.6	158.2	156.3	165.1	151.6	169.7	157.8	166.1	155.8
	MDC	Dissolved Oxygen (mg/L)	10.01	10.62	10.01	9.23	8.01	8.32	8.93	9.07	10.62
	MDC	Dissolved Oxygen (% saturation)	96.5	99.7	92.6	91.6	83.6	83.2	86.3	84.1	94
	MDC	Average Daily Flow @ Mill Stream (m^3/s)	0.666	0.508	0.372	0.443	0.374	0.315	0.267	0.281	0.332
	MDC	Rainfall @ Mill Stream (mm/72hrs)	0	10	3.5	1.5	22.5	2.5	30	0.5	0
	MDC	Rainfall @ Mill Stream (mm/24hrs)	0	0	1	0.5	22.5	2.5	0	0.5	0
	MDC	Temperature (°C)	13.6	12.5	11.9	15.3	17.4	15.3	13.9	12	9.9

Mill Stream South Tributary MST-26

			September	October	November	December	January	March	April	May	June
Test Code	**Auth.**	***Sampling date***	*18-Sep-08*	*2-Oct-08*	*6-Nov-08*	*4-Dec-08*	*8-Jan-09*	*5-Mar-09*	*2-Apr-09*	*7-May-09*	*4-Jun-09*
		Sample ID number	*20083680*	*NS*	*20085017*	*20085453*	*20090074*	*20091134*	*20091637*	*20092034*	*20093211*
0001	ELS	pH	6.5		6.6	6.5	6.3	6.4	6.7	6.4	6.8
0002	ELS	Suspended Solids (mg/L)	1.5		1.5	1.5	1.5	1.5	1.5	1.5	1.5
0055	ELS	Conductivity @ 25°C (µS/cm)	147		138	140	139	147	148	149	140
0084	ELS	Turbidity (NTU)	0.68		1.9	0.78	0.78	0.91	1.07	1.24	1.15
0089	ELS	Faecal Coliforms (cfu/100mL)	26		1300	250	200	140	14	76	900
0098	ELS	*E. coli* (cfu/100mL)	25		1200	250	200	140	13	61	900
0515	ELS	Nitrite nitrate nitrogen (mg/L)	3.58		2.43	2.74	1.99	2.19	2.23	2.12	2.02
0605	ELS	Nitrate - Nitrogen (mg/L)	3.49		2.52	2.84	2.06	2.25	2.17	2.52	2
0760	ELS	Ammonia Nitrogen (mg/L)	0.005		0.005	0.01	0.005	0.02	0.01	0.005	0.005
2088	ELS	Dissolved Reactive Phosphorus (mg/L)	0.013		0.011	0.018	0.022	0.019	0.021	0.015	0.016
	MDC	Conductivity @ 25°C (µS/cm)	148.3		140.9	146.9	137.8	148.7	152.5	157.4	145.8
	MDC	Dissolved Oxygen (mg/L)	9.29		7.28	6.13	7.07	7.07	8.18	7.57	8.05
	MDC	Dissolved Oxygen (% saturation)	87.8		68.5	59.7	71.8	69.1	80.5	72.1	74.1
	MDC	Average Daily Flow @ Mill Stream (m^3/s)	0.666	0.508	0.372	0.443	0.374	0.315	0.267	0.281	0.332
	MDC	Rainfall @ Mill Stream (mm/72hrs)	0	10	3.5	1.5	22.5	2.5	30	0.5	0
	MDC	Rainfall @ Mill Stream (mm/24hrs)	0		1	0.5	22.5	2.5	0	0.5	0
	MDC	Temperature (°C)	12.9		12.6	14.2	16.2	14.3	14.6	13.2	12

Huddleston Stream upper HDS-1

			September	October	November	December	January	March	April	May	June

Test Code	Auth.	***Sampling date***	*18-Sep-08*	*2-Oct-08*	*6-Nov-08*	*4-Dec-08*	*8-Jan-09*	*5-Mar-09*	*2-Apr-09*	*7-May-09*	*4-Jun-09*
		Sample ID number	*20083672*	*20083861*	*20085009*	*NS*	*20090066*	*20091126*	*20091629*	*20092026*	*20093203*
0001	ELS	pH	7.4	7.5	7.5		7.1	7.1	7	7.2	7.1
0002	ELS	Suspended Solids (mg/L)	6	5	56		5	1.5	1.5	1.5	1.5
0055	ELS	Conductivity @ 25^{o}C (µS/cm)	162	179	181		208	197	185	242	252
0084	ELS	Turbidity (NTU)	3.35	2.7	4.34		2.53	1.48	0.89	1.46	1.18
0089	ELS	Faecal Coliforms (cfu/100mL)	8	97	100		300	190	94	200	63
0098	ELS	*E. coli* (cfu/100mL)	8	97	100		200	190	94	170	63
0515	ELS	Nitrite nitrate nitrogen (mg/L)	3.08	3.74	3.43		2.17	2.54	2.73	2.33	2.33
0605	ELS	Nitrate - Nitrogen (mg/L)	2.9	2.85	2.62		2.28	2.55	2.71	2.69	2.38
0760	ELS	Ammonia Nitrogen (mg/L)	0.01	0.005	0.01		0.005	0.005	0.005	0.005	0.005
2088	ELS	Dissolved Reactive Phosphorus (mg/L)	0.027	0.022	0.02		0.031	0.017	0.017	0.019	0.017
	MDC	Conductivity @ 25^{o}C (µS/cm)	161.4	179.7	182.4		185.5	202.1	193.7	215.1	237.4
	MDC	Dissolved Oxygen (mg/L)	10.15	10.88	10.15		9.42	9.23	9.85	9.91	9.76
	MDC	Dissolved Oxygen (% saturation)	94.8	95.6	92		93.4	89.9	91.3	85.7	82.1
	MDC	Average Daily Flow @ Mill Stream (m^3/s)	0.666	0.508	0.372	0.443	0.374	0.315	0.267	0.281	0.332
	MDC	Rainfall @ Mill Stream (mm/72hrs)	0	10	3.5	1.5	22.5	2.5	30	0.5	0
	MDC	Rainfall @ Mill Stream (mm/24hrs)	0	0	1	0.5	22.5	2.5	0	0.5	0
	MDC	Temperature (^{o}C)	12.3	9.6	11.1		15	14.1	11.9	8.9	8.1

Huddleston Stream mid HDS-2

			September	**October**	**November**	**December**	**January**	**March**	**April**	**May**	**June**
Test Code	**Auth.**	***Sampling date***	*18-Sep-08*	*2-Oct-08*	*6-Nov-08*	*4-Dec-08*	*8-Jan-09*	*5-Mar-09*	*2-Apr-09*	*7-May-09*	*4-Jun-09*
		Sample ID number	*20083675*	*20083864*	*20085012*	*20085448*	*20090069*	*20091129*	*20091632*	*20092029*	*20093206*
0001	ELS	pH	7.7	7.8	8.3	7.6	6.9	6.7	7.1	7.1	7.4
0002	ELS	Suspended Solids (mg/L)	3	29	31	27	6	14	3	26	17
0055	ELS	Conductivity @ 25^{o}C (µS/cm)	155	178	180	169	178	191	187	242	257
0084	ELS	Turbidity (NTU)	2.72	17.2	12.1	17.4	4.42	1.66	2.76	20.1	8.87
0089	ELS	Faecal Coliforms (cfu/100mL)	41	84	92	280	200	250	1800	13000	35
0098	ELS	*E. coli* (cfu/100mL)	38	84	41	260	200	250	1800	10000	35
0515	ELS	Nitrite nitrate nitrogen (mg/L)	2.29	3.46	2.47	1.7	1.32	1.37	1.77	2.89	2.19
0605	ELS	Nitrate - Nitrogen (mg/L)	1.93	2.62	2.43	1.72	1.35	1.42	1.77	2.45	2.24
0760	ELS	Ammonia Nitrogen (mg/L)	0.03	0.02	0.02	0.04	0.02	0.01	0.09	0.09	0.06
2088	ELS	Dissolved Reactive Phosphorus (mg/L)	0.047	0.027	0.02	0.02	0.023	0.007	0.011	0.012	0.01

	MDC	Conductivity @ 25^{o}C (µS/cm)	155.2	178.9	180.1	179	183	195.7	152.6	221.9	240.2
	MDC	Dissolved Oxygen (mg/L)	11.22	10.97	11.09	9.02	6.74	6.15	8.03	9.28	10.67
	MDC	Dissolved Oxygen (% saturation)	119.3	103.9	108.7	95.3	70.9	61.2	76.4	81	85.5
	MDC	Average Daily Flow @ Mill Stream (m^3/s)	0.666	0.508	0.372	0.443	0.374	0.315	0.267	0.281	0.332
	MDC	Rainfall @ Mill Stream (mm/72hrs)	0	10	3.5	1.5	22.5	2.5	30	0.5	0
	MDC	Rainfall @ Mill Stream (mm/24hrs)	0	0	1	0.5	22.5	2.5	0	0.5	0
	MDC	Temperature (^{o}C)	18.2	12.9	14.4	18.1	17.7	15.1	13.1	9.4	5.8

Huddleston Stream lower HDS-3

			September	October	November	December	January	March	April	May	June
Test Code	**Auth.**	***Sampling date***	*18-Sep-08*	*2-Oct-08*	*6-Nov-08*	*4-Dec-08*	*8-Jan-09*	*5-Mar-09*	*2-Apr-09*	*7-May-09*	*4-Jun-09*
		Sample ID number	*20083677*	*20083866*	*20085014*	*20085450*	*20090071*	*20091131*	*20091634*	*20092031*	*20093208*
0001	ELS	pH	6.8	8.5	7.4	6.9	6.6	6.5	6.8	6.9	7.2
0002	ELS	Suspended Solids (mg/L)	4	1.5	3	4	1.5	1.5	1.5	1.5	1.5
0055	ELS	Conductivity @ 25^{o}C (µS/cm)	126	176	177	167	175	180	181	227	255
0084	ELS	Turbidity (NTU)	3.41	2.7	3.39	2.98	1.44	1.04	0.51	0.48	4.03
0089	ELS	Faecal Coliforms (cfu/100mL)	120	45	150	250	500	94	210	33	49
0098	ELS	*E. coli* (cfu/100mL)	43	39	150	250	500	94	210	28	49
0515	ELS	Nitrite nitrate nitrogen (mg/L)	2.03	3.26	2.32	1.04	0.157	0.0025	0.0025	0.298	1.93
0605	ELS	Nitrate - Nitrogen (mg/L)	1.87	2.44	2.23	1.08	0.15	0.005	0.005	0.33	1.88
0760	ELS	Ammonia Nitrogen (mg/L)	0.01	0.005	0.005	0.02	0.01	0.005	0.005	0.005	0.005
2088	ELS	Dissolved Reactive Phosphorus (mg/L)	0.016	0.017	0.012	0.011	0.013	0.007	0.009	0.009	0.006
	MDC	Conductivity @ 25^{o}C (µS/cm)	125.8	175	179.1	178.1	183.1	183.8	190.5	212.4	134.3
	MDC	Dissolved Oxygen (mg/L)	9.57	12.19	10.39	5.98	3.51	4.12	6.13	10.74	11.82
	MDC	Dissolved Oxygen (% saturation)	96.7	114.6	91.9	61.6	38.5	42.5	56.5	86.7	84.8
	MDC	Average Daily Flow @ Mill Stream (m^3/s)	0.666	0.508	0.372	0.443	0.374	0.315	0.267	0.281	0.332
	MDC	Rainfall @ Mill Stream (mm/72hrs)	0	10	3.5	1.5	22.5	2.5	30	0.5	0
	MDC	Rainfall @ Mill Stream (mm/24hrs)	0	0	1	0.5	22.5	2.5	0	0.5	0
	MDC	Temperature (^{o}C)	15.8	12.5	9.9	16.7	20.3	16.9	11.6	6.1	1.6