The Effect of Irrigation Runoff on Water Quality

May 2006

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Foreword – The Effect of Irrigation Runoff on Water Quality

Otago's natural water quality is of very high quality and this has come to be expected from our rural communities, urban dwellers and visitors. However, in some locations water quality is under pressure from intensive or changing land use.

To help protect water quality, the Otago Regional Council carries out long-term water quality monitoring as part of a State of the Environment programme. To supplement this information, targeted and detailed short-term monitoring programmes are also implemented in some catchments. This report explores the impact of a typical irrigation technique, flood irrigation, on water quality in six catchments in Central and North Otago.

The catchments monitored were selected because of the prevalence of flood irrigation. Other locations using this type of irrigation may show different results due to differing soil and slope characteristics. However, this report is intended to provide a baseline from which to work with the local community through Catchment Programmes, an initiative developed by the Otago Regional Council which aims to sustain and improve water quality by encouraging environmentally sound land use and water management practices.

Executive Summary

In September 2004, Otago Regional Council began a surface water quality monitoring programme in tributaries of the Manuherikia (Chatto Creek, Thompsons Creek, Ida Burn), Taieri River (Pig Burn, Sow Burn, Gimmer Burn) and Waitaki River (Welcome Creek). Physico-chemical and microbiological water quality samples were taken at two sites on each of the tributaries monitored, the objective being to determine whether a deterioration occurred in water quality (faecal bacteria, nitrogen and phosphorus) downstream of irrigation takes.

Flood irrigation is the main irrigation method used in the catchments monitored - this can be an inefficient method of application that generates runoff likely to re-enter surface water. This study clearly shows that water quality in all the tributaries monitored were degraded due to flood irrigation practices during the summer period. Generally the deterioration coincided with an increase in water temperature at the start of the irrigation season. In the Manuherikia catchment, water quality in Thompsons Creek showed the worst deterioration, whilst in the Taieri catchment, water quality was poorest in the Gimmer Burn. Welcome Creek, the spring fed system, also showed a deterioration - this was most evident in phosphorous concentrations.

As well as a deterioration in water quality, abstractions for irrigation may use all of the available flow. Two of the monitored sites, Gimmer Burn and Thompsons Creek, lost natural upstream flow to irrigation practice.

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1. Introduction

In September 2004, Otago Regional Council began a surface water quality monitoring programme in tributaries of the Manuherikia (Chatto Creek, Thompsons Creek, Ida Burn), Taieri River (Pig Burn, Sow Burn, Gimmer Burn) and Waitaki River (Welcome Creek).

The catchments chosen are heavily irrigated and it is known that surface water runoff from agricultural land contributes to declining water quality due to nutrient and faecal bacteria contamination (Doran & Linn 1979; McDowell et al. 2001). The issue of poor water quality in areas of intensive agriculture has also been highlighted in a report by the Parliamentary Commissioner for Environment (PCE, 2004).

Otago Regional Council had not previously undertaken any intensive monitoring on tributaries affected by irrigation, and therefore monthly physico-chemical and microbiological water quality samples were taken at two sites on each of the tributaries monitored, the objective being to determine whether a deterioration occurred in water quality (faecal bacteria, nitrogen and phosphorus) downstream of irrigation takes.

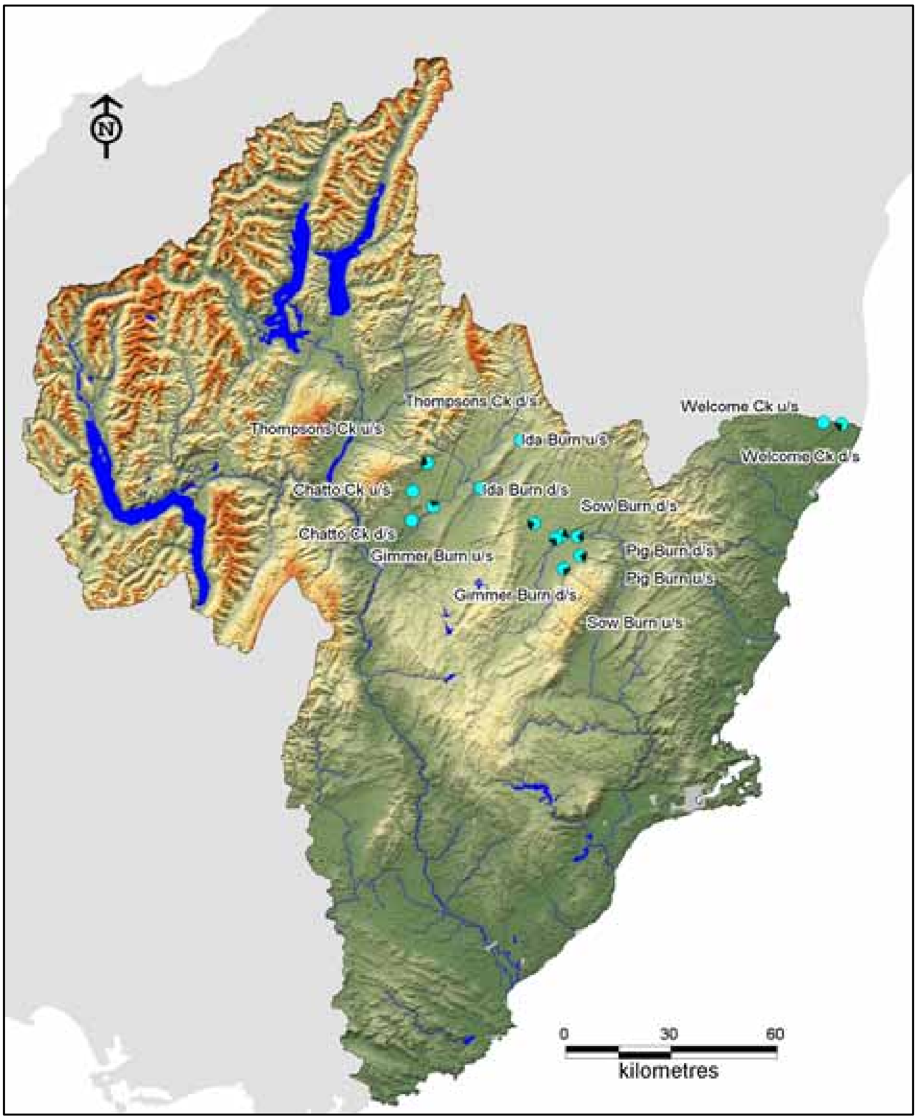


Figure 1.1 Location of water quality sampling sites

2. Background information

2.1 Irrigation history

During the 1860s and 1870s, much of the water in the Clutha River/Mata-Au and Taieri tributaries had been claimed under the Mining Act procedures (Hinchley, 1981), and it was not until gold mining activities decreased that water became available to any extent for irrigation. During the latter phases of the mining era, the higher priority and more valuable water rights from the larger sub catchments were taken over by water companies which developed the storage necessary to provide a reliable summer supply and the race systems from which water was sold to individual miners for sluicing purposes. As mining areas ceased to operate, these companies were purchased by the Crown as a basis for the development of communal irrigation systems.

2.2 Irrigation efficiency

The catchments in which water quality sampling was carried out are predominantly flood or border dyke irrigated. Figure 2.1 shows a simplified schematic of flood irrigation - water is taken from the watercourse (dark blue arrows), applied to land (black arrows) and excess irrigation water finds it way back into the watercourse (red arrows). The effect is cumulative - many takes on the same watercourse will see water quality quickly deteriorate downstream as water is reused for irrigation.

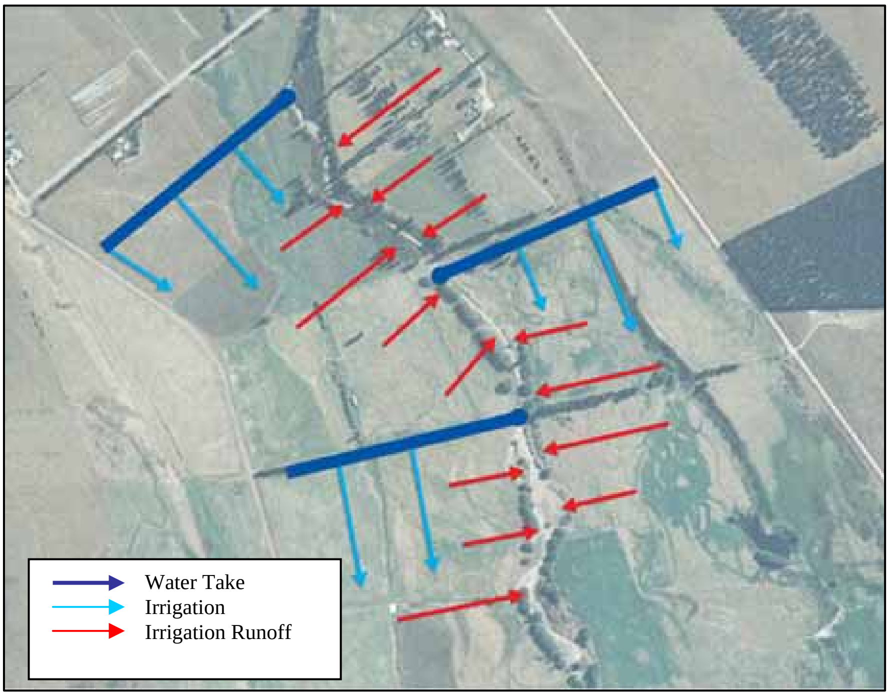


Figure 2.1 Schematic of flood irrigation. The red arrows show how irrigation runoff re-enters the watercourse

Irrigation efficiency is becoming a key issue facing farmers in New Zealand, with nutrient leaching likely to occur with poorly designed and installed systems that have a low application efficiency.

Table 2.1 shows that border dyke irrigation can have low application efficiency compared to other types of irrigation. That is, under border dyke irrigation a high proportion of the applied water can re-enter waterways.

Table 2.1 New Zealand border-dyke irrigation efficiencies (after Aqualinc 2006)

Lincoln Environmental (McIndoe & Carran, 1998; McIndoe, 1999).	**AE Range (1997)**	**Average AE**
Centre-pivot	34 to 100%	78% (1997) 96% (1998)
Border strip	31 to 61%	45% (1997) 34%* (1998)
Rotary boom		>90%**(1998)
Canterbury University (Evans, 1999)	**AE Range**	**Seasonal Efficiency**
Rotary Boom Irrigator	24 to 90%	61%
Border Strip	13%***	
Lincoln University (Stronge 1991)	**AE Range**	**Average AE**
Border Strip	30 to 90%	56%
Lincoln Environmental (Rout, *et al*., 2002)	**AE Range**	**Average AE**
Laser-level border (timber sill)	24 to 80%	48%
Laser-level border (grass sill)	37 to 93%	62%
Contour border (timber sill)	27 to 62%	44%
Travelling Irrigator (Roto-Rainer 100)	76 to 96%	85%
Travelling Irrigator (Homersham gun)	62 to 70%	67%
* variable flow rates and management decisions based on water supply restrictions, **deficit irrigation due to limited irrigation system capacity (with potential loss of yield), ***best practice irrigation not performed, stony soils. AE = application efficiency.		

2.3 Impact of pollutants on water quality

There are four main pollutants that enter waterways - nitrogen, phosphorous, sediment and faecal bacteria. Table 2.2 indicates why each pollutant is a problem and how it may enter watercourses in the first instance.

Well-managed waterway margins, grassed farm drains, seepage areas and wetlands help protect water quality by filtering surface runoff, taking up nutrients before they reach the water, removing nitrogen, reducing the amount of effluent reaching the water and preventing stock access (fencing reduces bank erosion from trampling). Flood irrigation practices generally don't incorporate methods of preventing runoff from returning to the watercourse, thus a deterioration in water quality is inevitable.

Table 2.2 Nitrogen, phosphorous, sediment and faecal bacteria. Why they are a problem, where they come from and how they get into water courses

Pollutant	Why it is a problem	Source of pollutant	How it gets to water
Nitrogen	Feeds nuisance plant and algae growth in waterways Algae and nuisance plants affect stream life, block water intakes and drains, and make water unpleasant for swimming and drinking Ammonia can be toxic to fish	Urine from stock Nitrogen in fertiliser Ammonia in dairy shed wastewater	Moves through soil (leaching) into groundwater and subsurface drains, which feed into streams Surface runoff Stock in streams Discharges from oxidation ponds
Phosphorus	Feeds nuisance plant and algae growth in waterways Algae and nuisance plants affect stream life, block water intakes and drains, and make water unpleasant for swimming and drinking	Dung from stock Phosphate in fertiliser Farm dairy effluent Soil sediment	Soil and bank erosion (phosphate binds to soil particles) Surface runoff Discharges from oxidation ponds Stock in streams Subsurface drains
Sediment	Makes water murky and affects stream life Poor water clarity makes water unsafe for swimming	Hillside erosion Stream bank erosion and trampling Tracks and races Surface of paddocks	Surface runoff Stream bank collapse Hillside erosion
Faecal matter (bacteria, viruses)	Creates a human health risk from swimming and drinking Affects stock health if present in stock water	Dung from stock Farm dairy effluent	Stock in streams Subsurface drains Discharges from oxidation ponds Surface runoff Poorly-managed effluent irrigation

Source: http://www.ew.govt.nz/enviroinfo/land/management/runoff/index.htm

2.4 Impact of rainfall on water quality

Rainfall has a great impact on water quality because surface water runoff effectively washes the land surface and therefore contains all four pollutants mentioned above. In the Manuherikia and Taieri tributaries, 10mm or more of rainfall within 3 days of sampling appears to have an effect on water quality. In Welcome Creek, rainfall within 24 hours of sampling has an effect, but due to the small catchment rainfall prior to this has little impact.

2.5 Impact of flood irrigation on temperature

Seasonal variation in water temperature is normal, with higher temperatures in summer. However, flood irrigation increases water temperature. As water flows over hot land it heats quickly and runoff re-entering the watercourse will have an elevated temperature compared to the watercourse. The actual effect will be the cumulative impact of all irrigated farms.

3. Physico-chemical and microbiological monitoring

To monitor the effects of irrigation runoff on water quality the following sites were sampled monthly:

- Welcome Creek in the Waitaki catchment.
- The Pig Burn, Sow Burn and Gimmer Burn in the Taieri catchment.
- Thompsons Creek, Ida Burn and Chatto Creek in the Manuherikia catchment.

Each river had two sampling sites and were monitored at various times between February 2004 and February 2006. Appendix 1 gives the full details of sampling.

Water samples were tested for a range of physico-chemical and microbiological parameters. These included DO, temperature, conductivity, pH, suspended solids, turbidity, faecal coliforms (Fc), *Escherichia coli (Ec)*, ammoniacal nitrogen (NH_4), nitrite-nitrate nitrogen (NNN), total nitrogen (TN), dissolved reactive phosphorus (DRP) and total phosphorus (TP). A continuous temperature logger was also installed at the downstream Taieri and Manuherikia sites.

Table 3.1 Abbreviations commonly used in this report

Abbreviation	Explanation
C	Concentration
Cfu	Colony forming units
Chl	Chloride
Cond	Conductivity mS/cm
Chla	Chlorophyll *a*
DO	Dissolved Oxygen
DRP	Dissolved reactive phosphorus mg/L
Ec	*Escherichia coli* bacteria, cfu/100mL
Ent	Enterococci bacteria, cfu/100mL
Fc	Faecal coliform bacteria, cfu/100mL
MIC	Maniototo Irrigation Company
NH_4	Ammoniacal-nitrogen mg/L
NNN	Nitrate and nitrite nitrogen, mg/L
T	Water temperature ºC
TN	Total nitrogen mg/L
TP	Total phosphorus mg/L
Turb	Turbidity, nephelometric Turb units (NTU)

4. Manuherikia

4.1 Catchment description

The Manuherikia has two branches and is joined by the Dunstan Creek which emerges from the south side of the St Bathans range. In places it is deeply incised in gorges and in other places flows in a clearly defined channel through low terraces, with small flood plains.

Tributaries of the west bank rise in the high catchments from the Dunstan Range and flow across the terraces of the western basins. The most notable of these are the Lauder, Thompsons and Chatto Creeks. The smaller tributaries rising from the foothills of the Dunstans are largely ephemeral.

Tributaries of the east bank of the upper catchment run directly off the Hawkdun Range and in the lower catchment there is some contribution from the backslope of the Blackstone-Raggedy block formation.

The Manuherikia catchment is dominated by exotic grassland, both high and low producing. Throughout the Manuherikia catchment sheep and beef farming predominate.

The Omakau Irrigation Scheme takes water from the Manuherikia River, using storage at the Falls Dam. The main intake for the Omakau scheme is near Blackstone Hill, approximately 4 km upstream of Becks. The races relevant to Thompsons Creek are the Clearwater race that takes water from Thompsons Creek, servicing the area west of Omakau, and the Matakanui sub-scheme that takes water from Thompsons Creek and supplies the Matakanui area.

Most of the watercourses that drain the Manuherikia side of the Dunstan Mountains are steady flowing, incised waterways in their upper reaches. However, as the creeks flow out of the hills and onto the Matakanui Plains, irrigation abstractions mean that a lot of surface flow in the lower reaches is lost, often being maintained by runoff from flood irrigation from irrigation company races and private mining privileges. Water is often reused several times by irrigators along the length of a creek.

4.2 Rainfall in the Manuherikia catchment

The amount of rainfall 24 hours, 48 hours and 72 hours prior to each sampling period was determined at the Hills Creek raingauge. Table 4.1 gives details.

Table 4.1 Rainfall recorded at Hills Creek 24 hrs, 48 hrs and 72 hrs prior to a sampling event. Only dates with recorded rainfall are listed

	24 hour	48 hour	72 hour
17-Nov-04	0	44.5	46
10-Feb-05	0	0	6
27-Sep-05	0.5	1	1.5
24-Nov-05	0	4	21
21-Dec-05	12.5	12.5	12.5
No rainfall recorded on: 9th Sep 2004, 26th Jan 2005, 15th March 2005, 25th May 2005, 27th July 2005, 25th Oct 2005, 21 Nov 2005, 1st Feb 2006			

4.3 Thompsons Creek


Figure 4.1 Thompsons Creek race and the Manuherikia at Omakau, downstream of the sampling sites

Water is taken from Thompsons Creek and diverted to the Clearwater Race (two red stars at top of Figure 4.2). Figure 4.2 shows the Thompsons Creek catchment to be dominated by flood irrigation and also shows a network of drains (sludge channels). Water is taken from the drains and reused for flood irrigation, before entering drains downstream, from which other takes retake the runoff water. Eventually the drains converge and run to Thompsons Creek just upstream of SH85. The water in the drains is almost wholly seepage from the Omakau Scheme race and runoff from upstream irrigation.

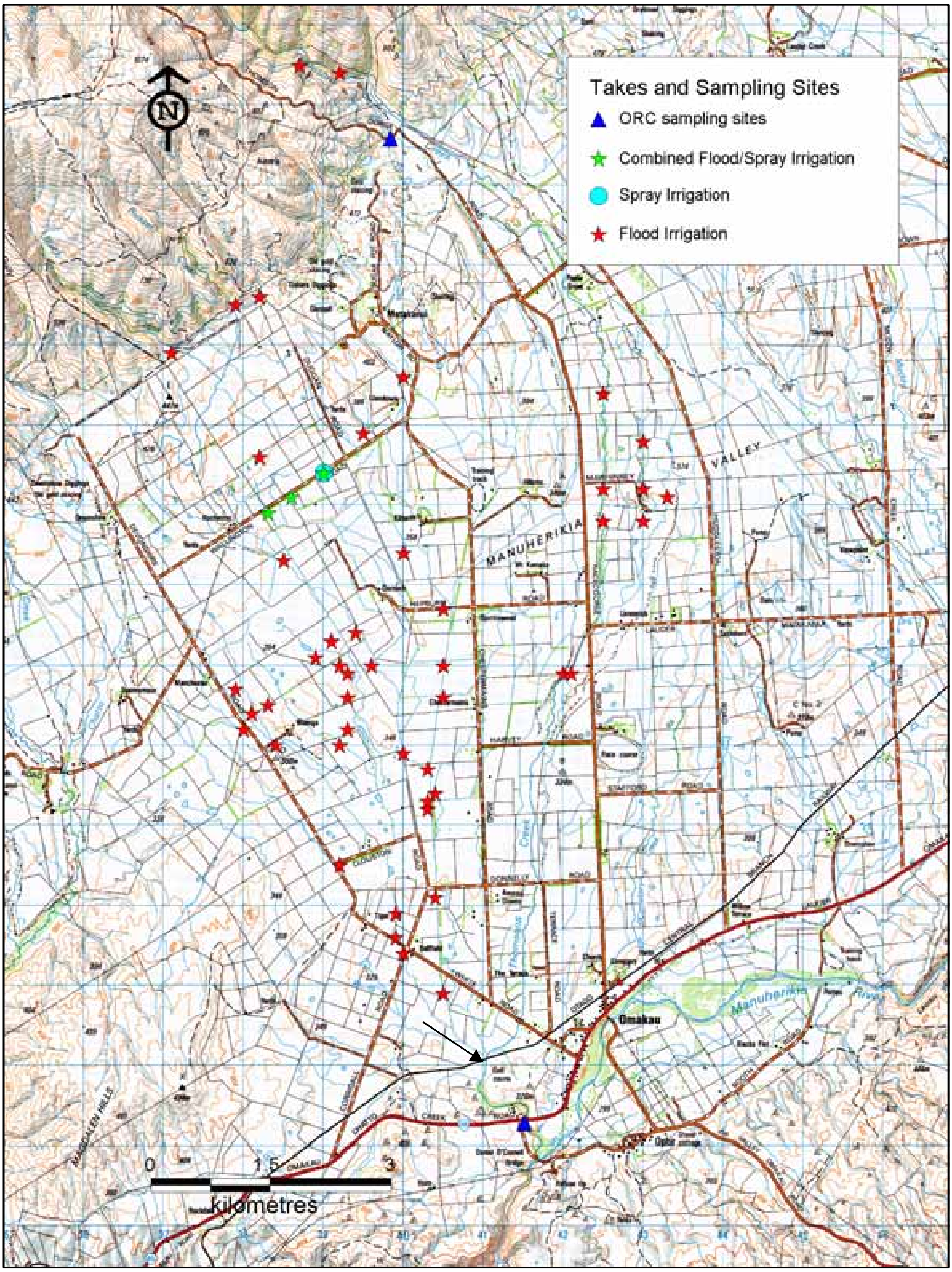


Figure 4.2 Thompsons Creek. ORC sampling points and takes. The arrow indicates the confluence of Thompsons Creek and a tributary dominated by flood irrigation practices

Thompsons Creek was monitored between September 2004 and February 2006. Figure 4.3 looks at selected analytes for both the upstream and downstream sites. Full results are located in Appendix 1.

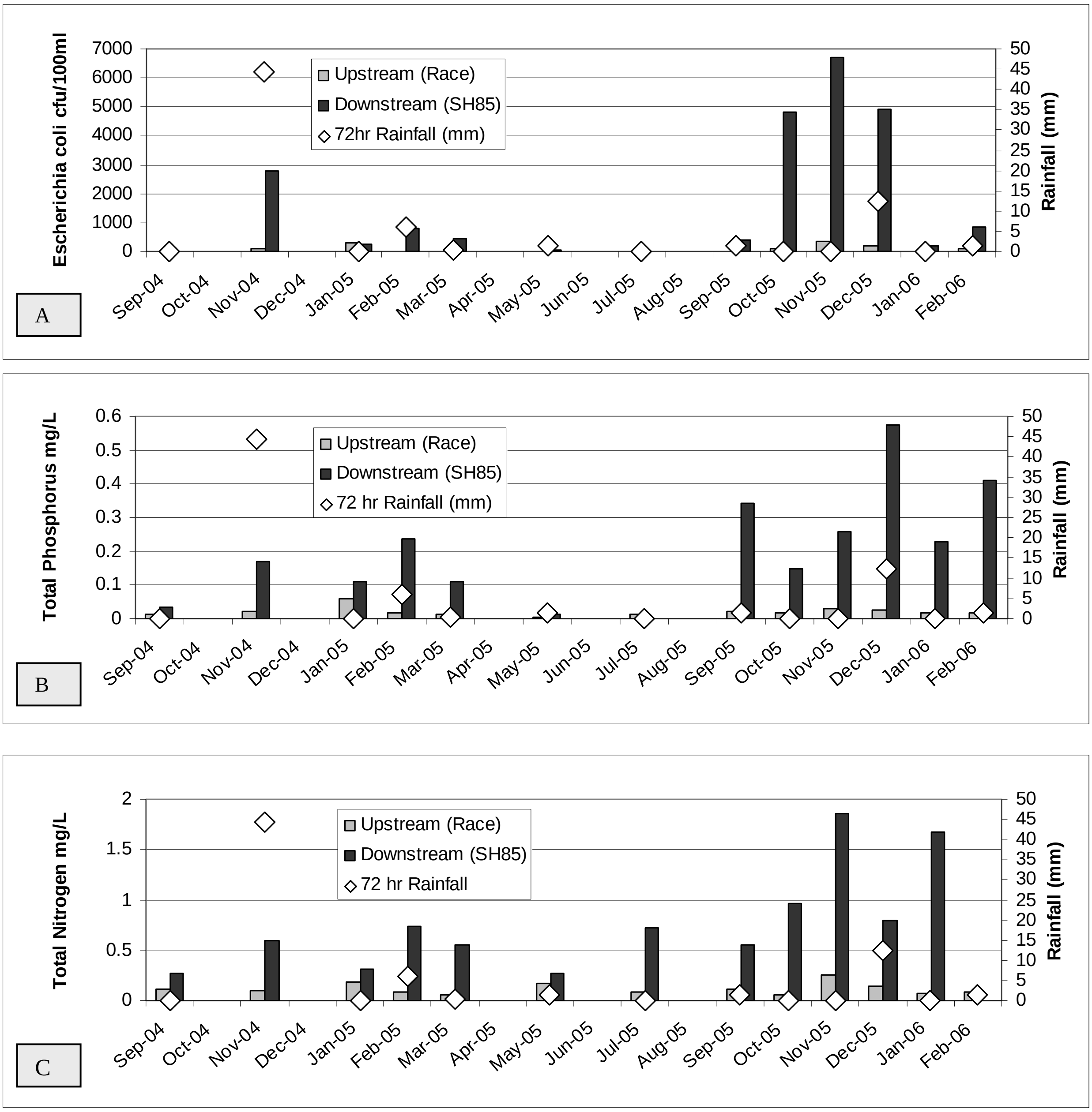


Figure 4.3 Thompsons Creek water quality. Samples taken between September 2004 and February 2006. A - *Escherichia coli;* B - Total phosphorus; C -Total nitrogen

Figure 4.3A shows Ec, with extremely elevated levels during summer 2006. Ec peaked at over 6000 cfu/100ml, which, when compared to MfE/MoH guidelines, greatly exceeds the contact recreation level high alert level of 550 cfu/100ml. When compared to the upstream site, all levels were all below this MfE/MoH level.

Figure 4.3B and C show elevated levels of nutrients, especially during the summer 2006 period. The rainfall of 21 December 2005 may be the cause of elevated nutrient levels. A TP concentration of 0.574mg/l was recorded, phosphorus clings tightly to soil particles and levels are likely to be elevated when runoff contains sediment. At the downstream site, TP exceeded ANZECC trigger value for upland streams on all occasions, and TN exceeded the trigger value (0.295 mg/l) on most sampling occasions. The upstream site had concentrations which were generally well within the guideline levels.

The downstream water quality deterioration was also shown by increases in Cond and decreases in DO levels (which dropped below 80% saturation on the last sampling occasion). The downstream site also showed much higher Turb levels compared to the upstream site. For example, in October 2005, Turb was 7.2 NTU at the downstream site, but only 1.2 NTU at the upstream site.

Water temperature was also monitored - Figure 4.6 shows a graph of temperature taken at the downstream site (SH85) on Thompsons Creek. The graph shows a typical seasonal pattern, with the minima in June/July and maxima early in the year. 2004 showed a much shorter period of elevated temperatures compared to 2005.

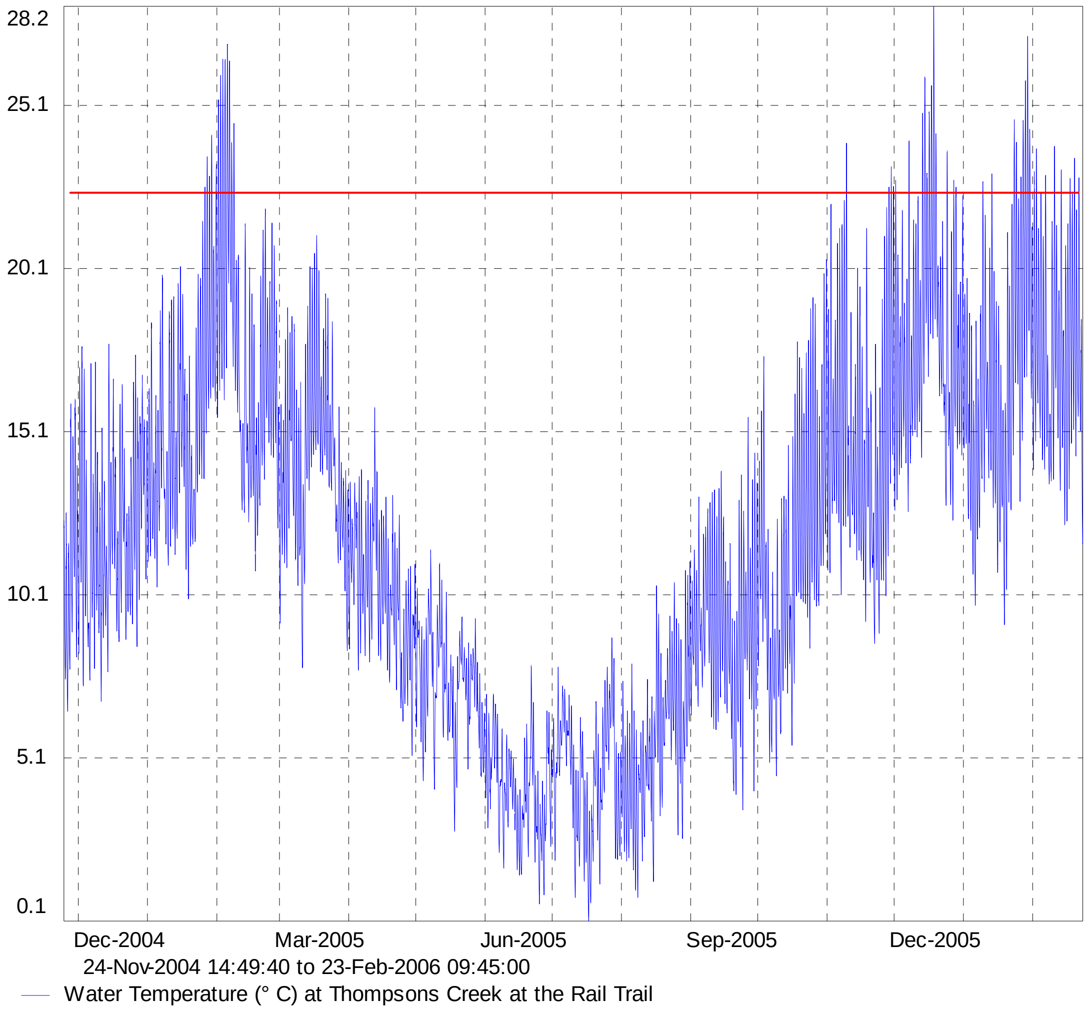


Figure 4.4 Thompsons Creek temperature, taken at 15 minute intervals between November 2004 and February 2005 (red line indicates very high temperature)

Although there is obviously a natural increase in water temperature as summer progresses, high temperatures, indicated by the values above the red line in Figure 4.4, are probably a reflection of irrigation runoff and low flows.

The downstream site showed a marked increase in temperature between September and October 2005 (Appendix 1). At the same time, there was a marked deterioration in water quality which may correspond to irrigation practices. The deterioration was not so pronounced in 2004/2005 as compared to the 2005/2006 period, probably due to 2004/2005 being a wetter year.

The lower site on SH85 generally had poorer water quality than the upper site in the race. Table 4.2 shows the dates when water temperature was highest and lowest. It can be seen that water quality deteriorated when temperatures were higher.

Table 4.2 Water quality on dates when maximum and minimum temperatures were recorded

Date	Site	Turb	Cond	DRP	EC	TN	TP	Temp
25/5/6	Upper	0.65	0.0538	0.007	2	0.17	0.006	5.57
Min	Lower	2.2	0.084	0.011	52	0.27	0.013	7.42
01/02/06	Upper	0.64	0.058	0.008	12	0.07	0.015	18.67
Max	Lower	2.8	0.09	0.0025	190	0.8	0.23	18.52

4.4 Chatto Creek

Chatto Creek is part of the Omakau Irrigation Scheme, the County sub-scheme which uses water from the County race and Devonshire race system on the Upper Chatto Creek catchment and supplies water to the Devonshire area.

Figure 4.5 shows Chatto Creek ORC sampling sites and takes. The catchment has two main stems, Chatto Creek and Younghill Creek (which discharges into Chatto Creek 100m upstream of the confluence with the Manuherikia River). It can be seen that the catchment is dominated by flood irrigation. Most of the takes are on Younghill Creek.

The upstream sampling site is below various takes used for flood irrigation, clearly seen in Figure 4.5. These takes are expected to have an adverse affect on water quality at this upstream site. The creek then flows down a gorge, and there is just one take between the upstream and downstream site.

It is therefore expected that the downstream site will have similar or better water quality than the upstream site. Water quality at the upstream site is compromised due to flood irrigation, and there is little available land available for flood irrigation between the upstream site and downstream site, therefore natural dilution may improve water quality at the downstream site.

Figure 4.6 shows an aerial photograph of the area bounded by the rectangle in Figure 4.5. This clearly shows flood irrigation practices in the area to the west of Coal Creek. The paddocks appear striped, irrigation is applied to the top of paddocks, but the flow towards the bottom of the paddocks is not uniform, some areas getting plenty of water (green), other areas not receiving enough water (brown).

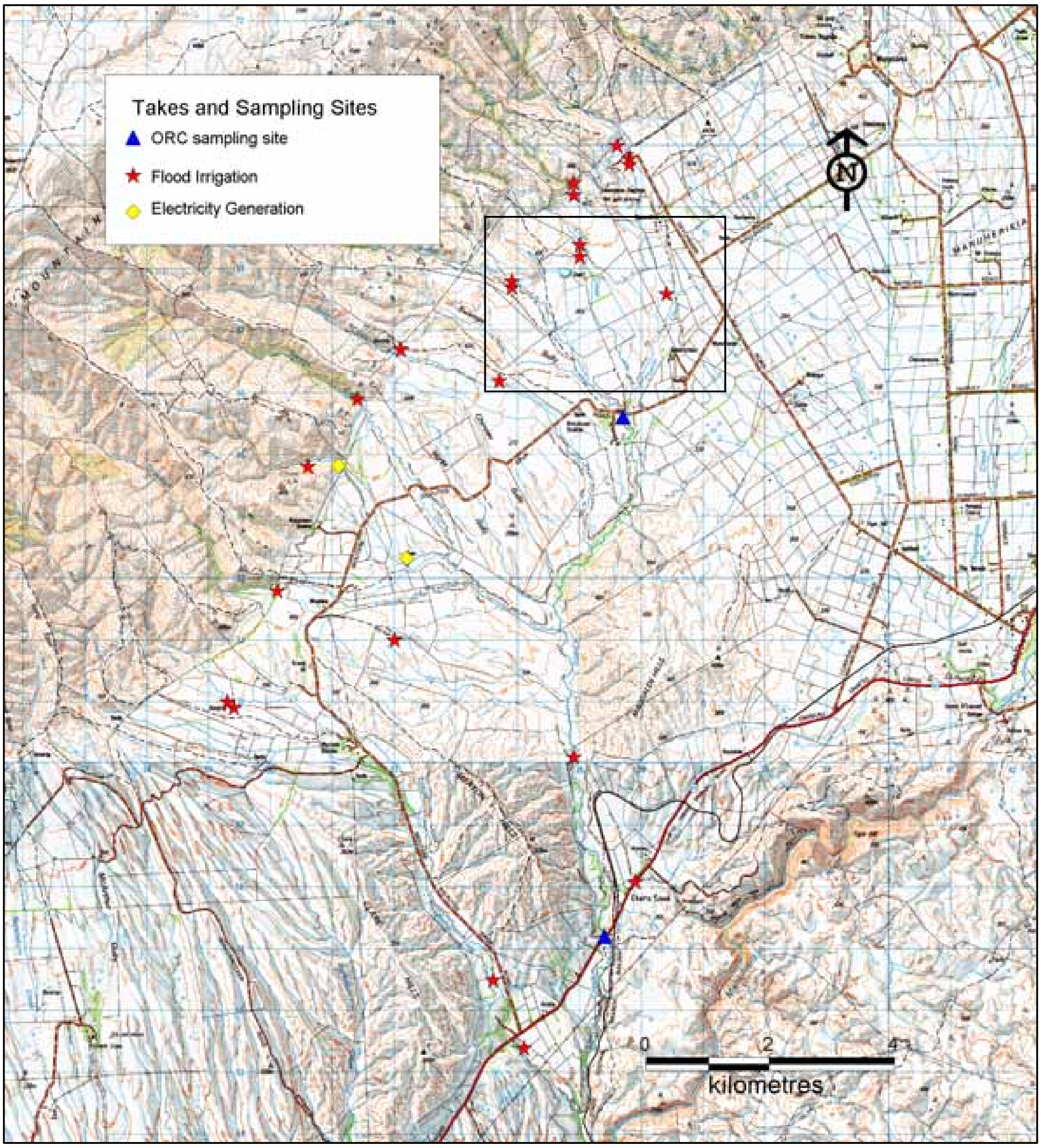


Figure 4.5 Chatto Creek. Water takes shown by red stars, ORC sampling sites shown by blue triangles. The area enclosed by the rectangle is shown in the aerial photograph (Figure 4.6)

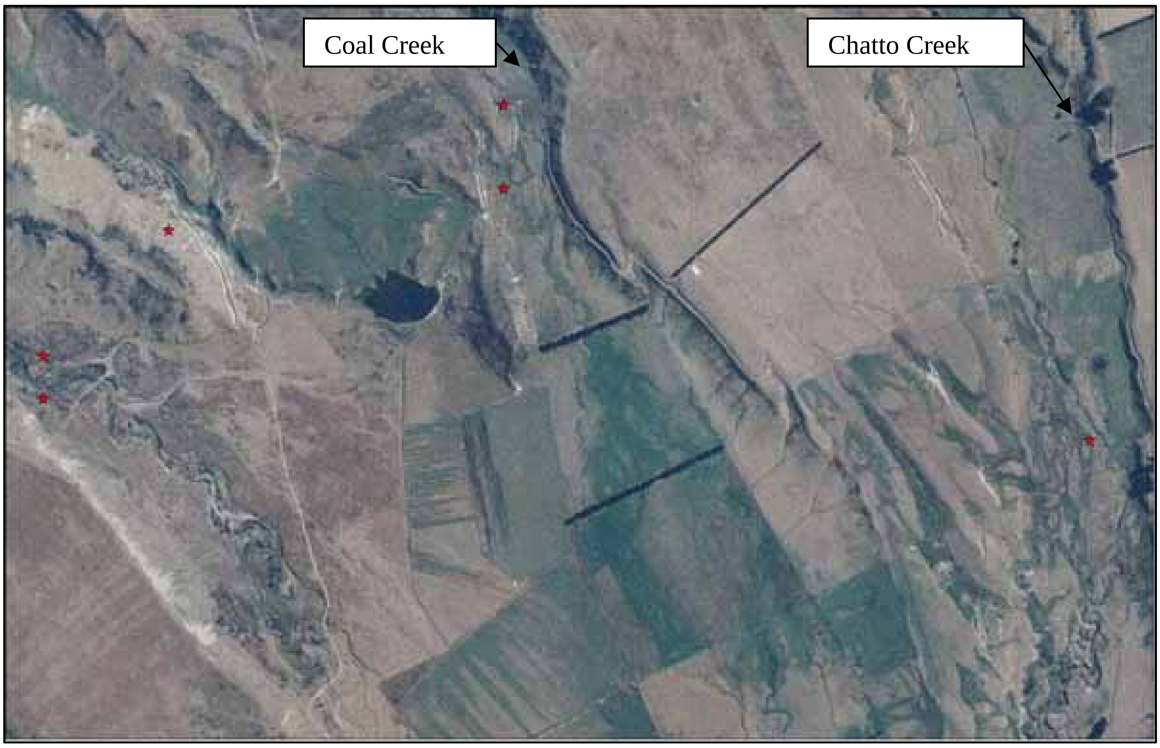
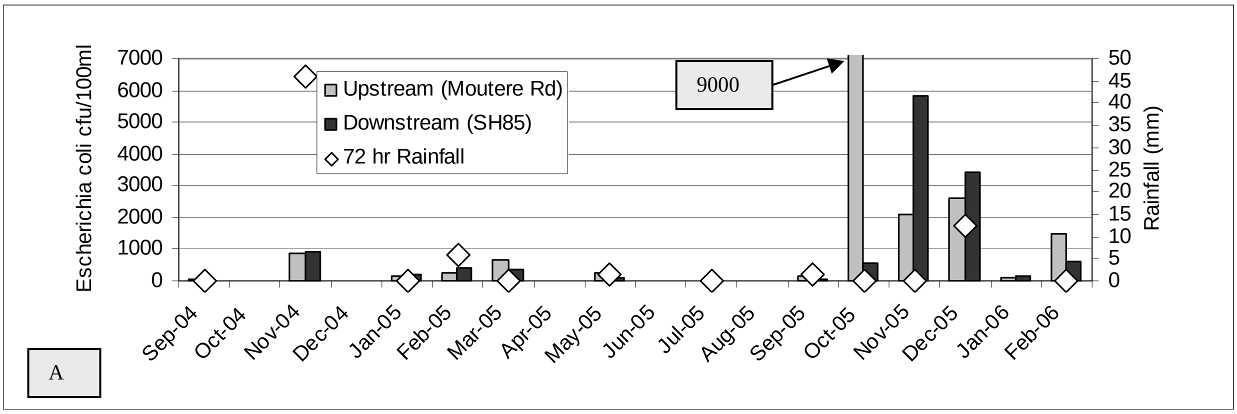
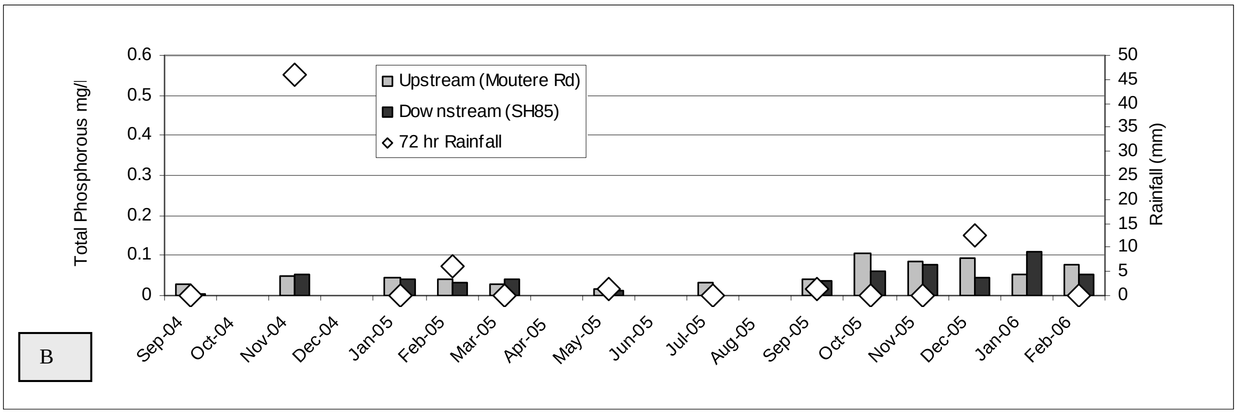


Figure 4.6 Aerial photograph of flood irrigation on Coal Creek and Chatto Creek

Chatto Creek was monitored between September 2004 and February 2006. Figure 4.7 looks at selected analytes for both the upstream and downstream sites over the period. Full results are located in Appendix 1. Over the summer period it is expected that upstream results will be of similar quality, or better than downstream results.





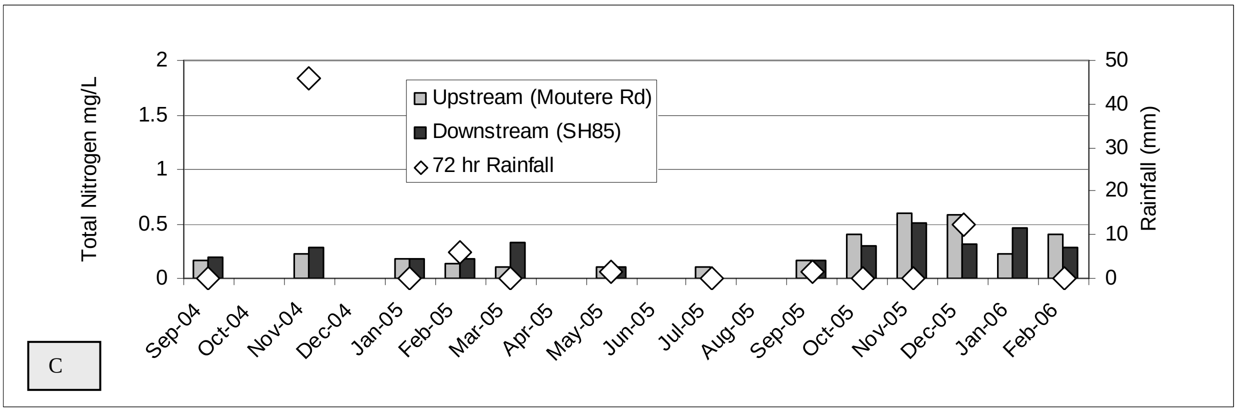


Figure 4.7 Chatto Creek water quality. Samples taken between September 2004 and February 2006. A - *Escherichia coli;* B - Total phosphorus; C - Total nitrogen

Figure 4.7A shows Ec, in November 2004 elevated levels can be linked to the 44.5mm of rain that fell 48 hours before the sample. However, it is not until the 2005 irrigation season that levels increase dramatically, particularly between October 2005 and December 2005. In October 2005, the upstream site recorded 9000 Ec/100ml, which may reflect irrigation practices immediately upstream as this was a much higher result than the downstream site. However, the November and December results have downstream results showing higher Ec concentrations.

Figure 4.7B shows TP - again it is not until the 2005 irrigation season that levels show a significant increase. However, it is worth noting that TP concentrations exceed the ANZECC default guideline value for upland rivers (0.026mg/l) at both upstream and downstream sites on most sampling occasions. Other than in January 2006, the upstream site shows higher levels of TP than the downstream site and the rainfall that coincided with the December sample seems to have had little impact. However, in January 2006 the downstream site had elevated levels compared to the upstream site. This is also reflected in the results for TN shown in Figure 4.7C, where the January 2006 results also showed lower levels of TN at the upstream site.

The upper site generally showed more deterioration than the lower site. For example, Turb tends to exceed the ANZECC default guideline value for upland rivers (<4.1 NTU) on the occasions when nutrient and bacteria levels are high (see Appendix 1). In October 2005, the upstream site recorded 6.9 NTU. In November 2005, whereas the downstream site recorded 4.7 NTU, in this month Cond, DRP, Ec, TN and TP were all elevated at the upper site compared to the lower site. The improvement in water quality between the upper and lower sites may be due to natural dilution, but there is also an opportunity for sediment to settle out.

The deterioration in water quality over the irrigation season is more marked in 2005/2006 as this was a drier year than 2004/2005. Figure 4.7B and C clearly shows that nutrient levels increase between September and December, which correlates nicely with the increasing temperature, and probably relates to increasing irrigation requirements.

Water temperature was taken continuously at the downstream site between August 2005 and February 2006. Temperatures increased to a daily mean maximum of 19.9Deg C on 18 December, with the highest temperature recorded on 23 January 2006 (25.8Deg C). There was a marked increase in temperature between September and October 2005 - at the downstream site temperatures rose by 5.99ºC. This increase in temperature probably reflects the beginning of the irrigation period.

Table 4.3 shows the dates when water temperature was highest and lowest. Although there is no clear deterioration downstream, it can be seen that the early summer sample in 2005 shows a marked deterioration from the winter sample in May.

Table 4.3 Water quality on dates when maximum and minimum temperatures were recorded

Date	Site	Turb	Cond	DRP	EC	TN	TP	Temp
25/5/6 Max	Upper Lower	2.3 1.4	0.044 0.085	0.013 0.01	180 62	0.1 0.11	0.016 0.012	6.82 6.59
01/02/03 Min	Upper Lower	2 1.7	0.058 0.208	0.016 0.045	79 130	0.23 0.46	0.053 0.111	19.92 20.17

4.5 Idaburn

The Idaburn Scheme supplies irrigation water to the northern area of the Ida Valley. This scheme also utilises the north branch of the Ida Burn (otherwise known as Hills Creek) and the Idaburn Dam.

The Idaburn race runs from the western slopes of the Hawkdun Range, crossing into flatter country of the Idaburn catchment, then to a weir at the catchment boundary between the Idaburn (Clutha) and the Wetherburn (Taieri). Various streams are crossed by the race and picked up, including: Hills Creek, Wades Creek, Hills Creek and Idaburn. Irrigation and stockwater is distributed to farms in the Idaburn valley through a mix of natural watercourses and distributary races. Additional water for the Idaburn Dam is also released from the Mt Ida race via Hills Creek.

Figure 4.8 shows that the main takes in this catchment are all for flood irrigation purposes. The upper ORC sampling site has several takes above it, and even though the water takes are upstream, it is likely that water is not actually used for irrigation until further downstream in the catchment. However, the upper site should not be a reference site as the irrigation practices may affect water quality. It is likely that water quality at the top site at SH85 will still be of higher quality than at the lower site on Auripo Road.

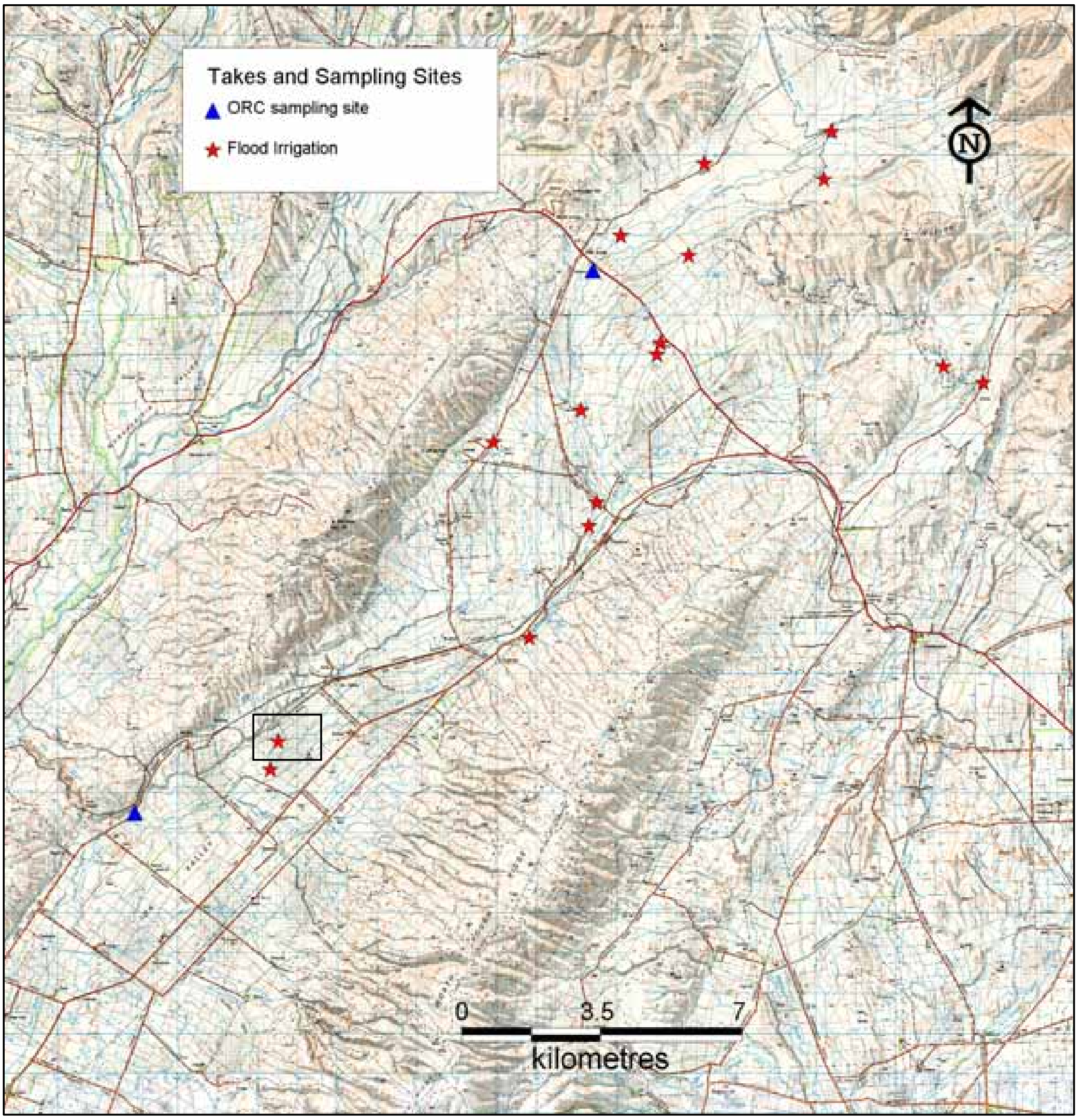
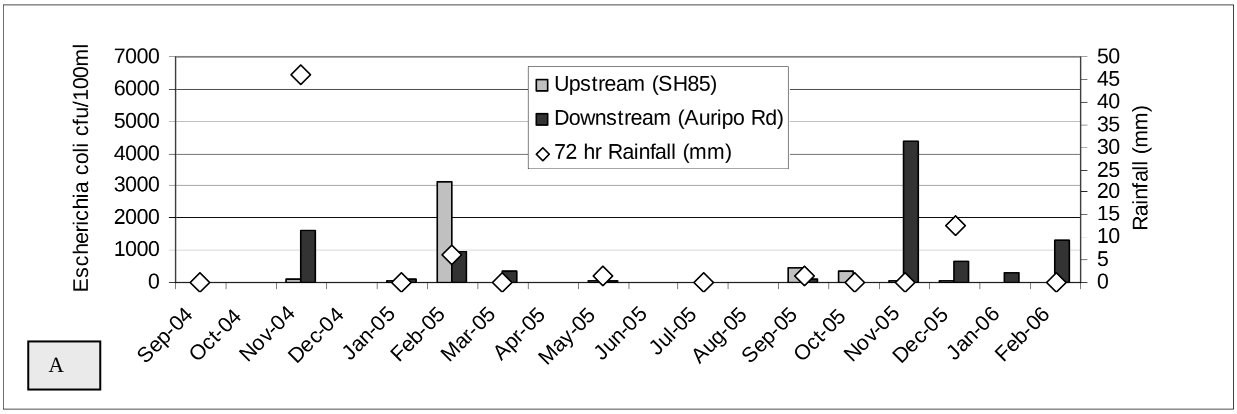


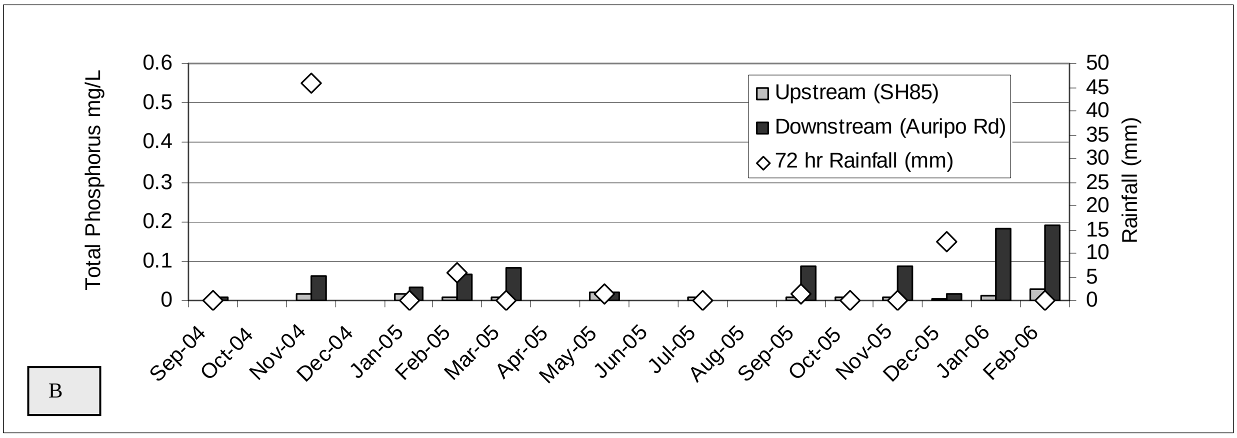
Figure 4.8 Ida Burn. Flood irrigation is indicated by red stars, ORC sampling sites by blue triangles. The area bounded by the rectangle is shown in Figure 4.9

Figure 4.9 Aerial photograph of flood irrigation and drainage channels in area bounded by rectangle in Figure 4.8

Figure 4.9 shows the area bounded by the rectangle in Figure 4.8 - the Ida Burn is in the centre of the photograph, the red star indicates a take from the Ida Burn and irrigation channels and irrigated paddocks can be seen clearly.

The Idaburn was monitored between September 2004 and February 2006. Figure 4.10 looks at selected analytes for both the upstream and downstream sites. Full results are located in Appendix 1.





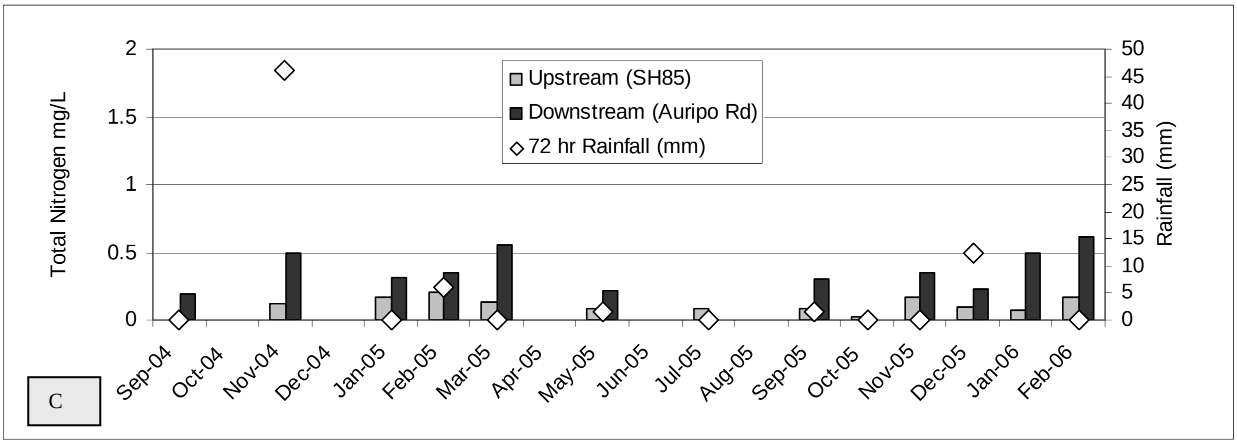


Figure 4.10 Ida Burn Creek water quality. Samples taken between September 2004 and February 2006. A - *Escherichia coli;* B - Total phosphorus; C - Total nitrogen

Figure 4.10A shows Ec, over the two irrigation seasons (November to February), levels were noticeably higher than in the winter period. Other than the February 2005 result, the downstream site had higher levels of Ec than the upstream site. Table 4.1 shows that 21mm of rainfall fell in the 72 hours prior to the November 2004 sample being taken. This probably caused an increase in Ec due to surface water runoff.

Figure 4.10B and C clearly shows the TP and TN concentrations are consistently higher at the downstream site, with most samples exceeding the default ANZECC trigger values (0.295mg/L for TN and 0.026mg/l for TP), whilst none of the upstream samples exceeded these trigger values.

Temperature was recorded continuously at the Ida Burn downstream site (Auripo Road) and showed that temperature increased sharply in September and remained elevated until the end of January, which coincides with the irrigation season and deterioration in water quality.

The lower site at Auripo Road generally had poorer water quality than the upper site at SH85.

Table 4.4 shows the dates when water temperature was highest and lowest. There is a clear deterioration in water quality in February when compared to the winter sample.

Table 4.4 Water quality on dates when maximum and minimum temperatures were recorded. Water quality in summer and winter

Date	Site	Turb	Cond	DRP	EC	TN	TP	Temp
25/5/6	Upper	0.55	0.026	0.005	69	0.09	0.022	7.22
Min	Lower	3.4	0.098	0.011	48	0.22	0.021	6.7
14/02/06	Upper	1.6	0.078	0.01	12	0.17	0.028	16.23
Max	Lower	9.4	0.107	0.105	1300	0.62	0.191	18.29

5. Upper Taieri

5.1 Catchment description

The Taieri River rises in the rolling tussock tops of the Lammermoor and Lammerlaw Ranges at an altitude of just under 1200m. From its headwaters it flows generally northwards to Taieri Falls where it drops abruptly over the fault scarp falling nearly 200m to Canadian Flat and then the larger Styx Basin. From Paerau the Taieri River drops through the Paerau Gorge to emerge in the Maniototo Basin at Hores Bridge. The Maniototo has characteristic meanders, cut-off loops and swampy flood plains.

A number of tributaries join the Taieri in the Maniototo Basin including the Sow Burn and Pig Burn from the east and the Gimmer Burn/Wether Burn and Ewe Burn from the north. All of these are heavily committed to the supply of water rights and rarely contribute much flow to the river except during the spring and at times of flood.

The Maniototo is mainly dominated by high producing exotic grassland. There has been an increase in dairy conversions in the area, however, the main farm type is still sheep and beef.

In 1975, the Maniototo West Side Irrigation Company Ltd race (MWSICL) was set up to supply farmers on the west and east sides of the Maniototo plains with irrigation water from the Taieri River. The east side scheme was completed in 1989 by the Maniototo East Side Irrigation Company Ltd (MESICL).

5.2 Rainfall in the Taieri catchment

The amount of rainfall 24 hours, 48 hours and 72 hours prior to each sampling period was determined the Ranfurly rain-gauge. Table 5.1 gives details.

Table 5.1 Rainfall recorded 24 hrs, 48 hrs, and 72 hrs prior to each sampling event. Rain-gauges located in Ranfurly

Taieri	24 hour	48 hour	72 hour
21-Sep-04	0	0	0.2
24-Nov-04	7	7	7
10-Feb-05	0	0.8	0.8
27-Sep-05	0	2.2	2.2
28-Sep-05	0	0	0.2
22-Nov-05	8.4	8.4	8.4
24-Nov-05	0	0.2	8.6
14-Dec-05	0	0	0.8
18-Jan-06	0	0	0.2
09-Feb-06	1.2	12	1.2
No rainfall recorded: 8th Sep 2004, 26th Jan 2005, 4th Apr 2005, 24 May 2005, 25 may 2005, 26th July 2005, 13th Oct 2005.			

5.3 Pig Burn

The Pig Burn rises on the western side of the Rock and Pillar Range and flows across the Maniototo Plain to its confluence with the Taieri River. The upper part of the catchment is constrained in a gorge and as the Pig Burn flows out of the gorge, water begins to seep through the gravels into groundwater. During the summer, it is often difficult for any users below the gorge to obtain water, due to the Pig Burn flowing underground.

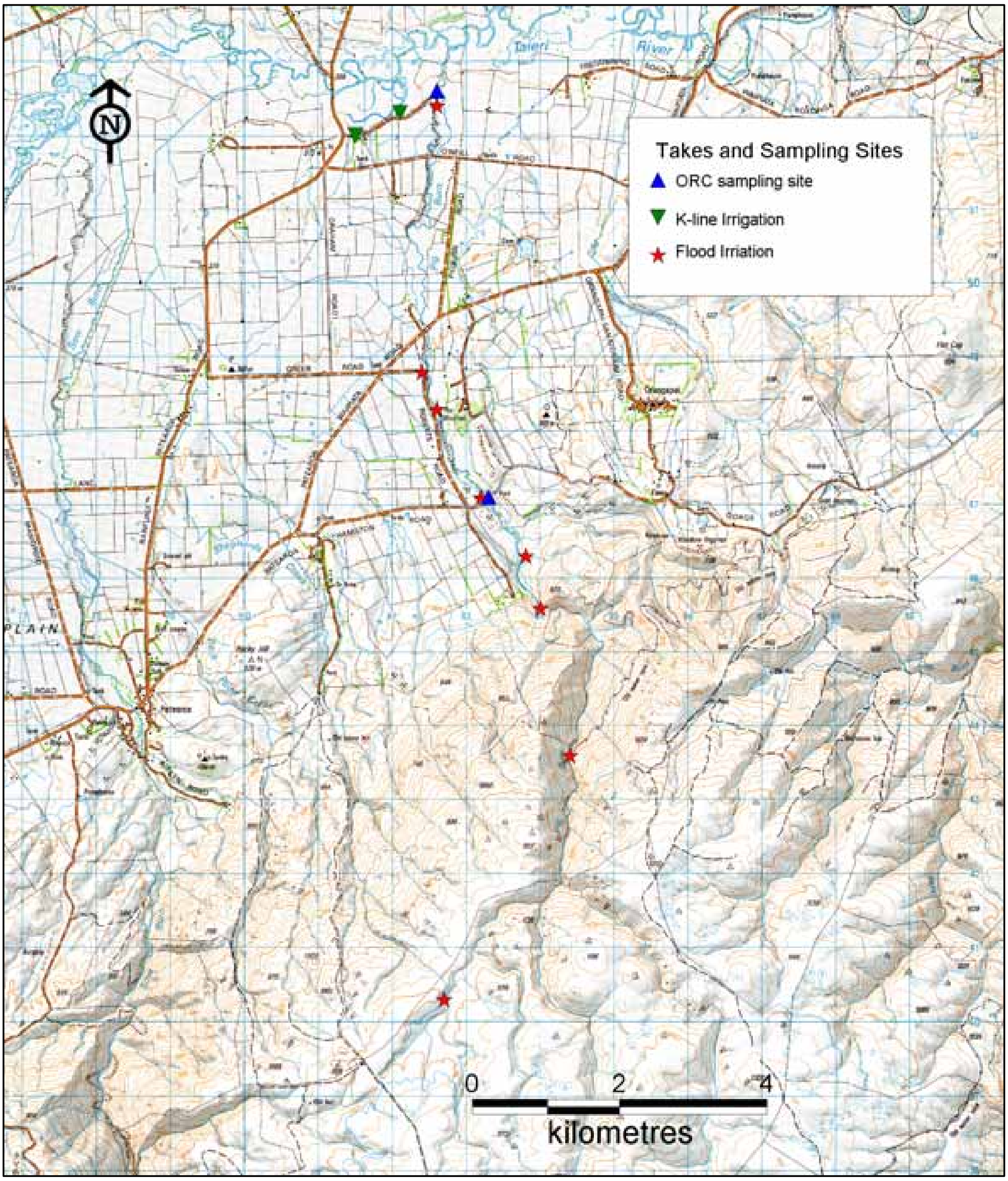


Figure 5.1 Pig Burn. Flood irrigation is indicated by red stars, ORC sampling sites by blue triangles

Figure 5.1 shows that flood irrigation dominates the upper catchment, whilst near the confluence of the Taieri, two takes utilise K-line irrigation. The upper sampling site has three takes upstream - this water is probably put in a race and used further down the catchment, as the land upstream is unsuitable for flood irrigation.

The Pig Burn was monitored between September 2004 and February 2006. Figure 5.2 looks at selected analytes for both the upstream and downstream sites. Full results are located in Appendix 1.

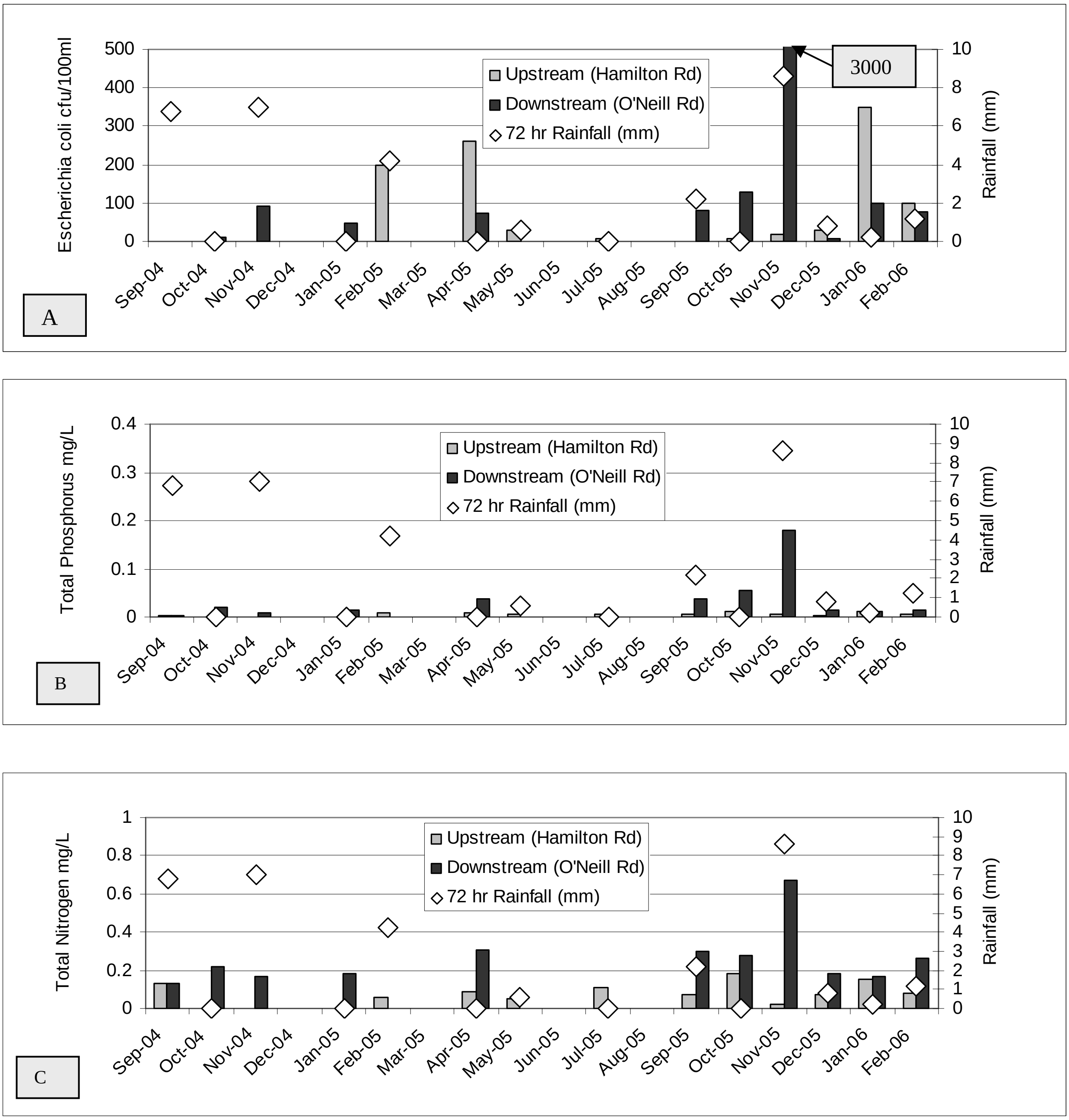


Figure 5.2 Pig Burn water quality. Samples taken between September 2004 and February 2006. A - *Escherichia coli;* B - Total phosphorus; C - Total nitrogen

Figure 5.2 shows that the downstream sites are generally elevated compared to the upstream sites.

Figure 5.2A shows that the downstream concentration of Ec was elevated in November 2005 - this coincided with 8.6mm rainfall that had fallen within 72 hours prior to sampling. This elevated level did not exceed the MfE/MoH red/alert trigger value of 550 Ec/100ml. In December, January and February 2006, the upstream site had higher levels of Ec than the downstream site, which probably reflects stock access upstream as the land is unsuitable for intensive agriculture, but it also highlights the lack of natural dilution in the Pig Burn during the summer months. Generally the bacteria levels at both the upper and lower sites meet the MfE/MoH 2003 microbiological guideline for contact recreation (<260 Ec/100ml).

Figure 5.2B shows TP, which is elevated at the downstream site at the start of the irrigation season, although the high reading in November 2005 can be attributed to rainfall. Later in the irrigation season the downstream concentration drops to below the ANZECC default trigger value for TP (0.026 mg/l). The same pattern can be seen for TN (Figure 5.2C), which only exceeds the ANZECC default trigger guideline (0.295mg/l) during the rainfall event in November 2005. This is probably because the Pig Burn is only viable as a source for irrigation purposes during the early summer, after which there is not enough water available for irrigation purposes and therefore its quality improves due to the lack of irrigation runoff.

Figure 5.3 Pig Burn downstream at O'Neill Road

Water quality in the Pig Burn over the irrigation season is good, with bacteria and nutrient levels generally below relevant guideline values. Temperatures in the Pig Burn did not rise as much as in the Manuherikia tributaries, the highest temperature was recorded in December 2005. Taking this sampling occasion, Table 5.2 shows that even though water quality is good, there is still a deterioration between the top and bottom sites.

Table 5.2 Water quality on dates when maximum and minimum temperatures were recorded

Date	Site	Turb	Cond	DRP	EC	TN	TP	Temp
28/9/5	Upper	0.49	0.053	0.005	1	0.07	0.005	6.22
	Lower	6.9	0.052	0.012	80	0.3	0.038	7.39
14/12/06	Upper	0.85	0.058	0.0025	30	0.07	0.0025	13.75
	Lower	1.1	0.126	0.006	8	0.18	0.014	14.63

5.4 Sow Burn

The Sow Burn drains the west side of the northern end of the Rock and Pillar range and is a steady flowing, incised waterway in its upper reach but as it flows out of the hills, there is a high soakage rate on the gravel outwash fans.

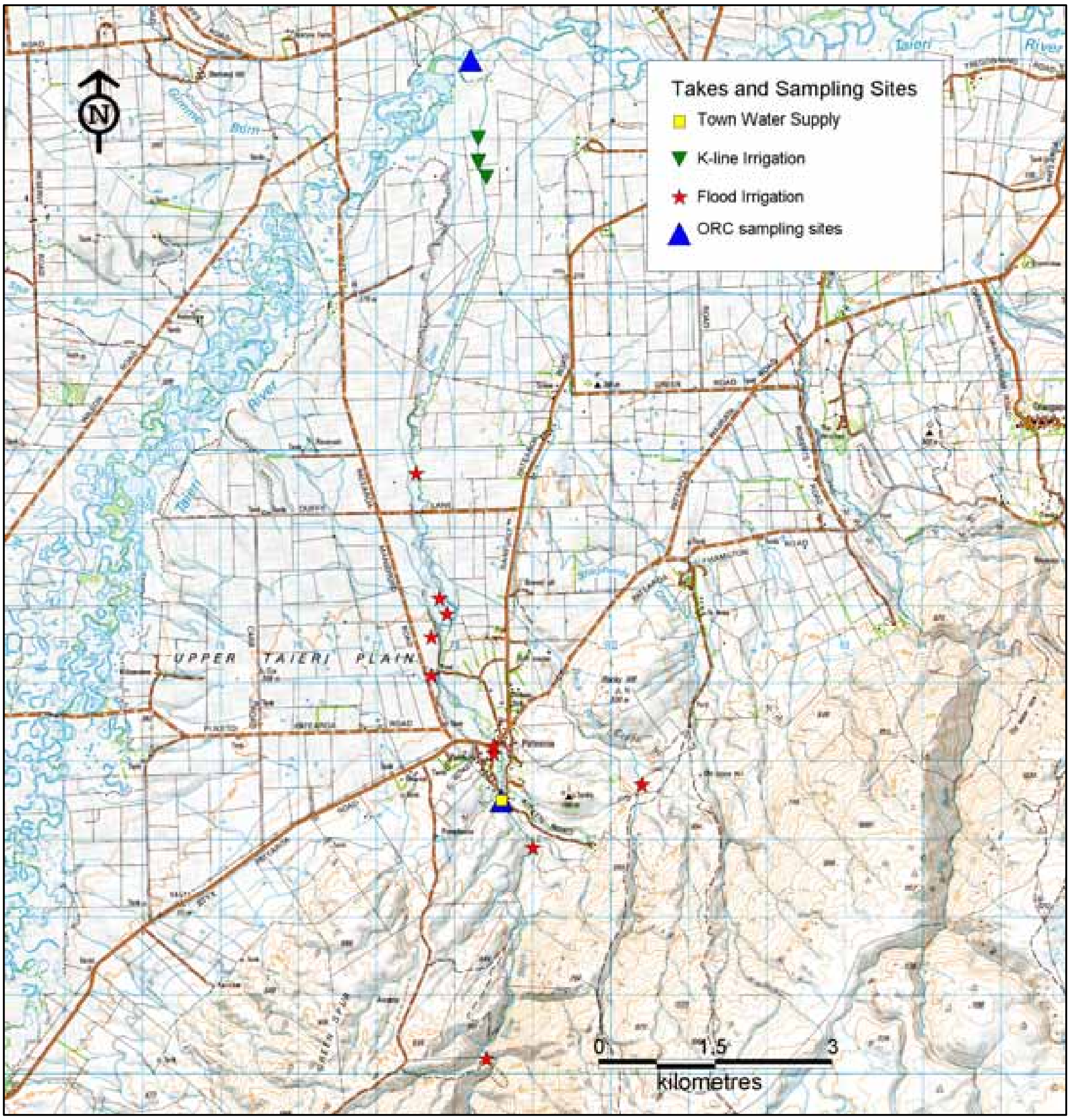


Figure 5.4 Sow Burn. Flood irrigation is indicated by red stars, ORC sampling sites by blue triangles

In summer it tends to lose surface flows in its lower reaches and often flows are only maintained by runoff from flood irrigation from irrigation company races that carry water sourced from the upper Taieri. Many of the takes from the lower Sow Burn are only viable as irrigation sources up until December each summer.

Figure 5.4 shows the upstream sampling site is at Patearoa and the downstream site is just above the Taieri confluence. There are three flood irrigation takes upstream of the upper site. However, the majority of takes are between Patearoa and the Taieri confluence, most of which are for flood irrigation purposes. It is expected that the water quality will deteriorate with distance downstream.

The Sow Burn was monitored between September 2005 and February 2006. Figure 5.5 looks at selected analytes for both the upstream and downstream sites. Full results are located in Appendix 1.

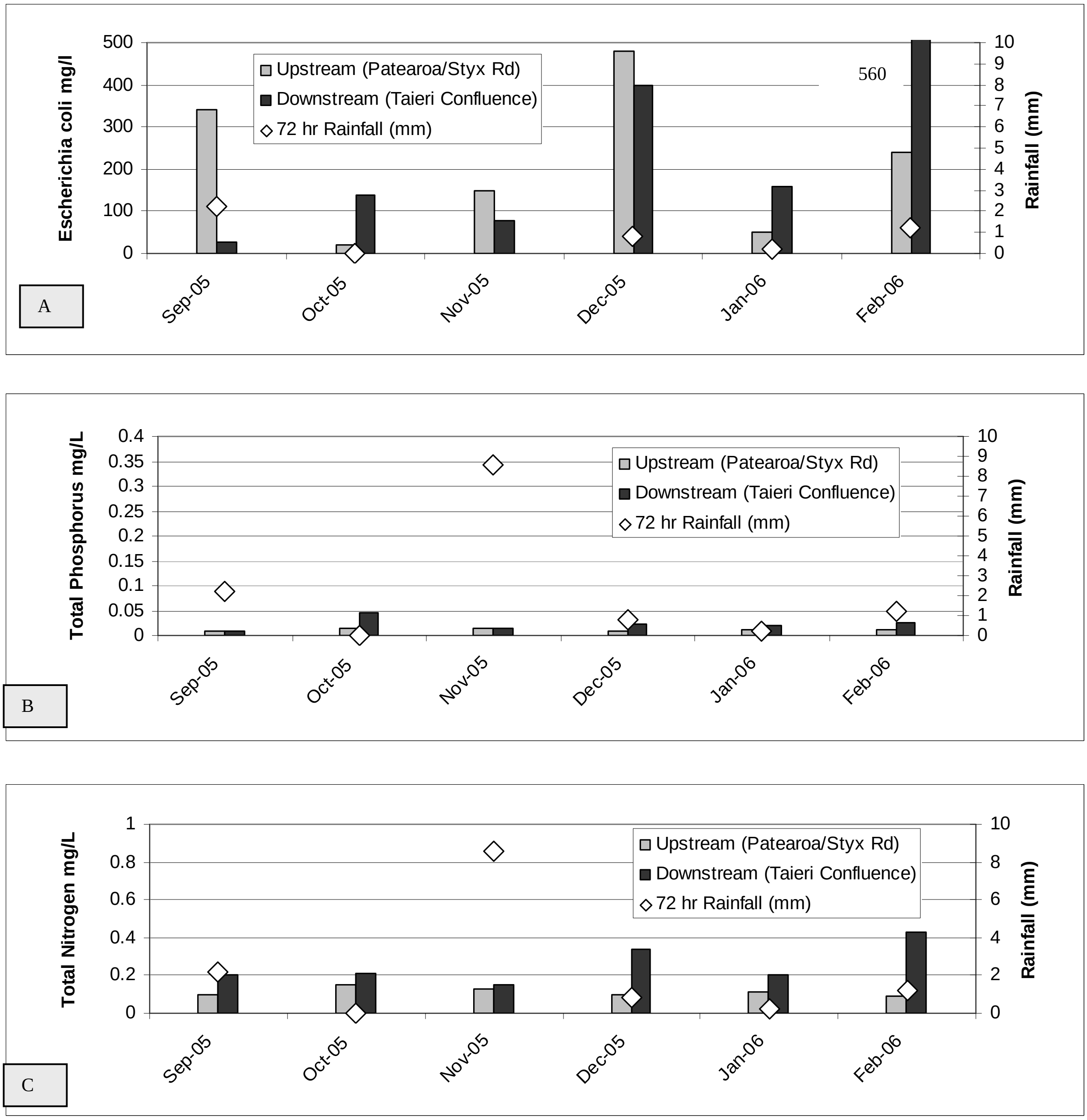


Figure 5.5 Sow Burn water quality. Samples taken between September 2005 and February 2006. A - *Escherichia coli;* B - Total phosphorus; C - Total nitrogen

Figure 5.6 Sow Burn at confluence of Taieri

Figure 5.5A shows that the most elevated Ec result was recorded at the downstream site in February, there had been 1.2mm of rain during the previous 24 hours, but this amount is unlikely to have had this adverse effect on water quality. There is not a clear pattern to the EC concentration, other than early in the irrigation season (September/October/November) levels seem to be lower than later in the season.

Figure 5.5B shows that generally the downstream site recorded higher levels of TP than the upstream site and there was no noticeable increase in concentrations over the summer period. The highest concentration of TP was recorded in October 2005 (0.047mg/l), which was the only time the ANZECC default trigger value was exceeded.

Figure 5.5C shows TN levels - again the downstream site had elevated concentrations compared to the upstream site and the highest concentration of TN was recorded in February 2006 (0.43mg/l), which coincided with rainfall. The ANZECC default trigger value for TN (0.295 mg/l) was exceeded on two occasions.

In November the temperature at the downstream site was 11.1ºC - by December it had risen to 16.8ºC. Figure 5.5 shows a marked increase in TN and EC in December compared to November which could be attributed to more intensive irrigation due to warmer weather. Table 5.3 compares water quality at the upper and lower sites on 13 October and 14 December - it is clear that a deterioration in water quality occurs, particularly an increase in nutrients between the two sites.

Table 5.3 Water quality on dates when maximum and minimum temperatures were recorded

Date	Site	Turb	Cond	DRP	EC	TN	TP	Temp
13/10/05	Upper	1.4	0.0353	0.005	20	0.15	0.014	5.8
Min	Lower	14	0.0418	0.009	140	0.21	0.047	8.3
14/12/06	Upper	1.2	0.03	0.005	480	0.1	0.008	13.85
Max	Lower	1.2	0.051	0.012	400	0.34	0.022	16.77

5.5 Gimmer Burn

The Hawkdun Irrigation District supplies water to the northern area of the Maniototo around Ranfurly and Naseby. The Wether Burn is a tributary of the Gimmer Burn which in turn flows into the Taieri River. The Idaburn Scheme supplies irrigation water to the northern area of the Ida Valley. The two schemes have been operated as one since the early 1940s and is known as the Hawkdun Idaburn Irrigation Scheme.

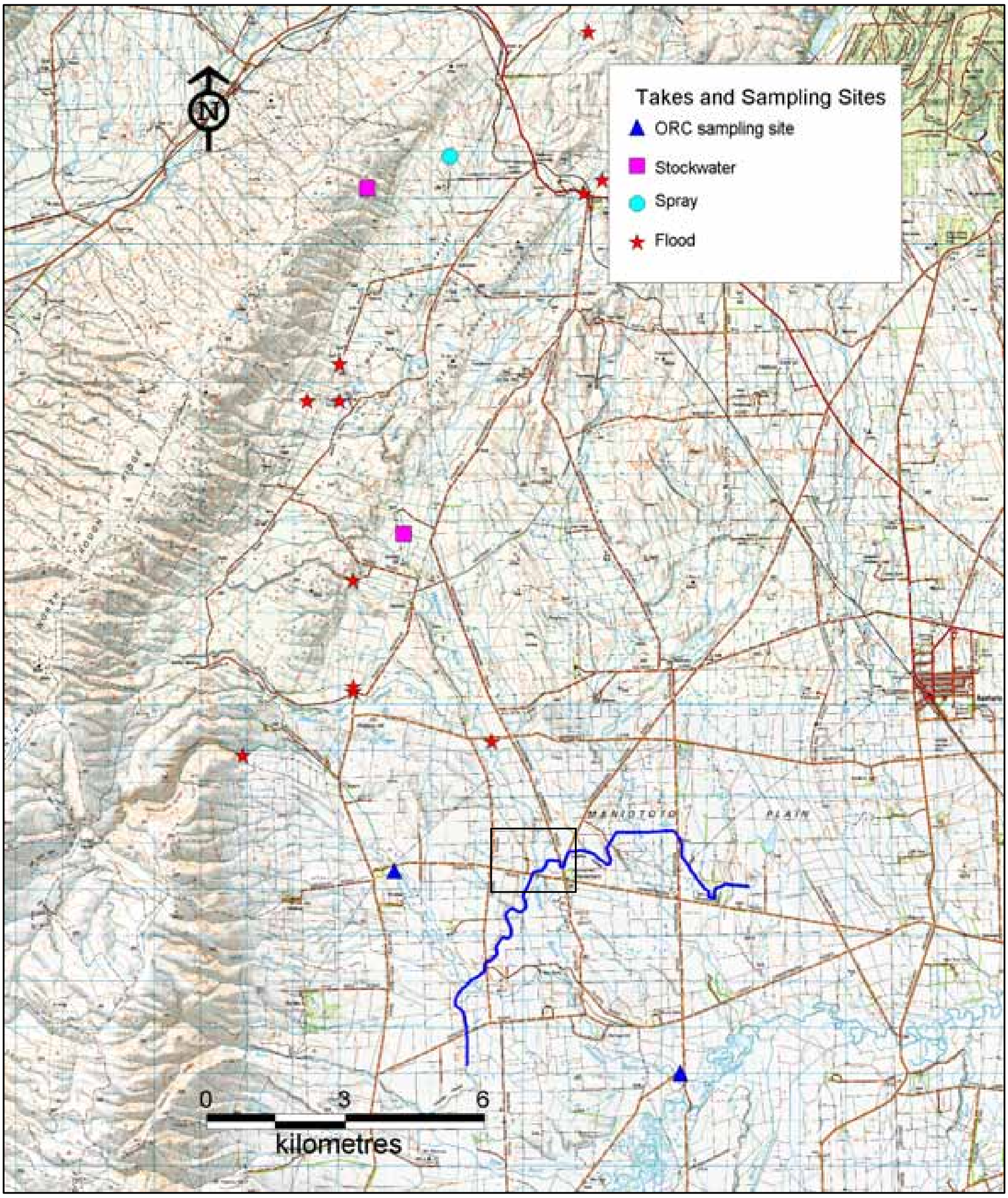


Figure 5.7 Gimmer Burn. Flood irrigation is indicated by red stars, ORC sampling sites by blue triangles. Blue line represents a section of the Maniototo Irrigation Company Scheme

The area supplied with water by the Hawkdun Idaburn Irrigation Scheme is mainly irrigated by contour ditch or wild flood techniques that have evolved on the properties with efficiencies being improved through pick up and reuse of water. Some border dyke and spray irrigation is carried out, generally augmented by on-farm storage.

Figure 5.7 shows that the main takes in this catchment are for flood irrigation, the majority of them being on the upper Wether Burn catchment. The Gimmer Burn catchment has just one flood irrigation take, and was dry most of the year. The MIC scheme is piped under the Gimmerburn and Wetherburn - the land below the scheme is suitable for flood irrigation and it is likely that runoff below the scheme will adversely affect water quality at the lower site. There is no upstream site for the Wether Burn, but it is appropriate to substitute the upper Idaburn site for comparative purposes as the watercourses originate in the Hawkdun Range and North Rough Ridge.

Figure 5.8 Aerial photograph of flood irrigation and drainage channels in area bounded by rectangle in Figure 5.7. The MIC scheme can clearly be seen as it passes under the Wether Burn

The Gimmer Burn was monitored between September 2004 and February 2006. Figure 5.8 looks at selected analytes for the downstream sites, the upper sampling site on the Idaburn is also shown as there is no upper Gimmer Burn site due to no flow. Full results are located in Appendix 1.

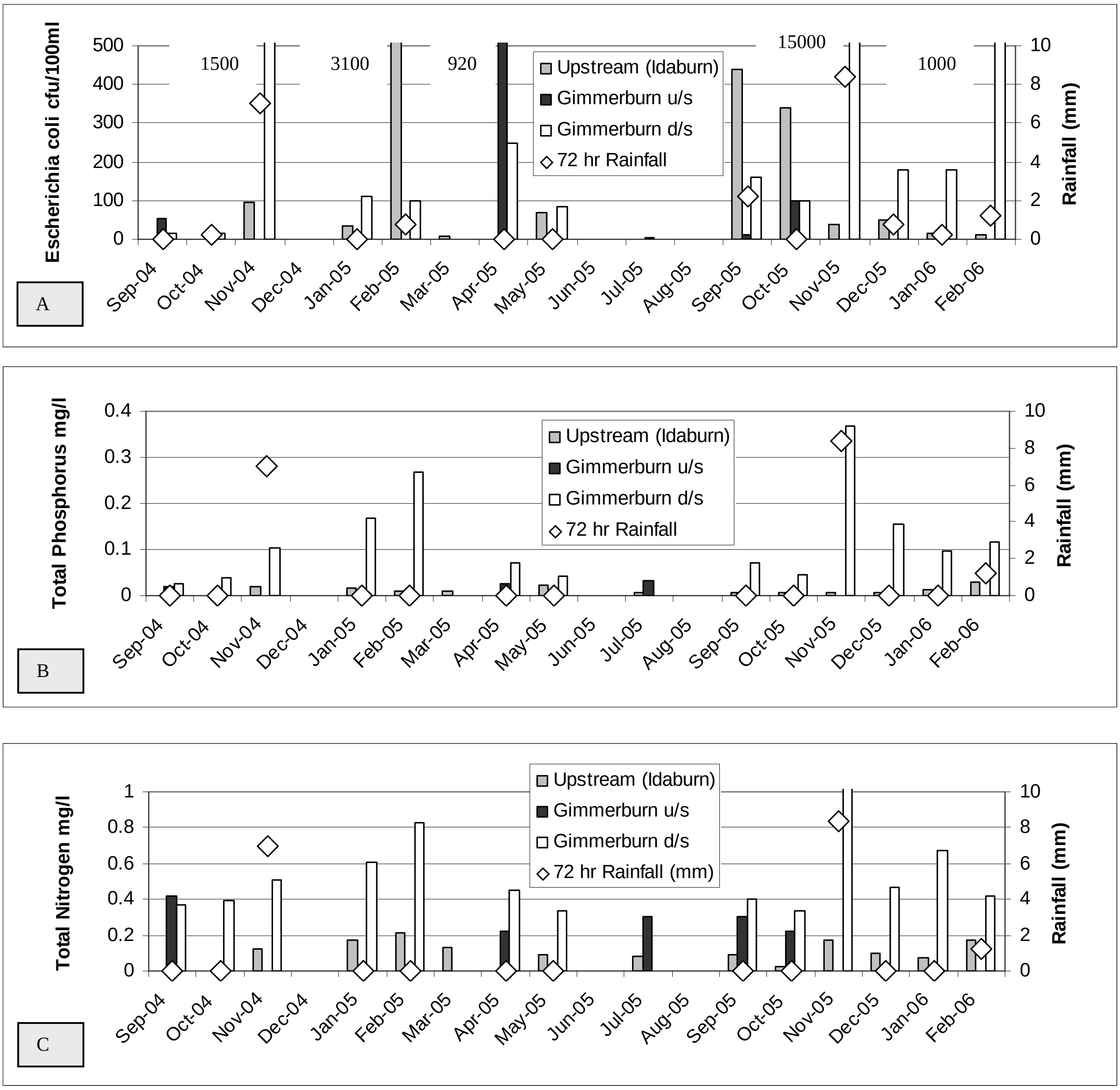


Figure 5.9 Gimmer Burn water quality compared to the upper Idaburn site. Samples taken between September 2004 and February 2006. A - *Escherichia coli;* B - Total phosphorus; C - Total nitrogen

Figure 5.8A shows that on three occasions the downstream concentration of Ec exceeded the MfE/MoH red/alert value of 550 cfu/100ml - in the same period the Idaburn only exceeded it on one occasion. In November 2005, an extremely high level of 15,000 Ec/100ml was recorded. However, this coincided with over 8mm of rainfall that fell in the catchment during the previous 24 hours. This rainfall also influenced the concentration of both TN and TP which are elevated on this sampling date. November 2004 also recorded a significant amount of rainfall, and again Ec levels are elevated (1500 cfu/100ml), but there was not such a significant effect on nutrient concentrations.

TP and TN show elevated levels compared to the Idaburn - the nutrient levels generally exceed relevant ANZECC default trigger guidelines. Figure 5.8B and C show that higher concentrations occur during the summer period.

On 29 January, the temperature in the Gimmerburn had risen to 28ºC. Figure 5.5 shows a marked increase in TN in January which could be attributed to more intensive irrigation due to warmer weather. Table 5.4 compares water quality at the lower Gimmerburn site between 25 May and 14 December. It is clear that a deterioration in water quality occurs, particularly an increase in nutrients.

Table 5.4 Water quality on dates when maximum and minimum temperatures were recorded

Date	Site	Turb	Cond	DRP	EC	TN	TP	Temp
25/5/05 Min	Lower	2	0.1787	0.018	85	0.34	0.042	4.3
14/12/06 Max	Lower	2.2	0.099	0.076	180	0.47	0.154	19.76

6. Welcome Creek

6.1 Catchment description

Unlike the other streams in this report, Welcome Creek is spring fed. It is a spring fed tributary of the Waitaki River that is essentially re-emergence of subsurface flows originating from the Waitaki River itself, as well as a significant contribution from groundwater seepage originating from irrigation of the higher terraces. The stream is about 6km long and flows back into the Waitaki River just above the State Highway bridge. Due to its spring fed nature, the water quality of the stream is often very good. Figure 6.1 shows the Welcome Creek catchment - the irrigation races and drains can clearly be seen. There is a fairly even split between flood irrigation and spray irrigation in the catchment.

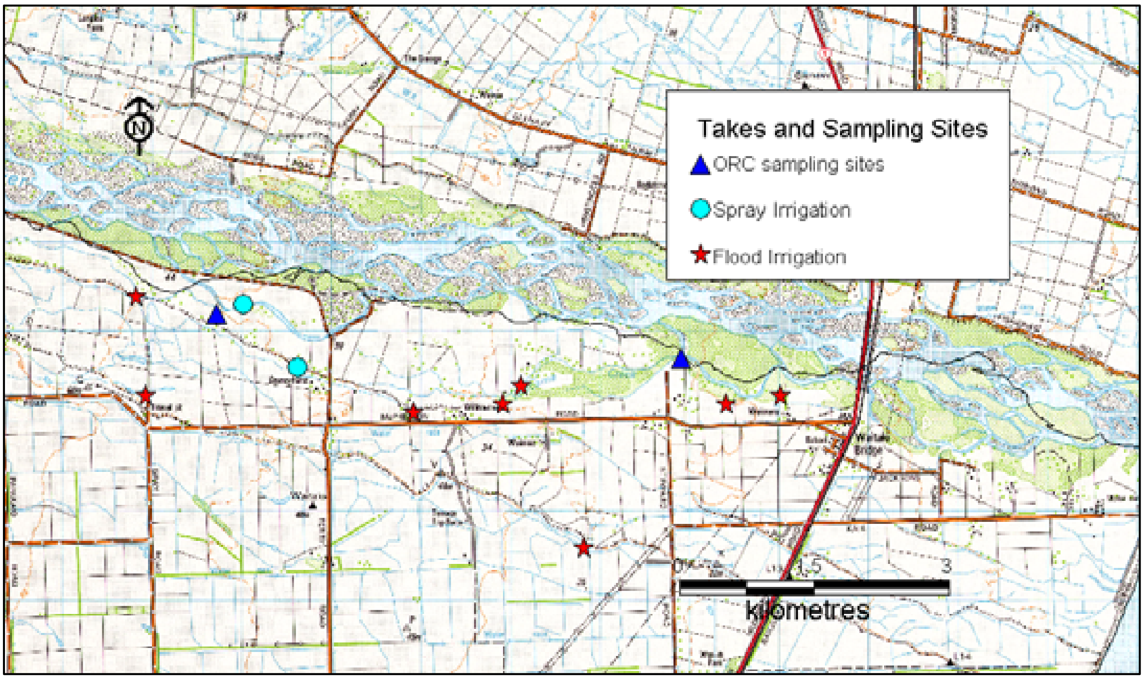


Figure 6.1 Welcome Creek. Water takes shown by red stars and ORC sampling sites shown by blue triangles

Lower Waitaki Irrigation Company (LWIC) provides irrigation water for over 19,000ha of the plains on the southern side of the Waitaki River. There is an extensive series of water races that interconnect and finally flow into the Waitaki River, its tributaries or out to the coastal marine area between the Waitaki River and the outskirts of Oamaru.


Figure 6.2 Welcome Creek, upstream and downstream sampling sites

6.2 Rainfall in the Welcome Creek catchment

Table 6.1 Rainfall recorded 24 hrs, 48 hrs, and 72 hrs prior to each sampling event. Rain-gauges located at Hills Creek (Manuherikia), Ranfurly (Taieri) and Clifton Falls (Welcome Creek)

Welcome Creek	24 hour	48 hour	72 hour
12-Oct-04	0	6	7
14-Dec-04	3.5	5.5	5.5
08-Feb-05	9.5	9.5	9.5
11-Apr-05	0	9	10.5
27-Sep-05	0.5	9	9
12-Oct-05	0	1	1
05-Dec-05	0.5	1.5	1.5
08-Feb-06	0	0	2.5
No rainfall: 7th September 2004, 26th May 2005, 14th June 2005, 16th August 2005, 3rd November 2005			

The amount of rainfall 24 hours, 48 hours and 72 hours prior to each sampling period was determined at Clifton Falls rain-gauge. Table 7.2 gives details.

6.3 Groundwater interaction

Figure 6.3 shows groundwater levels for which there is a marked seasonal cyclicity, with a gradual recovery in groundwater levels during summer months. It shows a gradual recession during winter, with peak levels occurring in the late summer months of February to March, due to recharge during the irrigation season.

Hamilton and Elliot (1994) reported that groundwater levels initially increased between 2m and 6m when large-scale irrigation commenced. With irrigation having such an effect on groundwater, it would be surprising if water quality did not show some sign of deterioration over the summer period due to irrigation runoff supplementing the groundwater levels.

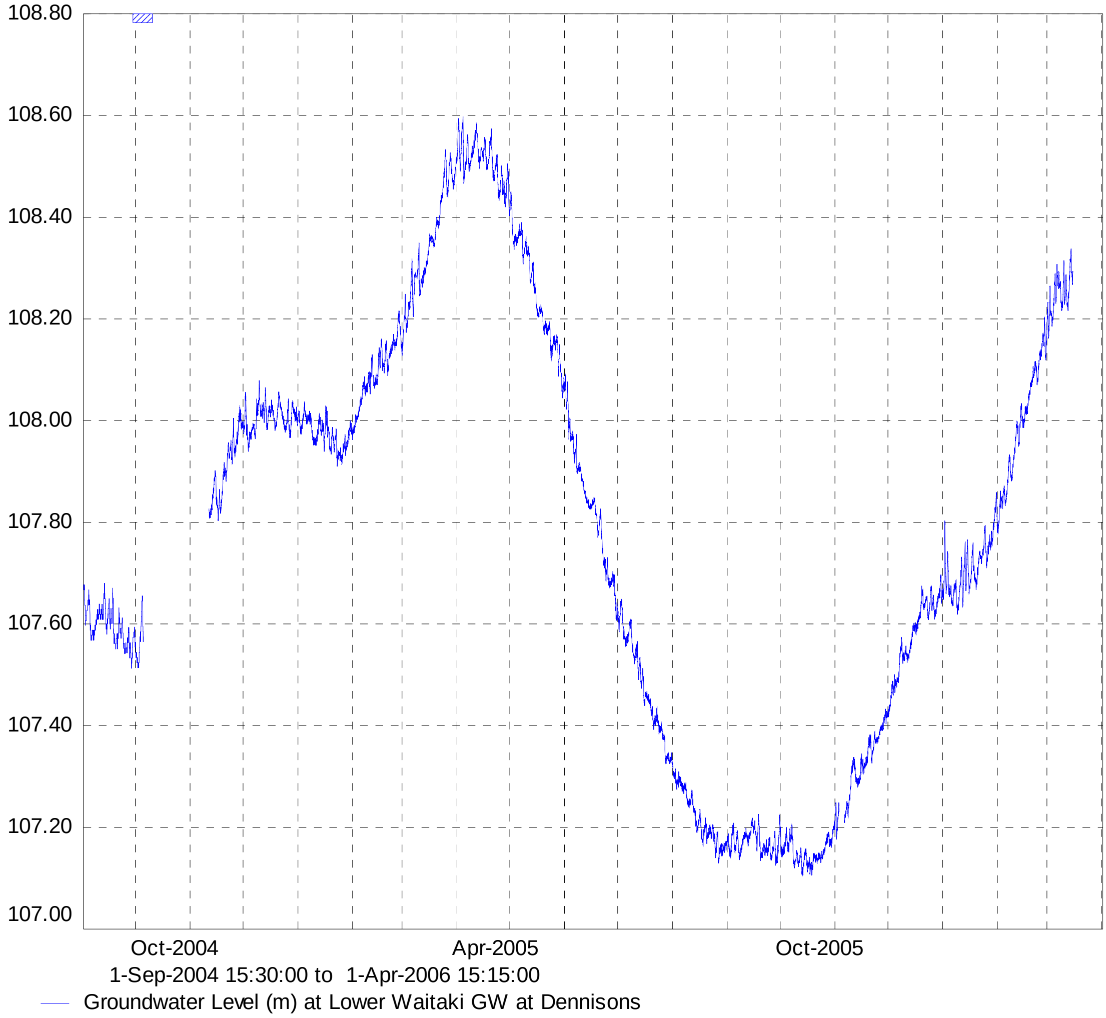


Figure 6.3 Groundwater hydrograph for Dennison's bore

6.4 Welcome Creek results

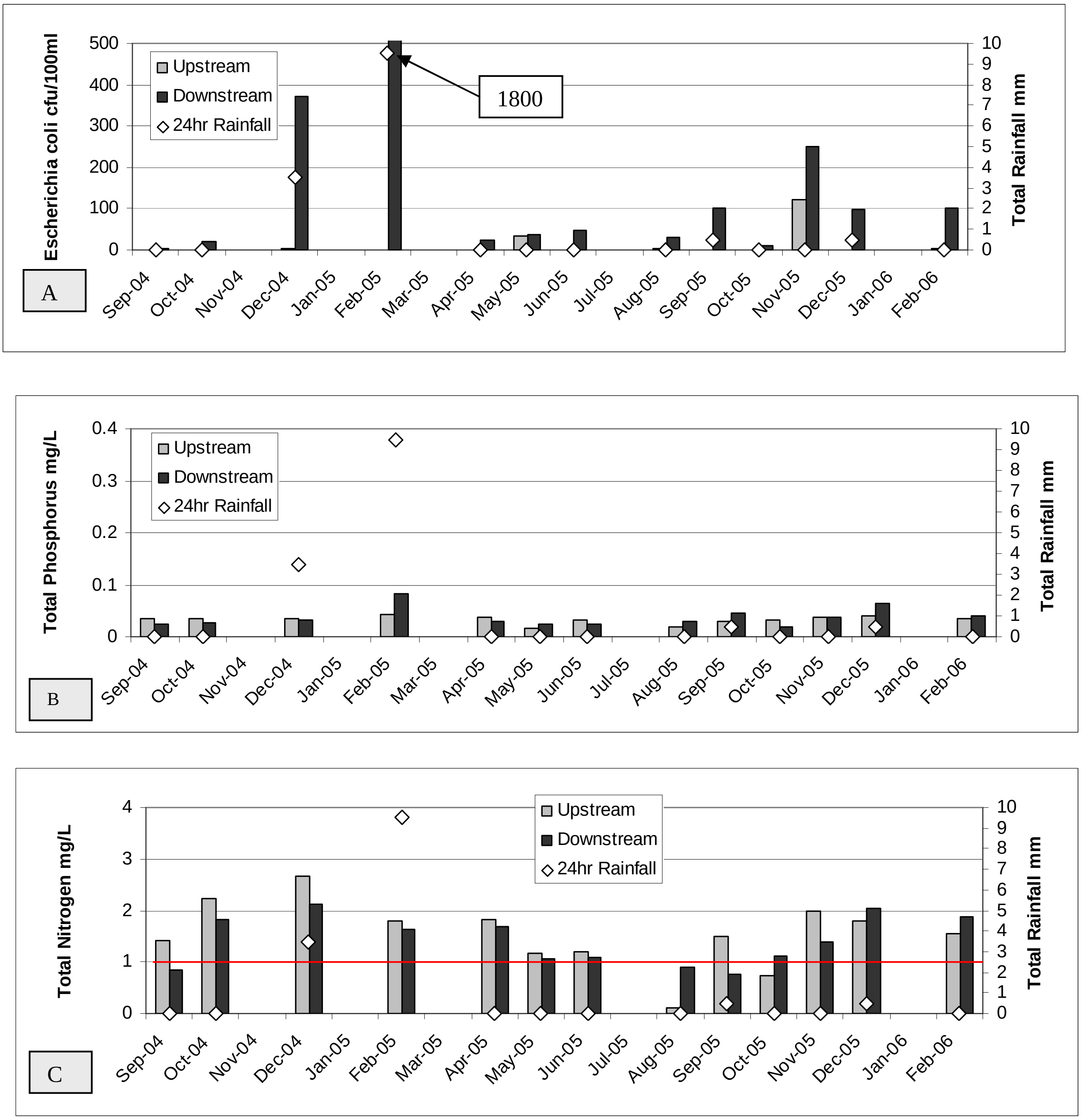


Figure 6.4 Welcome Creek water quality. Samples taken between September 2004 and February 2006. A - *Escherichia coli;* B - Total phosphorus; C - Total nitrogen (the red line indicates the maximum value shown in the rest of the report)

Welcome Creek was monitored between September 2004 and February 2006. Figure 6.4 looks at selected analytes for both the upstream and downstream sites. As Welcome Creek has a small catchment, the rainfall is shown as a 24 hour total, rather than a 72 hour total as in the rest of the report. Full results are located in Appendix 1.

Figure 6.4A shows Ec - it is apparent that the downstream sites have higher levels of bacteria than the upstream sites. Two elevated readings occurred in December 2004 and February 2005 - this is likely to be due to significant rainfall recorded 24 hours prior to the sample being taken. In summer 2005, the downstream site consistently recorded higher Ec than the upstream site.

Figure 6.4B shows TP levels. The largest concentration of TP coincided with high rainfall in February 2005, but there is no clear pattern of elevated concentrations at the downstream site when compared to the upstream site. Between September 2004 and June 2005 the upstream site tended to have the higher concentration of TP. However, this situation reversed between August 2005 and February 2006.

Figure 6.4C shows TN levels - the pattern here is more confusing, with the upstream site often showing higher concentrations than the lower site. One reason may be that the upstream site is spring fed. Otago Regional Council monitored groundwater in the lower Waitaki alluvium aquifer between 1999 and 2000. Bores J410415 and J410421 are located near the upstream sampling site and were sampled four times. At bore J410415 (above the upper sampling site) the mean concentration of TN was 0.785mg/L. At bore J410415 (below the upper sampling site) the mean concentration of nitrogen was 4.625mg/L. It is reasonable to suggest that the groundwater at the upper sampling site falls somewhere between the two, which fits the data well. It is also reasonable to suggest that the lower sampling site would be diluted by irrigation water, lowering the nitrogen levels (as groundwater has higher nitrogen levels than irrigation runoff water).

The upper site had much lower DO levels compared to the lower site, which is consistent with a groundwater source. Temperatures were highest in the December 2005 sample, and Table 6.2 compares December water quality at the upper and lower site to the August samples.

Figure 6.4 shows that water quality tends to be worse in the summer than in winter. Table 6.2 compares water quality at the upper and lower sites on 16 August and 8 February and it is clear that a deterioration in water quality occurs between these two dates.

Table 6.2 Water quality on dates when maximum and minimum temperatures were recorded

Date	Site	Turb	Cond	DRP	EC	TN	TP	Temp
16/8/04	Upper	0.4	0.1463	0.03	0.5	1.63	0.034	7.2
Min	Lower	0.5	0.1512	0.02	13	1.52	0.023	7.5
8/2/06	Upper	0.6	0.1065	0.041	2	1.54	0.036	16.2
Max	Lower	2.3	0.1243	0.025	100	1.84	0.04	15

7. Discussion

Originally this study was to be run over the 2004/2005 irrigation season only. However, Table 7.1 shows that a high amount of rainfall fell in November and December 2004, which would have some bearing on results and therefore the 2005/2006 season was also monitored.

Table 7.1 Monthly rainfall at Hills Creek 2004 - 2006

Rainfall (mm) at Ida Burn Rainfall at Hills Creek							
Year	Jan	Feb	Sep	Oct	Nov	Dec	Total
2004	69	58.5	28	56	82	152	639
2005	39	46.5	15	51	52	98.5	487
2006	51.5	32.5					

This study clearly shows that water quality in all the tributaries monitored was degraded due to irrigation practices during the summer period. Flood irrigation is the main irrigation method used in all the tributaries monitored. This is an inefficient method of application that may generate runoff likely to re-enter surface water. The runoff causes a deterioration in water quality in receiving watercourses.

Particularly good examples of high nutrient levels at the downstream site during the 2005/2006 irrigation season are Thompsons Creek and the Gimmer Burn. In 2005/2006 the upstream Chatto Creek site generally recorded degraded water quality compared to the downstream site. This could be expected as most takes were above the upper site, meaning that water quality at this site was already degraded. It was then being diluted by cleaner tributary water downstream.

Median concentrations of TN and TP at the lower sampling sites were higher than the acceptable critical limits for water quality. The ANZECC default trigger value for TP in upland rivers is 0.295 mg/l. During the summer period September 2004 to February 2005 only the Pig Burn had median concentrations for total phosphorous below this value, whilst in the period September 2005 to February 2006 only the Sow Burn had median concentrations below this value.

The ANZECC default trigger value for TN is 0.295 mg/l. During the summer period September 2004 to February 2005 only Chatto Creek and the Pig Burn had median concentrations below this value, whilst in the period September 2005 to February 2006 the Pig Burn and Sow Burn had median concentrations below this value. This is depicted in Table 7.2.

Levels of Ec were noticeably elevated not only seasonally, but particularly after significant rainfall. During the summer period September 2004 to February 2005 median values exceeded the MfE/MoH acceptable/green level of 260 *E.coli*/100ml in the Ida Burn, Thompsons Creek and Chatto Creek. During the summer period September 2005 to February 2006 only the Ida Burn and Thompsons Creek exceeded this value.

Rainfall of greater than 10mm in 72 hours influenced Ec levels. Good examples of this are the Idaburn (November 2004), Welcome Creek (December 2004, February 2005), Pig Burn (November 2005), Sow Burn (February 2006) and Gimmer Burn (November 2004, November 2005).

Table 7.2 The grey shading indicates that the median concentration exceeded the appropriate guideline value. Escherichia coli (Mfe/MoH 260cfu/100ml), total phosphorus (ANZECC 0.026mg/L) and total nitrogen (ANZECC 0.295mg/L). September 2004 - February 2005 and September 2005 - February 2006

	Manuherikia						Taieri						Waitaki	
	Ida Burn		Thomp. Ck		Chatto Ck		Gimmer Burn		Pig Burn		Sow Burn		Welcome Ck	
Year	05	06	05	06	05	06	05	06	05	06	05	06	05	06
EC														
TP											NS			
TN											NS			

NS = Not Sampled

TN concentrations in Welcome Creek were extremely elevated, with a median concentration over the 2004 - 2005 period of 1.39 mg/L. Historically the median TN level for the downstream site is 1.4 mg/l, showing that high concentrations occur outside the irrigation period and, as the Creek is spring fed, this can be attributed to naturally high TN concentrations in groundwater.

As well as a deterioration in water quality, abstractions for irrigation may use all of the available flow. Two of the monitored sites, Gimmer Burn and Thompsons Creek, lost natural upstream flow to irrigation practices. The upstream site at the Gimmer Burn was dry for most of the irrigation season, whilst Thompsons Creek was monitored in the irrigation race, rather than the creek, as the race takes all the natural water during the summer months.

This study has attempted to measure the adverse effects of irrigation by monitoring water quality. However, it is not just water quality that is affected. Adverse effects on water bodies also relate to effects on ecosystems and other non measurable uses such as cultural values. Tipa (2000) identified a number of impacts common to all irrigation schemes which are culturally important to Kai Tahu which included such water quantity issues.

8. Conclusion

Flood irrigation practices in the Manuherikia and Taieri Rivers resulted in a deterioration in water quality in all the tributaries monitored. Generally the deterioration coincided with an increase in water temperature at the start of the irrigation season.

In the Manuherikia catchment, water quality in Thompsons Creek showed the worst deterioration, whilst in the Taieri catchment, water quality was poorest in the Gimmer Burn.

Welcome Creek, the spring fed system, also showed a deterioration - this was most evident in phosphorous concentrations. Naturally high levels of nitrogen in groundwater masked any nitrogen contribution at the downstream site from irrigation runoff.

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Appendix 1

SOURCE	SITE_NAME	DATE	COND	DO	DO SAT	DRP	EC	NH4	NNN	PHF	SS	TEMP	TN	TP	TURB
Chatto Ck	Moutere Rd	09-Sep-04	0.0418	12	100.1	0.02	21	0.03	0.026	7.4	0.5	8.2	0.16	**0.027**	1.9
Chatto Ck	Moutere Rd	17-Nov-04	0.0454	10.4	97.3	0.022	730	0.005	0.016	7.23	7	12.3	0.22	**0.05**	2.7
Chatto Ck	Moutere Rd	26-Jan-05	0.0552	9.24	101.3	0.02	130	0.01	0.017	7.32	9	19.9	0.18	**0.046**	1.6
Chatto Ck	Moutere Rd	10-Feb-05				0.018	130	0.005	0.015	7.31	5		0.14	**0.041**	1.4
Chatto Ck	Moutere Rd	15-Mar-05	0.0437	10.6	110	0.016	570	0.005	0.018	7.43	4	17.31	0.1	**0.03**	1.6
Chatto Ck	Moutere Rd	25-May-05	0.0442	12.22	100	0.013	180	0.005	0.038	7.32	3	6.82	0.1	0.016	2.3
Chatto Ck	Moutere Rd	27-Jul-05	0.0613	11.5	97	0.017	12	0.005	0.038	7.1	4	8.1	0.11	**0.034**	3.7
Chatto Ck	Moutere Rd	27-Sep-05	0.04	10.3	94.6	0.019	160	0.005	0.02	6.7	5	11.56	0.16	**0.042**	2.7
Chatto Ck	Moutere Rd	25-Oct-05	0.0528	9.17	92.2	0.052	9000	0.02	0.026	6.9	15	15.7	**0.4**	**0.104**	**6.9**
Chatto Ck	Moutere Rd	21-Nov-05	0.0662	9.38	85.2	0.022	2100	0.02	0.063	6.9	12	11	**0.6**	**0.087**	**6**
Chatto Ck	Moutere Rd	21-Dec-05	0.058	9.12	95.6	0.027	2600	0.01	0.015	7.27	4	17.71	**0.58**	**0.092**	3.6
Chatto Ck	Moutere Rd	01-Feb-06	0.058	9.06	99.6	0.016	79	0.02	0.018	6.97	1.5	19.92	0.23	**0.053**	2
Chatto Ck	Moutere Rd	14-Feb-06	0.0617	9.41	94.7	0.026	1500	0.01	0.019	7.1	3	15.7	**0.41**	**0.079**	3
Chatto Ck	SH85	09-Sep-04	0.0808	11.94	101.1	0.016	9	0.03	0.072	7.64	24	8.77	0.2	0.0025	1.4
Chatto Ck	SH85	17-Nov-04	0.0965	10.04	99.1	0.029	980	0.005	0.048	7.62	6	14.8	0.29	**0.054**	2.6
Chatto Ck	SH85	26-Jan-05	0.1262	8.08	94.3	0.017	68	0.01	0.033	7.5	6	23	0.18	**0.04**	1.2
Chatto Ck	SH85	10-Feb-05				0.021	560	0.005	0.014	7.6	2		0.18	**0.032**	0.75
Chatto Ck	SH85	15-Mar-05	0.105	10.91	112.8	0.024	310	0.005	0.029	7.7	3	17.58	**0.33**	**0.04**	1.3
Chatto Ck	SH85	25-May-05	0.0855	12.88	104.6	0.01	62	0.005	0.04		1	6.59	0.11	0.012	1.4
Chatto Ck	SH85	27-Sep-05	0.09	9.63	89.2	0.016	52	0.005	0.026	7.4	1.5	11.71	0.16	**0.036**	1.2
Chatto Ck	SH85	25-Oct-05	0.01132	9.2	96.5	0.03	580	0.02	0.031	7.7	8	17.7	**0.3**	**0.06**	**4.3**
Chatto Ck	SH85	21-Nov-05	0.1508	9.72	88.9	0.036	5800	0.02	0.049	7	13	11.5	**0.51**	**0.078**	**4.7**
Chatto Ck	SH85	21-Dec-05	0.132	9	99	0.029	3400	0.01	0.019	7.62	4	20	**0.32**	**0.045**	3.2
Chatto Ck	SH85	01-Feb-06	0.208	7.6	84.1	0.045	130	0.01	0.045	7.31	5	20.17	**0.46**	**0.111**	1.7
Chatto Ck	SH85	14-Feb-06	0.1695	8.79	90.1	0.0025	600	0.03	0.0025	7.5	3	16.6	0.29	**0.053**	1.6
Ida Burn	Auripo Rd	24-May-04	0.221	9.57	80.2	0.032	19	0.01	0.026	7.78	1	7.4	0.26	0.062	2.1
Ida Burn	Auripo Rd	14-Jul-04	0.0532	14.24	103.1	0.008	17	0.02	0.014	7.2	1	2	0.12	0.009	1.6
Ida Burn	Auripo Rd	07-Sep-04	0.0443	13.19	109.3	0.008	4	0.01	0.012	7.98	2	7.75	0.19	0.008	0.85

SOURCE	SITE_NAME	DATE	COND	DO	DO SAT	DRP	EC	NH4	NNN	PHF	SS	TEMP	TN	TP	TURB
Ida Burn	Auripo Rd	17-Nov-04	0.0668	9.77	89.9	0.026	1600	0.01	0.082	7.28	7	11.6	0.49	0.062	3.6
Ida Burn	Auripo Rd	25-Jan-05	0.0878	9.33	96.2	0.012	110	0.005	0.007	7.47	3	17	0.31	0.032	1.1
Ida Burn	Auripo Rd	10-Feb-05				0.035	950	0.01	0.022	7.58	2		0.35	0.068	0.95
Ida Burn	Auripo Rd	14-Mar-05	0.11	10.13	104.7	0.05	330	0.02	0.031	7.37	4	17.65	0.55	0.081	4.4
Ida Burn	Auripo Rd	26-May-05	0.0988	12.2	98.9	0.011	48	0.02	0.051	7.56	3	6.7	0.22	0.021	3.4
Ida Burn	Auripo Rd	27-Sep-05	0.066	11.33	95.1	0.048	92	0.01	0.017	7.1	10	7.78	0.3	0.085	11
Ida Burn	Auripo Rd	24-Nov-05	0.1088	10.39	91	0.055	4400	0.01	0.015	7.3	21	9.5	0.35	0.087	11
Ida Burn	Auripo Rd	21-Dec-05	0.064	7.1	72.5	0.011	660	0.005	0.013	7.39	1.5	16.39	0.23	0.017	0.85
Ida Burn	Auripo Rd	01-Feb-06	0.115	9.66	102.6	0.121	290	0.03	0.01	7.16	5	18.29	0.5	0.183	5.6
Ida Burn	Auripo Rd	14-Feb-06	0.1075	8.1	81.6	0.105	1300	0.03	0.019	6.6	9	15.8	0.62	0.191	9.4
Idaburn N Br	SH85 bridge	18-Nov-04	0.0377	10.18	92.8	0.01	95	0.005	0.014	7.03	2	11.2	0.12	0.018	0.9
Idaburn N Br	SH85 bridge	25-Jan-05	0.0451	9.3	96.3	0.006	34	0.01	0.05	6.99	2	17	0.17	0.017	0.65
Idaburn N Br	SH85 bridge	10-Feb-05				0.016	3100	0.005	0.098	6.84	2		0.21	0.01	0.35
Idaburn N Br	SH85 bridge	14-Mar-05	0.036	9.16	91.5	0.01	8	0.005	0.067	6.59	2	15.72	0.13	0.009	0.4
Idaburn N Br	SH85 bridge	26-May-05	0.0267	11.18	91.8	0.005	69	0.005	0.018	7.13	0.5	7.22	0.09	0.022	0.55
Idaburn N Br	SH85 bridge	27-Jul-05	0.0327	13.09	103	0.01	1	0.005	0.01	7.6	1.5	5.4	0.08	0.008	0.6
Idaburn N Br	SH85 bridge	27-Sep-05	0.025	10.23	89	0.008	440	0.005	0.02	6.4	1.5	9.23	0.09	0.007	0.21
Idaburn N Br	SH85 bridge	25-Oct-05	0.0372	9.55	85.3	0.009	340	0.01	0.006	7.5	1.5	10.4	0.025	0.007	0.53
Idaburn N Br	SH85 bridge	24-Nov-05	0.0427	9.2	85.6	0.0025	40	0.005	0.006	7.2	1.5	12.1	0.17	0.008	0.32
Idaburn N Br	SH85 bridge	21-Dec-05	0.042	7.99	83.5	0.005	51	0.01	0.009	7.97	1.5	17.58	0.1	0.005	0.96
Idaburn N Br	SH85 bridge	01-Feb-06	0.036	7.51	76.6	0.008	17	0.01	0.029	5.73	1.5	16.23	0.07	0.013	0.38
Idaburn N Br	SH85 bridge	14-Feb-06	0.0781	7.36	74.1	0.01	12	0.005	0.01	6.6	1.5	15.8	0.17	0.028	1.6
Pool Burn	Auripo Rd	23-Mar-04	0.3887	8.17	77.9	0.059	11	0.02	0.006	8.45	0.5	13.3	0.56	0.086	0.5
Pool Burn	Auripo Rd	24-May-04	0.408	12.83	106.6	0.015	10	0.005	0.052	8.33	0.5	7.2	0.48	0.037	0.9
Pool Burn	Auripo Rd	14-Jul-04		14.61	103.4	0.018	2	0.02	0.254	7.75	1	1.1	0.62	0.035	0.9
Pool Burn	Auripo Rd	07-Sep-04	0.1177	14.22	113.3	0.022	4	0.01	0.011	8.02	3	6.34	0.55	0.051	1.7
Pool Burn	Auripo Rd	17-Nov-04	0.2208	9.49	86.6	0.067	320	0.005	0.006	7.67	2	11.6	0.75	0.113	1.4
Pool Burn	Auripo Rd	25-Jan-05	0.3055	9.68	104.3	0.064	100	0.02	0.053	7.91	2	18.5	0.75	0.194	0.2
Pool Burn	Auripo Rd	14-Mar-05	0.249	13.6	139.9	0.082	210	0.02	0.008	8.22	0.5	17.35	0.99	0.133	1.2
Pool Burn	Auripo Rd	27-Sep-05	0.246	8.36	73.9	0.024	58	0.005	0.006	7.5	1.5	9.89	0.55	0.037	0.41

SOURCE	SITE_NAME	DATE	COND	DO	DO SAT	DRP	EC	NH4	NNN	PHF	SS	TEMP	TN	TP	TURB
Pool Burn	Auripo Rd	24-Nov-05	0.4119	5.26	47.1	0.054	62	0.005	0.0025	7.5	1.5	10.5	0.49	0.072	0.51
Pool Burn	Auripo Rd	21-Dec-05	0.11	8.63	90.4	0.084	3200	0.01	0.024	7.5	6	17.51	0.46	0.136	6.1
Pool Burn	Auripo Rd	01-Feb-06	0.323	6.75	69.9	0.08	11	0.02	0.0025	8	1.5	16.89	0.57	0.111	0.48
Pool Burn	Auripo Rd	14-Feb-06	0.3501	3.18	32.1	0.096	40	0.01	0.0025	7	5	15.4	1.01	0.045	0.86
Thompsons Ck	Race	09-Sep-04	0.0446	13.12	104.5	0.011	5	0.02	0.027	7.9	3	6.29	0.12	0.011	0.95
Thompsons Ck	Race	18-Nov-04	0.0554	12.35	108.2	0.014	79	0.005	0.011	7.77	10	9.6	0.1	0.021	1
Thompsons Ck	Race	25-Jan-05	0.0605	9.43	98.7	0.011	320	0.005	0.014	7.77	38	17.4	0.18	0.059	4.2
Thompsons Ck	Race	10-Feb-05				0.014	10	0.005	0.01	7.77	5		0.08	0.016	0.7
Thompsons Ck	Race	15-Mar-05	0.0591	12.53	123.4	0.009	16	0.005	0.01	8.46	4	15.08	0.05	0.011	0.9
Thompsons Ck	Race	25-May-05	0.0538	13.74	108.7	0.007	2	0.01	0.005	8.15	0.5	5.57	0.176	0.006	0.65
Thompsons Ck	Race	27-Jul-05	0.0717	12.42	100.6	0.012	4	0.005	0.022	8	1.5	6.2	0.09	0.014	1.3
Thompsons Ck	Race	27-Sep-05	0.045	10.93	96.7	0.012	2	0.005	0.011	7.7	7	9.97	0.12	0.02	2.7
Thompsons Ck	Race	25-Oct-05	0.0476	10.99	98.6	0.01	78	0.01	0.006	7	7	10.7	0.05	0.017	1.2
Thompsons Ck	Race	21-Nov-05	0.0602	10.42	89.6	0.008	330	0.005	0.0025	7	12	8.7	0.26	0.031	3.4
Thompsons Ck	Race	21-Dec-05	0.048	10.25	100.2	0.006	220	0.01	0.005	7.46	5	14.24	0.14	0.024	2.5
Thompsons Ck	Race	01-Feb-06	0.058	9.65	102.6	0.008	12	0.01	0.0025	7.63	1.5	18.67	0.07	0.015	0.64
Thompsons Ck	Race	14-Feb-06	0.0706	10.64	101	0.009	90	0.005	0.008	7.9	4	13	0.09	0.018	1.4
Thompsons Ck	SH85	09-Sep-04	0.0635	12.62	106.1	0.019	14	0.02	0.062	7.76	5	8.56	0.27	0.032	1.9
Thompsons Ck	SH85	18-Nov-04	0.0856	10.32	98.2	0.097	2800	0.02	0.083	7.44	4	13	0.59	0.167	5.4
Thompsons Ck	SH85	25-Jan-05	0.0751	8.91	97.5	0.029	250	0.01	0.041	7.41	34	19.9	0.31	0.11	8.1
Thompsons Ck	SH85	10-Feb-05				0.122	800	0.01	0.027	7.2	8		0.74	0.236	3.3
Thompsons Ck	SH85	15-Mar-05	0.0795	10.38	106.4	0.048	460	0.01	0.044	7.39	2	17	0.55	0.11	4.5
Thompsons Ck	SH85	25-May-05	0.084	12.4	102.2	0.011	52	0.005	0.124	7.51	7	7.42	0.27	0.013	2.2
Thompsons Ck	SH85	27-Sep-05	0.079	11.19	100.3	0.276	400	0.01	0.081	7.4	9	10.46	0.72	0.343	4.9
Thompsons Ck	SH85	25-Oct-05	0.0682	8.84	91.2	0.083	4800	0.02	0.028	7.6	16	16.9	0.55	0.148	7.2
Thompsons Ck	SH85	21-Nov-05	0.1017	8.92	81.2	0.157	6700	0.02	0.05	7	15	11.2	0.97	0.257	6.6
Thompsons Ck	SH85	20-Dec-05	0.129	6.85	71.7	0.376	4900	0.02	0.032	7.02	12	17.57	1.86	0.574	6
Thompsons Ck	SH85	01-Feb-06	0.09	7.53	80.5	0.0025	190	0.02	0.0025	7.33	4	18.52	0.8	0.23	2.8
Thompsons Ck	SH85	14-Feb-06	0.1336	7.55	75.5	0.274	830	0.02	0.011	7	6	15.3	1.67	0.411	3.6

SOURCE	SITE_NAME	DATE	COND	DO	DO SAT	DRP	EC	NH4	NNN	PHF	SS	TEMP	TN	TP	TURB
Welcome Ck	Lower Site	09-Feb-04	0.1448	10.4		0.026	150	0.03	1.41	7.07	7	15.5	1.56	0.04	2.1
Welcome Ck	Lower Site	13-Apr-04	0.1034	11.87	111.5	0.033	240	0.005	1.69	6.83	9	12.47	1.99	0.056	2.7
Welcome Ck	Lower Site	08-Jun-04	0.1552	12		0.022	50	0.02	1.55	7.22	9	9.5	1.67	0.028	0.6
Welcome Ck	Lower Site	16-Aug-04	0.1512	12.5		0.02	13	0.02	1.64	7.06	1	7.5	1.52	0.023	0.5
Welcome Ck	Lower Site	07-Sep-04	0.0743	13.81	120.4	0.013	4	0.01	0.697	7.29	3	9.4	0.85	0.025	1.5
Welcome Ck	Lower Site	12-Oct-04	0.0831	13.12	118.4	0.02	19	0.01	1.8	7.08	0.5	10.29	1.83	0.027	0.55
Welcome Ck	Lower Site	14-Dec-04	0.14	10.3		0.017	370	0.005	1.15	6.95	3	12.7	2.13	0.031	0.8
Welcome Ck	Lower Site	08-Feb-05	0.1121	8.98	89.1	0.071	1800	0.02	1.29	6.66	2	15.64	1.64	0.083	0.6
Welcome Ck	Lower Site	11-Apr-05	0.0965	11.41	109.4	0.025	22	0.01	1.53	7	3	13.95	1.7	0.029	0.6
Welcome Ck	Lower Site	26-May-05				0.019	37	0.02	0.949	7.03	3		1.05	0.025	1.3
Welcome Ck	Lower Site	14-Jun-05	0.0556	10.74	94.7	0.014	48	0.02	0.775	6.76	4	9.32	1.09	0.024	2
Welcome Ck	Lower Site	14-Jun-05				0.014	48	0.02	0.775				1.09	0.024	
Welcome Ck	Lower Site	16-Aug-05				0.014	32	0.01	0.672		6		0.89	0.03	2.2
Welcome Ck	Lower Site	27-Sep-05	0.0833			0.032	100	0.005	0.573	6.3	6	10.6	0.76	0.045	3.5
Welcome Ck	Lower Site	12-Oct-05	0.1191	11.7		0.014	9	0.01	0.995	7.6	4	10.3	1.11	0.019	2.7
Welcome Ck	Lower Site	03-Nov-05				0.027	250	0.005	1.26		1.5		1.39	0.038	1
Welcome Ck	Lower Site	05-Dec-05	0.099	9.66	97	0.05	98	0.01	1.83	6.89	3	15.5	2.03	0.064	0.88
Welcome Ck	Lower Site	08-Feb-06	0.1243	8.83	87.6	0.025	100	0.06	1.93	7.3	12	15	1.87	0.04	2.3
Welcome Ck	Upper Site	09-Feb-04	0.1408	9		0.031	95	0.02	2.02	6.96	6	16.2	2.15	0.042	1.6
Welcome Ck	Upper Site	13-Apr-04	0.0927	10.47	101	0.042	93	0.005	1.6	6.72	2	13.4	1.75	0.052	0.6
Welcome Ck	Upper Site	08-Jun-04	0.1598	11.5		0.033	13	0.02	2.08	7.14	1	10.7	2.14	0.036	0.5
Welcome Ck	Upper Site	16-Aug-04	0.1463	10.9		0.03	0.5	0.01	1.69	6.8	0.5	7.2	1.63	0.034	0.4
Welcome Ck	Upper Site	07-Sep-04	0.0793	11.15	93.8	0.029	0.5	0.005	1.23	6.69	0.5	8	1.41	0.036	0.4
Welcome Ck	Upper Site	12-Oct-04	0.0911	9.65	85.1	0.03	1	0.01	2.2	6.69	0.5	9.44	2.22	0.036	0.55
Welcome Ck	Upper Site	14-Dec-04	0.1876	5.8		0.029	2	0.005	2.17	6.48	0.5	12.8	2.67	0.035	0.4
Welcome Ck	Upper Site	08-Feb-05	0.1105	5.36	52.3	0.039	1	0.005	1.68	6.35	2	15.17	1.79	0.042	0.65
Welcome Ck	Upper Site	11-Apr-05	0.095	6.48	63.3	0.037	1	0.005	1.68	6.4	0.5	14.99	1.82	0.038	0.45
Welcome Ck	Upper Site	26-May-05	0.177	17.2		0.013	33	0.02	1.05	7.91	2	10.9	1.16	0.015	1.4
Welcome Ck	Upper Site	14-Jun-05	0.0557	9.12	84.2	0.031	1	0.01	1	6.6	0.5	11.18	1.19	0.033	0.65
Welcome Ck	Upper Site	14-Jun-05				0.031	1	0.01	1				1.19	0.033	
Welcome Ck	Upper Site	16-Aug-05				0.03	2	0.05	0.604		1.5		0.1	0.02	0.61

SOURCE	SITE_NAME	DATE	COND	DO	DO SAT	DRP	EC	NH4	NNN	PHF	SS	TEMP	TN	TP	TURB
Welcome Ck	Upper Site	27-Sep-05	0.105			0.032	1	0.005	1.39	6.2	1.5	9.7	1.49	0.029	0.26
Welcome Ck	Upper Site	12-Oct-05	0.1069	11.5		0.029	1	0.005	0.614	7.9	1.5	9.7	0.73	0.031	0.65
Welcome Ck	Upper Site	03-Nov-05	0.115	7.1	65	0.036	120	0.005	1.92	6.2	1.5	11.5	1.98	0.038	0.49
Welcome Ck	Upper Site	05-Dec-05	0.084	5.76		0.034	0.5	0.005	1.73	6.62	1.5	13.22	1.79	0.039	0.37
Welcome Ck	Upper Site	08-Feb-06	0.1065	5.64	57.2	0.041	2	0.03	1.65	7.6	1.5	16.2	1.54	0.036	0.6
Gimmer Burn	Sharkey Rd	08-Sep-04	0.104	13.72	105.3	0.01	54	0.01	0.018	7.36	2	4.15	0.42	0.018	1.3
Gimmer Burn	Sharkey Rd	04-Apr-05	0.1439	9.22	84.2	0.009	920	0.02	0.0025	7.46	3	12.26	0.22	0.025	2.3
Gimmer Burn	Sharkey Rd	27-Jul-05	0.321	3.38	26.9	0.013	4	0.005	0.009	6.59	1.5	5.6	0.3	0.031	7.4
Gimmer Burn	Sharkey Rd	27-Sep-05	0.1627	12.89	106.9	0.0025	11	0.005	0.001	7.81	0.5	7.71	0.3	0.01	1.2
Gimmer Burn	Sharkey Rd	13-Oct-05	0.24	11.6		0.007	100	0.005	0.0025	7.2	1.5	6.7	0.22	0.01	1.3
Gimmer Burn	Wilson Road	24-Feb-04	0.226	6.6	61.8	0.058	10	0.005	0.0025	6.82	0.5	12.51	0.42	0.116	1.9
Gimmer Burn	Wilson Road	15-Mar-04		8.8		0.072	440	0.02	0.0025	7.44	1	15.2	0.53	0.137	1.6
Gimmer Burn	Wilson Road	25-May-04	0.1455	12.59	101.5	0.031	85	0.04	0.0025	6.74	1	6.19	0.3	0.054	2
Gimmer Burn	Wilson Road	29-Jul-04	0.257	14.4		0.018	10	0.005	0.006	7.45	0.5	0.4	0.27	0.026	0.75
Gimmer Burn	Wilson Road	08-Sep-04	0.116	13.25	103.8	0.017	16	0.01	0.0025	7.32	0.5	4.99	0.37	0.025	1
Gimmer Burn	Wilson Road	21-Sep-04	0.07	12.7	108	0.018	16	0.005	0.0025	6.71	1	8.26	0.39	0.039	2.3
Gimmer Burn	Wilson Road	24-Nov-04	0.129	11.3		0.048	1500	0.005	0.006	7.08	0.5	12.18	0.51	0.104	1.6
Gimmer Burn	Wilson Road	26-Jan-05	0.905	5.87	60.6	0.038	110	0.02	0.007	6.55	4	17.92	0.61	0.168	3.2
Gimmer Burn	Wilson Road	10-Feb-05	0.1687	3	30.1	0.114	100	0.04	0.008	6.91	2	18	0.83	0.269	2
Gimmer Burn	Wilson Road	04-Apr-05	0.0543	9.04	83.6	0.026	250	0.03	0.007	7.2	4	12.52	0.45	0.07	3.6
Gimmer Burn	Wilson Road	25-May-05	0.1787	11.57	89.4	0.018	85	0.01	0.0025	7.37	0.5	4.3	0.34	0.042	2
Gimmer Burn	Wilson Road	27-Sep-05	0.0501	10.23	87.3	0.032	160	0.005	0.001	7.72	5	9.05	0.4	0.07	3.9
Gimmer Burn	Wilson Road	13-Oct-05	0.1071	11.2		0.025	100	0.01	0.0025	6.6	3	8.9	0.34	0.046	3.3
Gimmer Burn	Wilson Road	22-Nov-05	0.08	9.3	88.4	0.259	15000	0.01	0.486	6.71	9	10.86	1.43	0.367	6.9
Gimmer Burn	Wilson Road	14-Dec-05	0.099	11.27	123.3	0.076	180	0.02	0.006	7.2	1.5	19.76	0.47	0.154	2.2
Gimmer Burn	Wilson Road	18-Jan-06	0.111	7.81	74.2	0.043	180	0.02	0.015	7.01	1.5	12.86	0.67	0.097	5.4
Gimmer Burn	Wilson Road	09-Feb-06				0.052	1000	0.02	0.0025	7.7	1.5		0.42	0.116	2.5
Ida Burn	Auripo Rd	23-Mar-04	0.2227	7.84	75.1	0.068	520	0.02	0.015	7.67	0.5	13.2	0.45	0.098	0.65
Sow Burn	Patearoa/Styx Rd	27-Jul-05	0.033	12.11	93.5	0.008	25	0.005	0.005	6.21	1.5	4.44	0.09	0.007	0.97

SOURCE	SITE_NAME	DATE	COND	DO	DO SAT	DRP	EC	NH4	NNN	PHF	SS	TEMP	TN	TP	TURB
Sow Burn	Patearoa/Styx Rd	27-Sep-05	0.03	12.39	101.1	0.0025	340	0.005	0.001	7.59	1	6.97	0.1	0.01	0.25
Sow Burn	Patearoa/Styx Rd	13-Oct-05	0.0353	12.8		0.005	20	0.005	0.0025	6.5	4	5.8	0.15	0.014	1.4
Sow Burn	Patearoa/Styx Rd	24-Nov-05	0.025	9.98	85.5	0.0025	150	0.005	0.0025	6.71	1.5	8.73	0.13	0.014	0.38
Sow Burn	Patearoa/Styx Rd	14-Dec-05	0.03	9.38	90.8	0.005	480	0.01	0.0025	6.78	1.5	13.85	0.1	0.008	1.2
Sow Burn	Patearoa/Styx Rd	18-Jan-06	0.027	10.76	95.8	0.008	52	0.005	0.0025	6.33	1.5	10.21	0.11	0.012	1.1
Sow Burn	Patearoa/Styx Rd	09-Feb-06				0.008	240	0.01	0.0025	7.1	1.5		0.09	0.011	0.89
Sow Burn	u/s Taieri Confluence	08-Sep-04	0.037	14.44	114	0.006	5	0.005	0.013	7.64	7	5.28	0.12	0.019	6.3
Sow Burn	u/s Taieri Confluence	04-Apr-05	0.0315	10.53	96.6	0.007	430	0.03	0.049	6.97	14	11.93	0.16	0.028	5.1
Sow Burn	u/s Taieri Confluence	27-Sep-05	0.0413	12.4	106.5	0.006	19.9	0.005	0.05	7.52	6	9.04	0.2	0.01	2
Sow Burn	u/s Taieri Confluence	13-Oct-05	0.0418	9.6		0.009	140	0.005	0.016	6.4	60	8.3	0.21	0.047	14
Sow Burn	u/s Taieri Confluence	24-Nov-05	0.039	10.87	98.7	0.006	79	0.005	0.092	6.64	1.5	11.07	0.15	0.013	1.2
Sow Burn	u/s Taieri Confluence	14-Dec-05	0.051	10.4	103.4	0.012	400	0.02	0.18	6.82	1.5	16.77	0.34	0.022	1.2
Sow Burn	u/s Taieri Confluence	18-Jan-06	0.038	10.36	96.5	0.011	160	0.005	0.078	6.29	8	12.17	0.2	0.019	1.2
Sow Burn	u/s Taieri Confluence	09-Feb-06				0.015	560	0.02	0.352	7.2	1.5		0.43	0.027	2.2
Pig Burn	900m d/s O'Neill Rd	24-Feb-04	0.1842	7.33	68.6	0.0025	68	0.01	0.078	6.86	2	12.28	0.28	0.01	1.8
Pig Burn	900m d/s O'Neill Rd	16-Mar-04	0.2	4.34	41.91	0.0025	68	0.03	0.093	7.15	2	13.4	0.24	0.0025	1.7
Pig Burn	900m d/s O'Neill Rd	29-Jul-04	0.1357			0.0025	4	0.01	0.134	7.39	0.5	2.1	0.22	0.007	0.55
Pig Burn	900m d/s O'Neill Rd	08-Sep-04	0.061	12.56	107.9	0.006	0.5	0.005	0.023	7.35	2	8.71	0.13	0.0025	0.9
Pig Burn	900m d/s O'Neill Rd	22-Sep-04	0.043	13.2	102	0.0025	12	0.005	0.014	6.46	10	4.52	0.22	0.02	2.6
Pig Burn	900m d/s O'Neill Rd	24-Nov-04	0.089	11.9		0.0025	91	0.005	0.051	7.24	0.5	10.37	0.17	0.01	0.7
Pig Burn	900m d/s O'Neill Rd	26-Jan-05	0.102	11.16	107.1	0.0025	48	0.005	0.028	7.22	1	14.09	0.18	0.015	0.9
Pig Burn	900m d/s O'Neill Rd	04-Apr-05	0.0605	10.11	95.5	0.007	75	0.02	0.047	7.13	12	13.29	0.31	0.039	4.6
Pig Burn	900m d/s O'Neill Rd	28-Sep-05	0.0527	12.13	100	0.012	80	0.005	0.014	7.37	14	7.39	0.3	0.038	6.9
Pig Burn	900m d/s O'Neill Rd	13-Oct-05	0.0558	11.6		0.007	130	0.005	0.01	6.3	51	8.6	0.28	0.054	13
Pig Burn	900m d/s O'Neill Rd	24-Nov-05	0.06	8.68	82.4	0.101	3000	0.05	0.063	6.7	16	12.98	0.67	0.181	16
Pig Burn	900m d/s O'Neill Rd	14-Dec-05	0.126	2.8	27.6	0.006	8	0.01	0.034	6.67	1.5	14.63	0.18	0.014	1.1
Pig Burn	900m d/s O'Neill Rd	18-Jan-06	0.075	10.34	97.2	0.008	100	0.005	0.028	6.7	1.5	12.57	0.17	0.011	1.1
Pig Burn	900m d/s O'Neill Rd	09-Feb-06	0.1385	9.01	91.3	0.011	76	0.01	0.056	7.3	1.5	14.5	0.26	0.015	1.1
Pig Burn	Hamilton Rd	24-Feb-04	0.0936	9.79	92	0.0025	99	0.005	0.017	7.1	0.5	12.51	0.05	0.0025	0.05

SOURCE	SITE_NAME	DATE	COND	DO	DO SAT	DRP	EC	NH4	NNN	PHF	SS	TEMP	TN	TP	TURB
Pig Burn	Hamilton Rd	08-Sep-04	0.041	12.34	103.2	0.006	1	0.01	0.006	7.22	1	7.64	0.13	0.0025	0.45
Pig Burn	Hamilton Rd	10-Feb-05	0.0813	8.82	88.8	0.006	200	0.01	0.007	7.22	0.5	15.6	0.06	0.009	0.15
Pig Burn	Hamilton Rd	04-Apr-05	0.058	10.5	96.5	0.0025	260	0.02	0.007	7.25	1	12.07	0.09	0.009	0.45
Pig Burn	Hamilton Rd	24-May-05	0.0692	14.36	117.1	0.0025	29	0.005	0.0025	7.36	1	11.43	0.05	0.006	0.4
Pig Burn	Hamilton Rd	26-Jul-05	0.044	12.14	94.2	0.007	6	0.005	0.007	6.45	1.5	4.64	0.11	0.007	0.77
Pig Burn	Hamilton Rd	28-Sep-05	0.0539	12.06	96.9	0.005	1	0.005	0.006	7.49	1.5	6.22	0.07	0.005	0.49
Pig Burn	Hamilton Rd	13-Oct-05	0.0425	12.3		0.0025	8	0.005	0.005	6.5	3	6.3	0.18	0.013	1.1
Pig Burn	Hamilton Rd	24-Nov-05	0.053	9.52	86.3	0.0025	18	0.005	0.005	6.8	1.5	10.99	0.025	0.006	0.26
Pig Burn	Hamilton Rd	14-Dec-05	0.058	9.57	92.3	0.0025	30	0.01	0.0025	6.44	1.5	13.75	0.07	0.0025	0.85
Pig Burn	Hamilton Rd	18-Jan-06	0.046	10.34	94.7	0.007	350	0.005	0.0025	6.44	1.5	11.38	0.15	0.012	1.5
Pig Burn	Hamilton Rd	09-Feb-06				0.007	99	0.005	0.006	7.2	3		0.08	0.007	0.37

Otago Regional Council