Water Quality State of Jed River and tributaries 2010-11: Summary Report

Prepared by Kimberley Robinson and Michele Stevenson
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1. Background

The Jed River within the Cheviot Basin is classed as a hill-fed river in the Natural Resources Regional Plan, and has low rainfall, high evapotranspiration and losses to ground water. Therefore the Jed River is characterised by low flows for extended periods of time, with occasional floods during heavy rainfall events. The majority of the flow comes from the two main tributaries; Woolshed Creek, which arises from the north-east of Cheviot, and Crystal Brook, which arises from the south-west (Lockington et al. 2007).

Historically, the Cheviot sewage treatment plant has discharged wastewater into Crystal Brook. In the early days wastewater was discharged directly from a sludge plant, which was upgraded in 1982 to irrigation onto a border dyke area (Hurunui District Council, 2006). Over time the plant has been upgraded. Currently the plant discharges treated wastewater onto land via spray irrigation, “which shall not result in runoff into waterways or drains” (consent CRC091326, condition 8). However, the irrigation area is prone to flooding and, should ponding on the spray irrigation area occur, treated wastewater is discharged via overland flow into a drain which runs into Crystal Brook (consent CRC091326).

The water quality of the Jed River has raised community concern due to its poor aesthetic appearance and public health warnings in relation to the wastewater discharges. Additionally, the Jed River catchment has undergone agricultural development over many years; stream walks by Environment Canterbury staff have identified that most of the land adjacent to the waterway is used for grazing with no fencing between the grazed land and the river. Unrestricted stock access to waterways can result in direct inputs of faecal contamination, sedimentation via bank erosion, and associated poor water clarity.

This report provides a brief summary on the state of water quality in the Jed River, Crystal Brook and Woolshed Creek. The summary is based on one year of monthly water quality monitoring by Cheviot community members and Environment Canterbury staff.

2. Monitoring

The Jed River and tributaries were sampled on a monthly basis from July 2010 to September 2011, with the exception of March and April, when monitoring was disrupted following the February 2011 earthquake in Christchurch. Five sites on the Jed River, Woolshed Creek and Crystal Brook were monitored (see Table 1 and Figure 1), with a maximum of 13 monthly samples taken from each site, provided the sites were flowing.

Table 1: Water quality monitoring sites for the Jed River and tributaries.

Site ID	Source	Site Name	East	North
SQ35710	Crystal Brook	50 m upstream of Cheviot effluent discharge	2531845	5821101
SQ35712	Jed River	Below SH1, approximatley 70 m downstream of bridge	2532274	5821119
SQ35713	Woolshed Creek	at Botanical Gardens	2532603	5821586
SQ35717	Jed River	Down stream woolshed Creek confluence	2532969	5820844
SQ35711	Jed River	Upstream of tidal influence	2535225	5817631

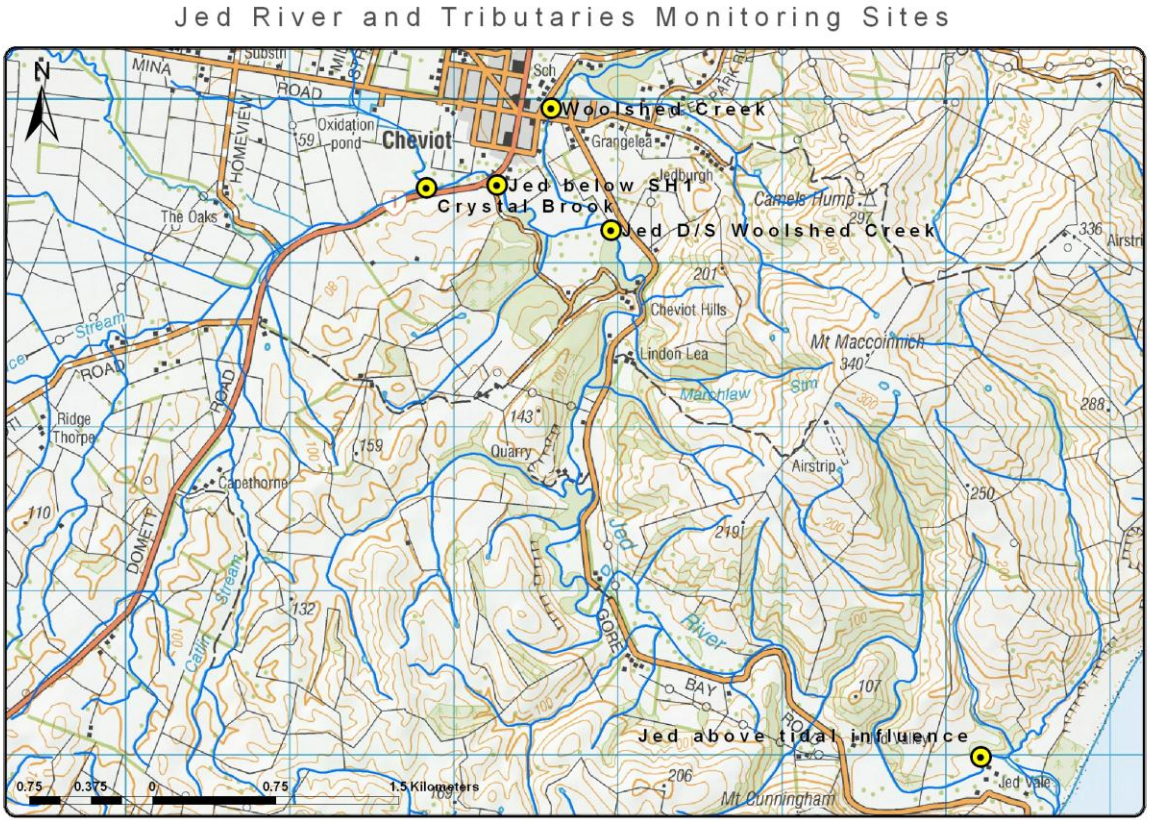

Figure 1: Location of water quality monitoring sites for the Jed River and tributaries

Samples were analysed for a range of physical, chemical and microbiological parameters by Environment Canterbury's water quality laboratory (see Table 2). Additionally, Biochemical Oxygen Demand (BOD_5) was monitored at two sites; one at the Crystal Brook site upstream of the Cheviot effluent discharge, and one on the Jed River downstream of SH1 below the effluent discharge. Water clarity was measured on site using a SHMAK clarity tube.

Table 2: Physical, chemical and microbiological parameters analysed

Lab Tests		
Conductivity pH E. coli	Ammoniacal Nitrogen Nitrite + Nitrate Nitrogen Total Nitrogen	Dissolved Reactive Phosphorus Total Phosphorus

3. Data Analysis

Data were analysed using Microsoft Excel 2003. Summary statistics describing water quality state for the Jed River and tributaries are presented in a table (Appendix 1) and as scatterplots (Figures 2 - 9).

Water quality state was compared to various guideline values as described in Appendix 2. Effluent discharge data were provided by Hurunui District Council and were analysed using scatterplots to assess if the discharge of treated effluent into Crystal Brook correlated with Jed River water quality parameters.

It must be noted that the sampling was only carried out for one year and therefore the description of the state of water quality in the Jed River provided here may not be representative of long-term state. However, the data are sufficient to draw general conclusions and identify some key issues of concern.

4. Water Quality State

Conductivity and pH

Conductivity is a measure of the ability of water to conduct an electrical current and is related to the concentrations of total dissolved solids and major ions in water (APHA 1992). Minimum conductivity in samples from all the Jed River and tributary sites was well above the recommended guideline value of 17.5 mS/m for aquatic ecosystems (Biggs 1988) and above the median conductivity of 11 mS/m found in hill-fed lower river types throughout Canterbury (Stevenson *et al.* 2010) (Appendix 1). Median pH in the Jed River and tributaries ranged from 7.85 to 8.2 (Appendix 1), which is above the ANZECC (2000) water quality guideline range of 7.2-7.8 for aquatic ecosystem protection, and above the median pH of 7.6 found in hill-fed lower river types in Canterbury (Stevenson *et al.* 2010).

Conductivity and pH can be influenced by the geology of a catchment. Catchments of soft sediments such as limestone may have elevated conductivity and pH from leaching of soluble ions from rocks and soils. The geology of the Jed River catchment includes tertiary marine sediments such as limestone, and calcareous mudstone (Snelder *et al.* 2004; Geology of the Kaikoura Area QMap. 2006). This trend of elevated conductivity and pH mirrors that of the Waipara River catchment which similarly originates from areas of tertiary marine sediments (Hayward *et al.* 2003). It is noted by Hayward *et al.* (2003) that not many catchments in Canterbury are of a similar geological classification and hence the conductivity and pH values of the Waipara River and Jed River are greater than for most Canterbury rivers, which have greywacke dominated geology.

Water Clarity

Water clarity is the measure of light attenuation through water and is affected by material suspended in the water column. Water clarity can be affected by soil erosion and eroding stream banks, wastewater discharge containing high organic load, stormwater runoff, re-suspended bed sediments and excessive algal growth, which can influence aesthetic or recreational values in fresh waters. The clarity tube was designed as part of the Stream Health Monitoring Assessment Kit (SHMAK) for measuring water clarity by non-scientists (Biggs et al. 2002) based on the principles of the black disc method (Davies-Colley, 1988). Observations are made of the distance that a black disc can be seen against a black background along a clear Perspex tube; a greater distance, and hence higher result recorded, indicates better water clarity.

Water clarity in the Jed River and tributaries varies between sites with poorer water clarity in the middle reaches of the Jed River and Crystal Brook (Figure 2, Appendix 1). A recreational guideline value of 85cm for clarity tube measurements is derived from the guideline value of 1.6m for black disc water clarity (Biggs et al. 2002; Davies-Colley, 1988; Kilroy and Biggs, 2002). Water clarity in Crystal Brook, Jed River sites below SH 1 and downstream of Woolshed Creek confluence, fall below the guideline value on all occasions indicating poor water clarity; which has implications for aesthetic and recreational appeal. Water clarity is generally better in Woolshed Creek and the lower site on the Jed River, however median water clarity measured in Woolshed Creek was still below the guideline value (Appendix 1). It is difficult to determine the direct cause of poor water clarity in the Jed River and Crystal Brook. With poor water clarity in Crystal Brook upstream of the wastewater plant and with discharges to Crystal Brook only on occasion, wastewater cannot be the sole cause of poor water clarity in the Jed River. The occurrence of unfenced areas within the Jed River catchment (ECan stream walk, 2010) allows for unrestricted stock access, which can influence water clarity via bank erosion and sediment release, and direct faecal input, leading to increased suspended material in the water column. Water clarity was poorest in streams classified by the River Environment Classification (Snelder et al. 2004) as cool-dry climate, low elevation and soft sedimentary geology, therefore the soft sediment nature of the catchment is likely to be prone to soil erosion resulting in high suspended solids concentrations and reduced water clarity.

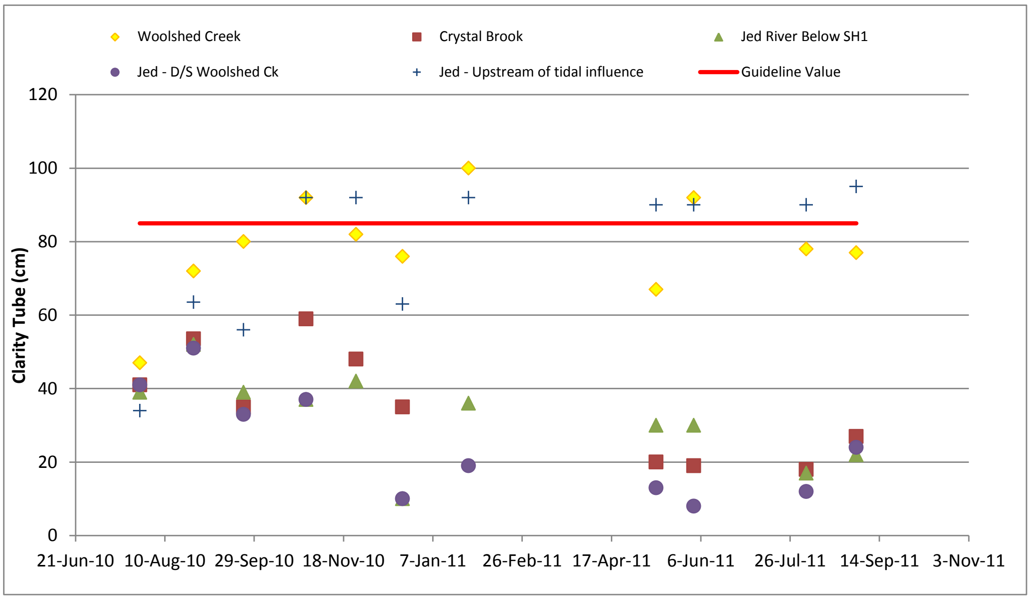

Figure 2: Water Clarity of the Jed River and Tributaries. Concentrations above the red line guideline value of 85cm are considered "clear" and suitable for freshwater recreation

Biochemical Oxygen Demand (BOD_5)

Biochemical Oxygen Demand (BOD_5) is a measure of the amount of oxygen consumed by micro-organisms during the decomposition of organic matter, hence the greater the BOD_5 of a water body, the greater the amount of oxygen depleted in a 5 day period. The reduction of dissolved oxygen in water is a physiological stressor for aquatic organisms and therefore a guideline value of 1 mg/L has been applied for BOD_5; however the current laboratory detection limit for BOD_5 is 2 mg/L (Hayward *et al.* 2009). Organic matter can be sourced from either in-river production (plant growth) or inputs of organic compounds via discharges. It is for this reason that BOD_5 was measured upstream and downstream of the Cheviot sewage treatment plant discharge. Both the upstream and downstream sites had a median BOD_5 of 3 mg/L but higher concentrations were measured at the downstream site on occasion (Figure 3, Appendix 1). The median concentrations exceed the 1 mg/L guideline, indicating that BOD_5 is of concern in both Crystal Brook and the Jed River. The higher concentrations downstream may be a result of the treated wastewater discharge; however the source of the problem upstream of the discharge is unknown. BOD_5 is generally higher in slow sluggish streams such as the Jed River, where organic matter can accumulate (USEPA, 1997).

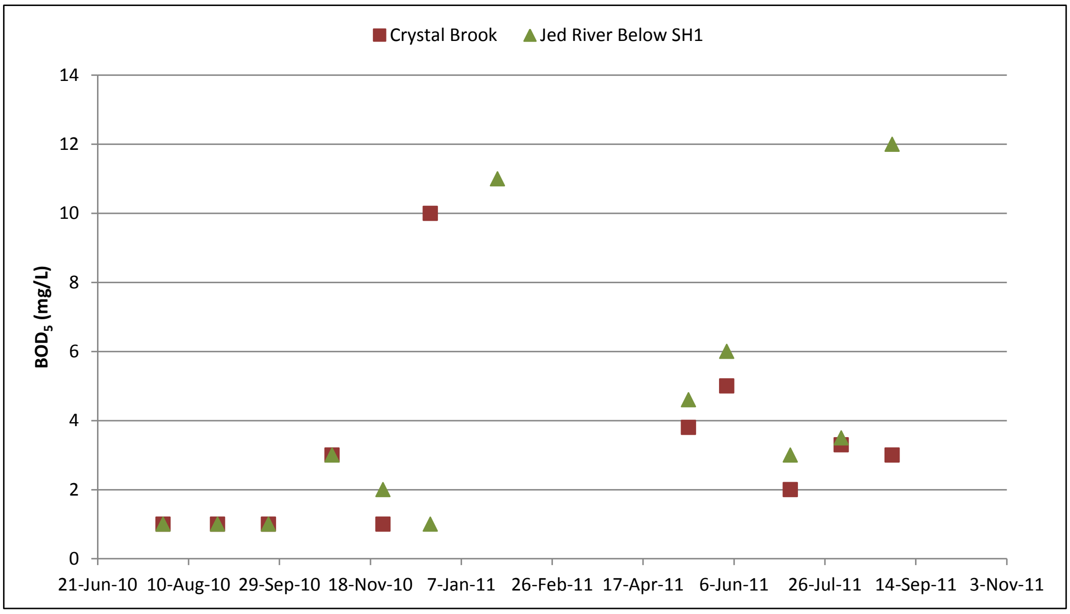

Figure 3: Biochemical Oxygen Demand in Crystal Brook and the Jed River at SH 1 (upstream and downstream of the Cheviot treatment plant discharge)

Nutrients

Dissolved inorganic nitrogen (DIN) comprises the inorganic soluble nitrogen compounds that are readily available to plants and can stimulate plant and algal growth under favourable conditions. DIN is the sum of nitrate-N, nitrite-N and ammonia-N concentrations, which may enter surface waters via surface runoff, leaching through groundwater, direct input from effluent application, wastewater discharges, livestock access or fertilizer application.

Median DIN at all sites on the Jed River and tributaries exceeded the guideline value of 0.01mg/L, which is the threshold for protection of aquatic biodiversity related to periphyton growth (MfE, 2000; Appendix 1). Elevated DIN concentrations are common for the lower reaches of a hill-fed river system and Stevenson *et al.* (2010) reported a median DIN concentration for sites on hill-fed lower rivers in Canterbury of 0.321 mg/L. DIN measured in the Jed River and tributaries was greatest in Crystal Brook and the middle reaches of the Jed River, with the highest DIN concentrations for the Jed River at the site below SH 1 (Figure 4). There is a noticeable increase in DIN between the Crystal Brook site and the Jed River below SH 1 during the winter period of 2011. A source of this DIN may be the treated wastewater discharge that is irrigated to land; less infiltration due to saturated soil and reduced uptake of nutrients by plants in winter may allow for greater run-off potential. DIN concentrations in Woolshed Creek were very low and appear to dilute the concentrations in the Jed River, based on the results from the site downstream of Woolshed Creek.

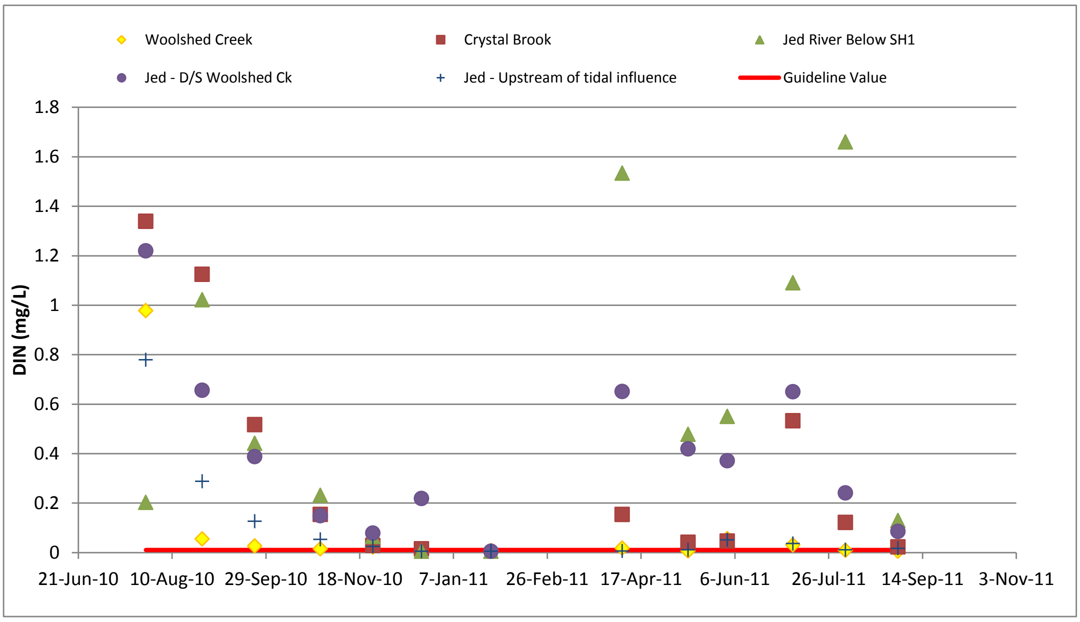

Figure 4: Dissolved Inorganic Nitrogen concentrations in the Jed River and tributaries. Concentrations above the red line 0.01mg/L indicates excessive concentrations for the growth of aquatic weeds

Ammonia nitrogen is one of the components of DIN, which originates from urine inputs, breakdown of urea and animal proteins, industrial processes, or reduced nitrogen under anoxic conditions. Given the nature of this catchment, ammonia nitrogen is of particular interest due to inputs from the wastewater discharges.

Ammonia nitrogen concentrations were well below the toxicity trigger value of 0.9 mg/L at a pH of 8 for aquatic ecosystems, with the exception of one result at the Jed River SH 1 site (ANZECC 2000; Figure 5, Appendix 1). This single result occurred during a period of rainfall, as indicated by the Lowry Hills rain gauge, with a high likelihood of run-off (Figure 6). Median concentrations varied across sites when compared against the guideline value for managing excessive weed growths (0.021 mg/L, ANZEEC 2000), with Crystal Brook and the middle reaches of the Jed River exceeding this guideline value. There appears to be a spatial pattern of an increase in ammonia nitrogen concentrations in distance downstream from Woolshed Creek and Crystal Brook to Jed River at SH 1 and downstream of Woolshed Creek confluence. This may be due to the influence of treated wastewater discharge and a cumulative effect of diffuse sources (run-off and stock access) contributing to these elevated concentrations between the SH 1 site and the Woolshed Creek confluence site. The elevated ammonia-nitrogen results seen during the winter-spring period of 2011 occurred during a period of intermittent discharges of treated wastewater (Figure 6). It should be noted that in accordance with the resource consent (CRC091326) the overland flow and resulting discharge into the Jed River shall occur only if there is visual ponding on the spray irrigation area or when discharge is required to maintain plant growth on the overland flow area. Given the elevated ammonia-nitrogen results during periods of intermittent overland flow and discharge during winter, it could be assumed that ponding is occurring with limited infiltration of wastewater to soil, and hence potential for increased run-off to waterways.

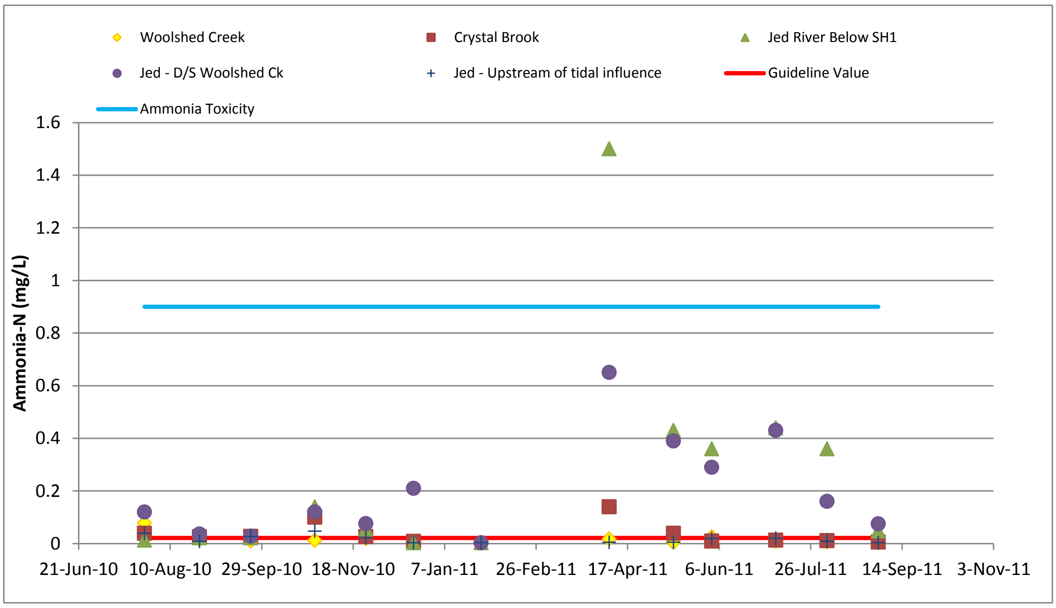

Figure 5: Ammonia Nitrogen (mg/L) concentrations in the Jed River and tributaries. Concentrations above the dashed orange line at 0.021mg/L indicates excessive concentrations for the growth of aquatic weeds; and above the red line at 0.9mg/L indicate ammonia toxicity at pH 8

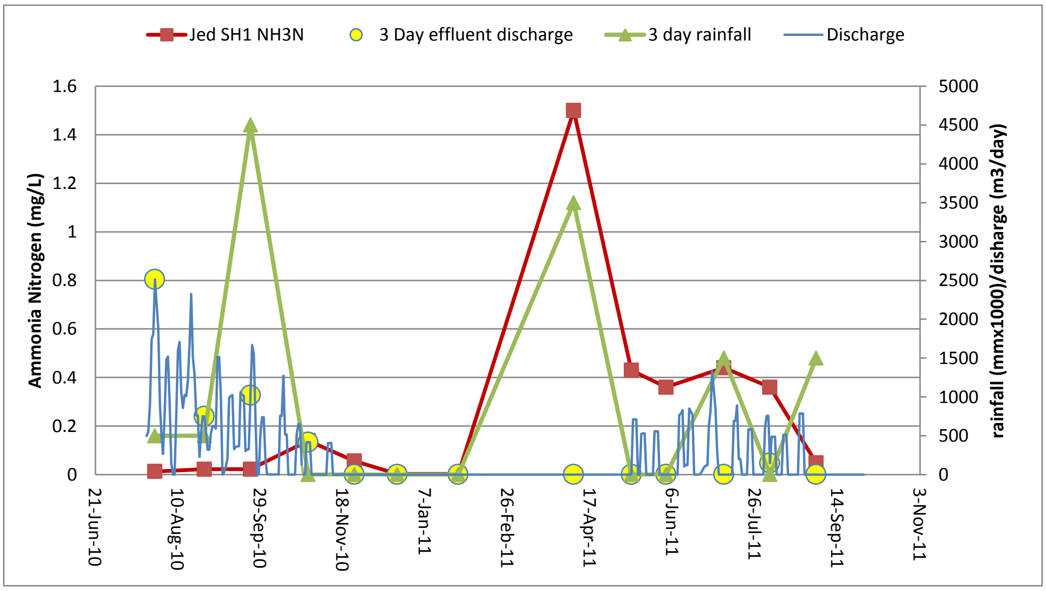

Figure 6: Ammonia Nitrogen (mg/L) concentrations at the Jed River at SH 1 site in relation to overland effluent flow discharge and rainfall 3 days before each sampling event. (Note: the yellow dot depicts effluent discharge 3 days prior to sampling, whilst the blue line depicts daily discharge activity over the entire sampling period.)

Dissolved Reactive Phosphorus (DRP) is a dissolved form of phosphorus and, like DIN, its ready availability to plants can stimulate growth under favourable conditions. Sources of DRP include wastewater containing detergents, animal manure, phosphatic fertilisers, breakdown of phosphatic rock and soil components. Phosphorus binds to soil particles and is transported to waterways via overland flow.

DRP concentrations for all samples in the Jed River and tributaries were above the periphyton guidelines of 0.001 mg/L (MfE, 2000) in all samples at all sites, however, concentrations were lower and less variable at the Woolshed Creek site compared to the other sites (Figure 6, Appendix 1). Median DRP increased between Crystal Brook and the Jed River at SH 1 and then decreased downstream. These results show that phosphorus concentrations were higher in the Crystal Brook tributary than the Woolshed Creek tributary, which may lead to the dilution of DRP at the downstream sites. While median DRP in the Jed River and tributaries is well above the median DRP concentration of 0.005mg/L for hill-fed lower rivers in Canterbury (Stevenson et al. 2010), a high natural phosphorus concentration is not uncommon in catchments of soft-sedimentary geology. Thus, elevated background DRP results could be expected, especially during flood events when suspended sediment concentrations are elevated (Snelder et al. 2004). However, because this trend is not as prominent in the Woolshed Creek catchment despite the same geological setting, the increase in DRP is likely to be influenced by wastewater discharges. Jarvie *et al.* (2006) found that point source inputs of phosphorus from wastewater discharges were a greater risk to waterways than diffuse agricultural sources of phosphorus.

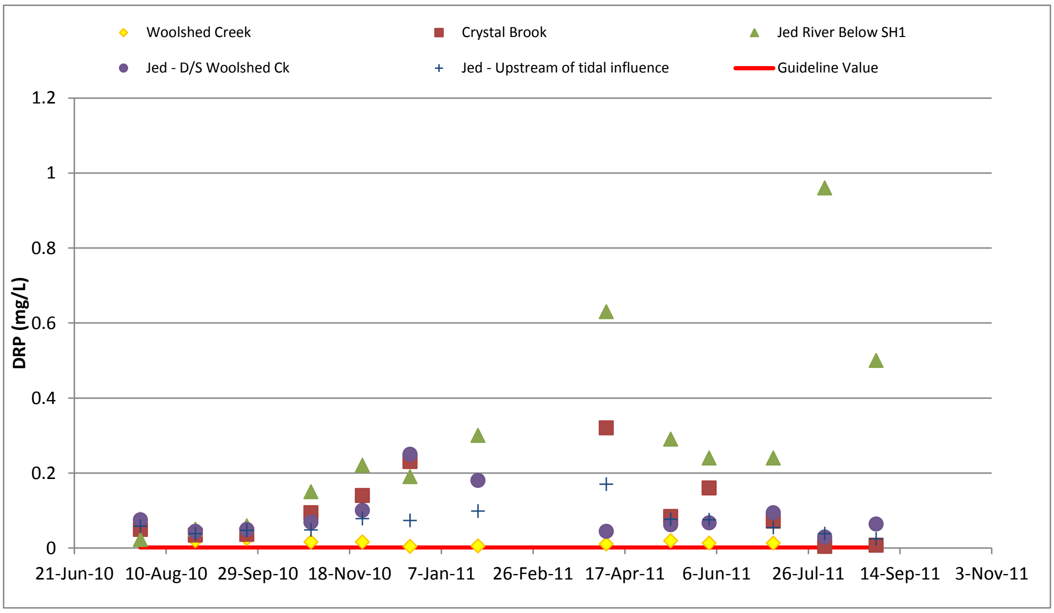

Figure 7: Dissolved Reactive Phosphorus (mg/L) concentrations in the Jed River and tributaries. Concentrations above the red line 0.001mg/L indicate excessive concentrations for the growth of aquatic weeds.

Microbiological contamination

Microbiological contamination is measured in fresh waters by *Escherichia coli* (*E. coli*), a faecal indicator organism which when present indicates the likely presence of harmful micro-organisms such as other bacteria, protozoa and viruses. Faecal contamination poses a risk to both human and stock health.

E. coli concentrations were generally below both the alert and action recreational guidelines of 260 MPN/100mL and 550 MPN/100mL respectively (MfE, 2003); with the exception of the Jed River downstream of the Woolshed Creek confluence site (Appendix 1, Figure 8). During effluent discharge periods, *E. coli* results were variable. Elevated *E. coli* results (represented by the 3 red spikes on Figure 9) did not coincide with heavy discharge events or rainfall, therefore discharges from the Cheviot treatment plant do not appear to have a great influence on the microbial status of the Jed River at SH 1 (Figure 9). *E. coli* is likely to be eliminated both during treatment of the wastewater and by infiltration to ground during overland flow and spray irrigation discharge.

E. coli concentrations were greatest at the Jed River site downstream of the Woolshed Creek confluence (Figure 8). Likely sources of *E. coli* contamination for this site are unrestricted stock access, with a stream walk by ECan staff viewing this site to be one of high impact from lack of fencing and direct access of grazing stock. Additionally, at the time of sampling, it was noted that there was a presence of stock with access to the stream, and ducks. This indicates vulnerability from grazing stock and associated faecal inputs, either diffuse from overland runoff or direct from wallowing animals.

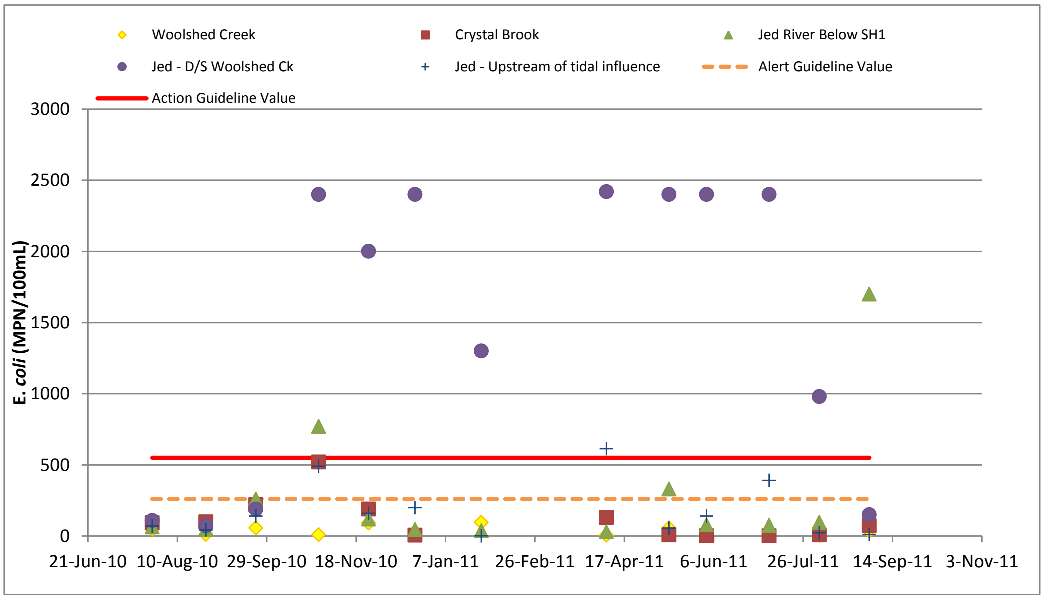

Figure 8: ***Escherichia coli*** **(E.*coli*) (MPN/100mL) concentration in the Jed River and tributaries. The recommended alert guideline value is indicated by a dashed orange line = 260 MPN/100mL, action guideline value is indicated by a red line = 550 MPN/100mL.**

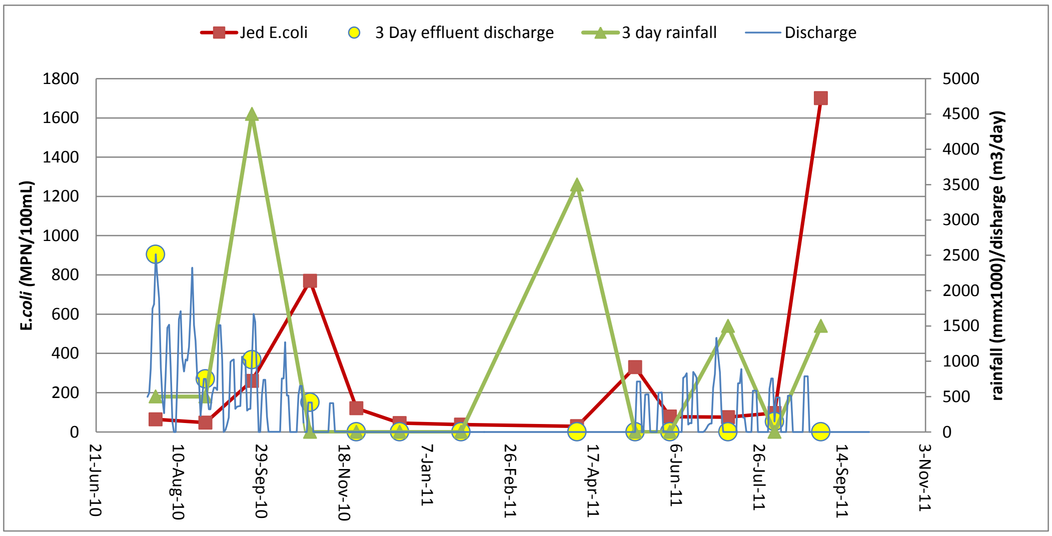

Figure 9: Escherichia coli (E.coli) (MPN/100mL) concentrations at the Jed River at SH 1 site in relation to overland effluent flow discharge (mm) and rainfall (mm) 3 days before each sampling event. (Note: the yellow dot depicts effluent discharge 3 days prior to sampling, whilst the blue line depicts daily effluent discharge activity over the entire sampling period.)

5. Conclusions

Water quality in the Jed River and tributaries is likely to be influenced by a number of activities ranging from catchment geology to wastewater discharges to grazing animals. Water quality in the Woolshed Creek tributary appears generally to be better than that of the Crystal Brook tributary and main stem of the Jed River downstream of the Crystal Brook confluence, with the exception of the lowest Jed River site. The Crystal Brook tributary is of particular concern with issues of poor water clarity, elevated BOD_5, and nutrient enrichment; these issues occur despite being upstream of any wastewater influences.

It is likely that the treated wastewater discharges are having some influence on Jed River water quality. Elevated DIN, ammonia-nitrogen and DRP results at the Jed River SH 1 site during winter are potentially influenced by wastewater discharges during a period of reduced nutrient uptake by plants and when wet soils limit infiltration potential. However, it appears the treatment process is relatively effective at removing *E. coli*. Further downstream below the Woolshed Creek confluence, *E. coli* results were elevated, indicating a need to address the agricultural source of these inputs.

Conductivity, pH, water clarity and DRP are likely to be influenced in some way by catchment geology, with leaching and erosion of soft tertiary marine sediments. However with unrestricted stock access to many of the stream margins; bank erosion and faecal inputs are likely. These inputs can influence visual clarity and increase particulate-bound phosphorus. Inputs of sediment and associated phosphorus can be partially mitigated by fencing and riparian planting, which has been found to be relatively effective in filtering particulate material (suspended solids and associated bound phosphorus) from overland runoff (Thorrold et al., 2000, McDowell 2008).

Water quality issues seem to be catchment-wide in the Jed River. It is therefore recommended that any mitigation attempts should include the entire catchment, with particular emphasis on the smaller first-order tributaries where riparian planting appears to be more effective. Riparian plantings in Crystal Brook in particular could be of benefit for Jed River water quality. Fencing off stock grazing areas from the river margins would be beneficial to reduce the impacts of stock access on water clarity and faecal inputs. Best practice farm management initiatives such as efficient use of fertilizer and appropriate treatment and discharge of dairy effluent may additionally help to reduce nutrient inputs to the river. This is important given the elevated NNN and DRP results in the Jed River catchment.

6. References

Australian and New Zealand Environment and Conservation Council (ANZECC), 1992. *Australian and water quality guidelines for fresh and marine waters.* Australian and New Zealand Environment and Conservation Council, Agriculture and Resource Management Council of Australia and New Zealand.

Australian and New Zealand Environment and Conservation Council (ANZECC), 2000. *Australian New Zealand guidelines for fresh and marine water quality.* Australian and New Zealand Environment and Conservation Council, Agriculture and Resource Management Council of Australia and New Zealand.

Biggs BJF, 1988. Algal proliferations in New Zealand's shallow stony foothills-fed rivers: toward a predictive model. *Verhandlungen der Internationalen Vereinigung für Theoretische und Angewandte Limnologie 23*: 1405-1411.

Biggs, BJF. Kilroy, C. Mulcock, CM. Scarsbrook, NMR. 2002: *New Zealand Stream Health Monitoring and Assessment: Kit Stream Monitoring Manual Version 2*. NIWA Technical Report 111 190 p

Davies-Colley, R.J. 1988. Measurement of water clarity using a black disk. *Limnology and Oceanography 33*: 616–623

Environment Canterbury, 2012: *Surface Water Quality Procedures Manual.* Environment Canterbury unpublished draft report.

Hayward, S.A; Meredith, A.S; Lavender, R.M. 2003: *Waipara River: assessment of water quality and aquatic ecosystem monitoring, 1999 to 2002.* Environment Canterbury Report U03/11

Hickey CW, Martin, ML 2009. *A review of nitrate toxicity to freshwater aquatic species*. Environment Canterbury report R09/57.

Hurunui District Council (2006) *Assessment of Water and Sanitary Services.* Technical report

Jarvie, HP. Neal, C. and Withers, PJA. 2006. Sewage-effluent phosphorus: A greater risk to river eutrophication than agricultural phosphorus? *Science of the Total Environment 360*: 246–253

Kilroy, C. & Biggs, B.J.F. 2002. Measuring water clarity with the SHMAK clarity tube: comparison with the black disk. *New Zealand Journal of Marine and Freshwater Research 36*(3)

Lockington, P, Griffiths, G. and Martin, A (2007) *Jed River and Leamington Stream: Water Resources Summary*. Environment Canterbury Report U07/83

McIntosh, A. (unpublished) Enhancing the effectiveness of riparian and in-stream management for protecting stream ecosystems from intensive land use.

Ministry for the Environment (MfE), 1992. *Water quality guidelines No. 1. Guidelines for the control of undesirable biological growths in water.* Ministry for the Environment, Wellington.

Ministry for the Environment (MfE), 2000. *New Zealand periphyton guideline: detecting, monitoring and managing enrichment of streams.* Ministry for the Environment, Wellington.

Ministry for the Environment and Ministry of Health (MfE/MoH) 2003. *Microbiological water quality guidelines for marine and freshwater recreational areas.* Ministry for the Environment, Wellington.

Rattenbury, M.S.; Jongens, R.; Cox, S.C. (compilers) 2010: Geology of the Haast area: scale 1:250,000. Lower Hutt: Institute of Geological & Nuclear Sciences Limited. Institute of Geological & Nuclear Sciences 1:250,000 geological map 14. 58 p. + 1 folded map.

Snelder, T; Biggs, B; Weatherhead, M. 2004. New Zealand River Environment Classification User Guide. Ministry for the Environment, Wellington. (Revised 2010).

Stevenson, M; Wilks, T; Hayward, S.A. 2010. *An overview of the state and trends in water quality of Canterbury's rivers and streams*. Environment Canterbury Technical Report R10/117.

Thorrold, B., Singleton, P., Bagshaw, C., Gillingham, A., Matthews, L., Cooke, J., Nguyen, L., Elliott, S., Quinn, J., Rutherford, K., Yong, K. (2000) Review of the effectiveness of buffer strips and wetlands in preventing sediment, nutrients and micro-organisms entering surface waterways from dairy farms. Report prepared for the New Zealand Dairy Research Institute.

USEPA (1997) *Volunteer Stream Monitoring: A Methods Manual*. EPA 841-B-97-003

Appendix 1: Jed River and tributaries summary data

		Cond	pH	Clarity Tube	NH3-N	NNN	DIN	TN	DRP	TP	BOD5 (total)	E coli
		mS/m		cm	mg/L	mg/L		mg/L	mg/L	mg/L	mg/L	MPN/100mL
Woolshed Creek	**Median**	78	8	78	0.009	0.0025	0.018	0.22	0.013	0.052		30
	Mean	71.1	8.0	78.5	0.016	0.079	0.095	0.405	0.018	0.062		36
	Max	85	8.1	100	0.078	0.9	0.978	2.6	0.077	0.17		96
	Min	38	7.5	47	0.0025	0.001	0.005	0.09	0.004	0.023		5
Crystal Brook	**Median**	80.5	7.85	35	0.0255	0.0455	0.1375	1.15	0.0775	0.18	3	82
	Mean	76.7	7.8	35.6	0.037	0.304	0.341	1.569	0.102	0.345	3.1	112
	Max	120	8.1	59	0.14	1.3	1.339	4.4	0.32	0.87	10	520
	Min	45	6.9	18	0.006	0.002	0.015	0.58	0.004	0.058	1	1
Jed River Below SH1	**Median**	74	7.8	36	0.056	0.091	0.442	1.4	0.24	0.52	3	78
	Mean	63.5	7.7	32.2	0.261	0.309	0.570	1.705	0.296	0.657	4.1	281
	Max	84	8.1	52	1.5	1.3	1.66	3.6	0.96	2.2	12	1700
	Min	26	7.4	10	0.0025	0.0025	0.005	0.42	0.022	0.068	1	29
Jed River D/S Woolshed Creek Confluence	**Median**	78	8	21.5	0.12	0.029	0.371	1.1	0.067	0.18		2000
	Mean	75.1	8.0	24.8	0.199	0.196	0.395	1.119	0.087	0.278		1479
	Max	86	8.1	51	0.65	1.1	1.22	2	0.25	0.64		2420
	Min	49	7.8	8	0.0025	0.001	0.005	0.5	0.029	0.1		71
Jed River Upstream of tidal influence	**Median**	94	8.2	90	0.008	0.006	0.0245	0.54	0.058	0.091		140
	Mean	228.8	8.1	78.0	0.016	0.093	0.109	0.590	0.067	0.108		180
	Max	1400	8.3	95	0.047	0.74	0.779	1.6	0.17	0.2		613
	Min	45	7.7	34	0.0025	0.001	0.005	0.21	0.024	0.049		1

Appendix 2: Guideline values for water quality parameters

Parameter	Value & relevance	Standards & guidelines	Reference
pH	Aquatic ecosystems – aquatic life protection	6 - 9 6.5 - 9.0 7.2 - 7.8	RMA (1991) ANZECC (1992) ANZECC (2000)
Conductivity	Aquatic ecosystems – indicator of nutrients for weed growth	< 175 µS/cm	Biggs (1988)
Ammonia-nitrogen (NH_3-N)	Aquatic ecosystems – nutrient for weed growth, toxic at higher concentrations	< 0.021 mg/L < 0.9 mg/L (at pH 8.0)	ANZECC (2000)
Nitrate-nitrite nitrogen (NNN)	Aquatic ecosystems – nutrient for weed growth, toxic at higher concentrations	< 0.444 mg/L < 1.7 mg/L	ANZECC (2000) Hickey & Martin (2009)
Dissolved inorganic nitrogen (DIN)	Aquatic ecosystems – nutrient for weed growth Benthic biodiversity values (20 day and 40* day accrual periods) Recreational/aesthetic values (20 day and 40* day accrual periods)	<0.02 mg/L <0.01* mg/L <0.295 mg/L <0.034* mg/L	MfE (2000)
Dissolved reactive phosphorus (DRP)	Nuisance periphyton growth Aquatic ecosystems – nutrient for weed growth Benthic biodiversity values (20 day and 40* day accrual periods) Recreational/aesthetic values (20 day and 40* day accrual periods)	<0.015-0.030 mg/L <0.001 mg/L <0.001* mg/L <0.026 mg/L <0.003* mg/L	MfE (1992) MfE (2000)
Black Disc Clarity Tube	Recreational use of Freshwater	1.6m 85cm (Black disc guideline of 1.6m converted for clarity tube using the equation $y_{BD}=7.28x10^{[y_{CT}/62.5]}$)	Davies-Colley (1988) MfE (1994) Biggs, Kilroy, Mulcock & Scarsbrook (2002) Kilroy & Biggs (2002)
E. coli	Recreational – safe for contact recreation	< 550 cfu/100mL (single sample)	MfE (2003)
		< 126 cfu/100mL < 410 cfu/100mL (median values)	MfE (2002)