Ecological Assessment of LII Headwaters (Liffey Springs)

Prepared for:

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Upper reaches of the LII

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Executive Summary

An application is being made to change the Selwyn District Plan in the vicinity of the Lincoln Township. The proposed rezoning of rural land adjacent to the headwaters of the LII River is a necessary first step for the development of a residential sub-division and small business area.

It is intended that treated stormwater from the proposed subdivision be discharged into the LII headwaters, upstream of the LI confluence. An environmental assessment of the LII River was requested, and that the impacts of the discharge on the aquatic fauna be evaluated. This is the subject of this report.

The aquatic fauna in the LII River headwaters was composed of four common fish species; common bully, longfin eel, shortfin eel, and upland bully. They form a typical species community for lowland spring-fed streams in good health. No rare species were identified. The invertebrate fauna was numerically dominated by the common freshwater crustacean (*Paracalliope fluviatilis,* an amphipod).

Usefully, there is good ecotoxicology data for *Paracalliope fluviatilis,* which is known from contaminant testing to be the one of the most sensitive organisms in New Zealand. However, expected mixed and treated stormwater concentrations were well below those that would compromise the health of this species. Based on available data, it was therefore reasonable to conclude that other elements of the freshwater biota (i.e. fish and other invertebrates) will not deleteriously affected by the stormwater discharge. Toxicology tests on New Zealand fish have demonstrated that these have a markedly lower sensitivity to common stormwater contaminants than invertebrates, especially *P. fluviatilis*. Therefore, the impacts of the treated stormwater discharge on the resident fish fauna is considered to be no more than minor. Indeed, the riparian revegetation of the banks associated with the residential development could enhance instream values and maintain bank stability.

1 Introduction

It is proposed that some of the rural land between the LI Creek and the mainstem of the LII River be rezoned to allow the development of a residential subdivision (termed “Liffey Springs” and small business area. The land rezoning will require a Change of the SDC (Selwyn District Council) Plan. It is intended that the sub-division be composed of between 178 and 220 lots.

It is proposed that stormwater be discharged into the LII via a treatment train. During construction, a sediment control plan will be implemented, and the final stormwater treatment train be constructed before the staged development of the subdivision. The treatment train will comprise a 1st flush basin which will treat the first 25 mm of rain of any rain event. Trickle flow from this basin, plus stormwater volume greater than 25 mm, will enter the main detention pond, which will detain stormwater for an average of 24 hrs. The main detention basin will be capable of holding the stormwater volume created by a 1:50 year storm, with stormwater volume for greater storms overflowing directly into the LII via an overflow channel and weir.

It is the purpose of this report to describe the instream ecology of the LII River adjacent to the rezoned land, and predict the impact of stormwater on the LII ecology, where known, on identified species.

2 Catchment description

The LII River rises from a large springhead pond near Edward Street, 1 km due east of the Lincoln township. In its headwaters, the waterway has a deep, sluggish flow, and the channel is choked with water weeds. Approximately 1150 m downstream from its source, the LII River is joined by the LI Creek, itself a spring-fed tributary which flows through the Lincoln Township. Downstream of this confluence, the LII River meanders slowly downstream for a further 11 km before discharging into Lake Ellesmere. Catchment landuse was a mixture of horticulture and agriculture, with most of the channel effectively fenced from stock.

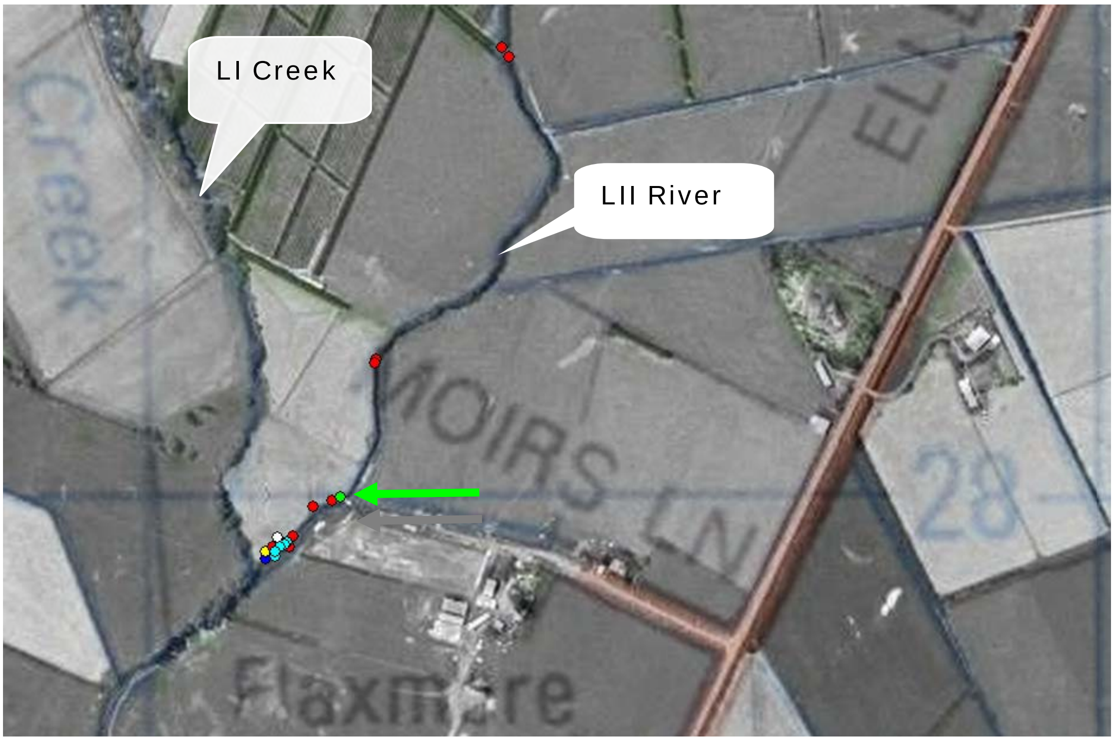

Figure 1. Red dots show fyke net and Gee-Minnow trap placements, blue dot denotes water chemistry sample, green denotes flow gauging, blue denotes channel transect measurements, yellow denotes invertebrate sample, white denotes DO sample. Green arrow denotes approximate location of the proposed stormwater discharge. One blue grid square is equal to 1 km^2.

3 Objectives

The objectives of this study were to:

- Assess the aquatic biota in the headwaters of the LII River.
- Identify environmentally sensitive species
- Ascertain the ecological impact of the treated stormwater discharge from the rural land proposed to be re-zoned (i.e. "Liffey Springs sub-division); particularly in respect to water quality criteria stipulated in the PNRRP (Proposed Natural Resources Regional Plan).

4 Methods

4.1 Hydraulics

Flow gaugings were obtained using conventional field techniques, using a calibrated pygmy Ott meter across a measured transect comprising 19 verticals (Fenwick 1994).

4.2 Water chemistry

Two water samples were obtained near the outlet, one for bacteriological assay (Feacal-coliform count, and one for general water chemistry. These were stored in a chilled insulated container before being delivered to a certified laboratory (i.e. Hill Laboratories). Dissolved oxygen levels were obtained with a calibrated dissolved oxygen meter.

4.3 Invertebrate sampling

A semi-quantitative collection technique called "protocol C2" was employed to collected macroinvertebrates (invertebrates which can be seen with the naked eye) (Stark *et al.* 2001). This technique is consistent with data collection from soft-bottomed habitats for compliance monitoring for AEE (Assessment of Environmental Effects) and SOE (state of the environment) reporting.

A collection site was chosen near the location of the proposed stormwater outfall, with a composite sample composed of invertebrates collected from aquatic plants, woody debris, and riparian vegetation. The sample was field-preserved in 60% isopropyl alcohol (IPA), before being transported to a laboratory for identification to the lowest practicable taxonomic level. Ranges of invertebrate indices were calculated.

4.4 Fyke netting

Owing to the deep (> 0.6 m) water, electric fishing was not considered to be effective in this environment. Instead, a combination of six baited fyke nets and three Gee Minnow traps were deployed over night (16-17/5/07) and processed on 17 May 2007. Nets were set upstream and downstream of the proposed stormwater outlet, with a deployment schedule provided in Table 1.

Six baited fyke nets were set at intervals between the LII headwaters and the confluence of LI in waters sufficiently deep to submerge the net leader which was set perpendicular to the bank. Fyke nets were of standard design and construction, and of two sizes. Large or small nets were deployed depending on the water depth in the local habitat. The smaller nets possessed a single wing of 2.1 m in length, and a hoop size of 0.45 m. The larger nets had a single wing 3.3 m long, and a hoop size of 0.60 m. The stretched-mesh size of the nets was approximately 12 mm.

Table 1. Deployment schedule of fishing gear in the LII River.

Distance from proposed outlet	Net type	Set time	fishing time (hrs)
575 m up stream	Large fyke (LF3)	16/05/07 10:31	25.07
570 m up stream	Gee Minnow (4 traps, GM3)	16/05/07 10:39	25.07
160 m up stream	Large fyke (LF1)	16/05/07 11:04	25.08
155 m up stream	Gee Minnow (2traps, GM0)	16/05/07 11:08	25.08
90 m down stream	Gee Minnow (4 traps, GM2)	16/05/07 13:40	24.88
105 m down stream	Large fyke (LF4)	16/05/07 13:40	24.84
80 m down stream	Large fyke (LF2)	16/05/07 13:53	24.83
40 m down stream	Small fyke (SF7)	16/05/07 14:02	24.85
15 m down stream	Small fyke(SF4)	16/05/07 14:10	24.85

4.5 Gee Minnow trap lines

Rope lines with four, or two baited Gee Minnow traps were between the LII headwaters and the confluence of LI.

4.6 Geo-referencing and mapping

GPS waypoints were downloaded from the receiver onto MapToaster™ (ver. 3.0) software for mapping purposes. The resulting maps in this report were produced from this software.

5 Results

5.1 Hydrology

The base flow of the LII, gauged 130 m upstream of the confluence of L1 was 0.183 m^3/s (17 May 2007). The same transect was gauged the following day by Environment Canterbury (ECan) staff, with excellent agreement to this estimate (ECan flow estimate 0.187 m^3/s). ECan staff gauged the LI flow at 0.206 m^3/s (18 May 2007).

The stream profile was measured at five equidistant transects immediately below the proposed outfall. The mean channel width was 5.3 m, with a mean mid-channel depth of 0.8 m. The depth of the water, height of aquatic plants, and free water (flowing water above the plants) is depicted graphically in Appendix I. In the lower reaches, most of the stream profile was filled with aquatic macrophytes, dominated by *Myriophyllum* sp., water cress (*Rorippa* sp.), and monkey musk (*Mimulus guttatus*).

5.2 Water quality

The water quality assay is provided in Table 1. The water is near neutral in pH, and highly oxygenated. Faecal coliform levels were moderate to low for a rural stream, with moderate levels of nutrients.

Table 1. Water quality results from L11. Dissolved oxygen and temperature were measured directly in the field. Note mg/L is equivalent to g/m^3.

Analysis	Value	Units
pH	7.1	pH units
Total Ammoniacal-N	0.03	mg/L
Dissolved Inorganic Nitrogen	4.19	mg/L
Nitrate-N + Nitrite-N (TON)	4.16	mg/L
Dissolved Organic Carbon (DOC)	3	mg/L
Faecal Coliforms	350	cfu/100mL
Temperature	13	°C
Dissolved Oxygen Concentration	8.38	mg/L

The data in Table 1 was supplemented with water quality data obtained from the lower reaches of the LI provided by ECan from the monitoring station CRC300884 (Appendix II).

5.3 Invertebrate fauna

The identified macroinvertebrate fauna is provided in Table 2, with the relevant derived biotic indexes provided in Table 3. The results indicate a moderately sparse

(10 taxa) macroinvertebrate fauna dominated by amphipods (*Paracalliope fluviatilis*), and to a much lesser extent snail (*Physella, Potamopyrgus antipodarum*). Of the biotic indices, the soft-bottom MCI (MCI-sb) is the most relevant in respect to the sampled habitat and the semi-quantitative sampling method.

Table 2. Percentage abundance of macroinvertebrate taxa from L1, as collected on 16/5/07.

Taxa	No. of organisms	% Abundance (incl. rare taxa)
Austrosimuliidae	16	0.19
Orthocladiinae	16	0.19
Sigara sp.	2	0.02
Physella	80	0.97
Paracalliope fluviatilis	8080	97.89
Xanthocnemis zealandica	16	0.19
Oxyethira	16	0.19
Potamopyrgus antipodarum	24	0.29
Paradixa	2	0.02
Triplectides cephalotes	2	0.02
Grand Total	8254	

Table 3. Derived biotic indexes from the collected invertebrate fauna.

Biotic indice	LI River
No. of taxa	10
MCI-hb	76
MCI-sb	67.60
UCI	3.22
QMCI-hb	4.96
QMCI-sb	5.42
QUCI	0.64
No. of EPT taxa	2
No. of EPT taxa (-Hydrops)	1
% EPT Taxa	0.22%
% EPT Taxa (-Hydrops)	0

5.4 Fish fauna

The fish catch is presented in Table 4, with four fish species identified, and one adult freshwater crayfish (koura, *Paranephrops zealandica*).

Table 4. Fish and crayfish (koura) caught overnight in nets and traps from the LII headwaters on the evening of 16 May 2007.

		Fishing method*									
Species	Length (mm)	GM0	GM2	GM3	LF1	LF2	LF3	LF4	SF4	SF7	Summary statistics
Common bully	n	18	1	4							23
	Min	51	53	66							51
	Max	76	53	69							76
	Mean	62.2	53	67.8							62.7
Koura	n						1				1
	Min						65*				65
	Max						65				65
	Mean						65				65
Longfin eel	n				3	5	5	1	3	2	19
	Min				563	528	512	888	519	553	512
	Max				1000	1038	950	888	720	648	1038
	Mean				750	722.6	760.6	888	642	600.5	720.1
Shortfin eel	n								1		1
	Min								760		760
	Max								760		760
	Mean								760		760
Upland bully	n			2							2
	Min			60							60
	Max			61							61
	Mean			60.5							60.5
Total		18	1	7	3	5	5	1	4	2	46

* GM = Gee Minnow trap line, SF = Small fyke net, LF = Large fyke net.

A total of 45 fish were caught, and in order of catch abundance, these were the common bully (*Gobiomorphus cotidianus*), longfin eel (*Anguilla dieffenbachii*) and upland bully (*Gobiomorphus breviceps*). Only one shortfin eel (*Anguilla australis*) was identified and one koura (Fig. 1). Koura and upland bullies were only obtained from the most upstream nets and traps, and the shortfin eel in the most downstream fyke-net.

Common bullies and longfin eels were well-distributed and identified from all set trap lines and fyke nets respectively. Some of the longfin eels were large (Fig. 2), and over one metre in length.

Figure 1. Koura from the headwaters of the LII River.

Figure 2. One of the larger longfin eels identified from the LII river.

6 Discussion

6.1 Expected stormwater water quality and quantity from Liffey Springs

Stormwater contaminant concentrations discharging from a flat residential untreated stormwater catchment in Christchurch (Main 1994) are summarised in Table 5. These contaminant concentrations are similar to those published from other untreated stormwater catchments in New Zealand (Williamson 1993).

It is expected that the mitigating effect of the 1st flush and detention ponds will reduce contaminant concentrations leaving the treatment train. The stormwater treatment retention (i.e. retention of 1st 25 mm, storm retention of 1:50 year storm, and at least 24 hr average retention) follows best-practice guidelines provided by the Christchurch City Council (CCC) (Christchurch City Council 2003), except for the absence of swales which have been excluded by request from the Selwyn District Council. The CCC guidelines suggest, for example, that a 'considerable' percentage of the particulate pollutant removal is possible if detention is for 24 hrs or more. This would be potentially effective at removing large suspended sediment particles and some contaminants bound to them (e.g. heavy metals).

The stormwater management guidelines produced by Auckland Regional Council (ARC) quantify the reduction in stormwater contaminants (Auckland Regional Council 2003). Chapter 5 of the ARC document presents the results of a study of contaminant reduction in three wet stormwater treatment ponds over a short time frame (1-3.5 months). These showed total suspended solid (TSS) reductions of between 71-83%, with a general criterion of 75% reduction in suspended solids (incl. bound contaminants). Expected percentage reduction of this and other contaminants are presented in the second column of Table 5, although there were no data provided for hydrocarbons, although with time light hydrocarbons will volatise on the water surface, and others will be decomposed by microbial activity (Auckland Regional Council 2003). Overall, while removal efficiencies vary, it is clear that wet ponds are considered effective at reducing concentrations of most contaminants.

Table 5. Expected EMC contaminant concentrations from untreated stormwater (Main 1994; Williamson 1993), range (10%-90% percentiles) and median, and expected percentage reductions (Auckland Regional Council 2003). N.d. = no data.

Contaminant	**Event mean concentrations (EMC)**	**% wet-pond contaminant reduction**	**Expected EMC concentrations after treatment, assuming mid-range reduction (g/m^3)**
Sediment	50-170-470 g/m^3	50-90 %	15-51-141 g/m^3
Total hydrocarbons	1-5 g/m^3	n.d.	n.d.
Total nitrogen	1.3-2.5-4.3 g/m^3	30-60	0.6-1.13-1.9 g/m^3
Inorganic nitrogen[1]	0.4-0.9-1.75	30-60	0.18-0.41-0.79
Dissolved reactive phosphorous	13-40-70 mg/m^3	30-80	7.2-22-39 mg/m^3
Total ammonia[1]	25-100-250 mg/m^3	30-60	13.8-55-138 mg/m^3
Lead	60-110-190 mg/m^3	30-90	24-44-76 mg/m^3
Zinc	90-260-800 mg/m^3	30-90	36-104-320 mg/m^3
Copper	15-40-110 mg/m^3	30-90	6-16-44 mg/m^3
Bacteria[2]	8000 fcu/100 ml	20-80	4000 fcu/100 ml

1 We have assumed that inorganic nitrogen (NO_3 + NO_2 + NH_4) and ammonia is reduced equally with total nitrogen.
2 Bacterial loadings often vary considerably over time and rainfall events

Stormwater flow into the LII is controlled by a 450 mm diameter pipe leading from the storm detention basin into the LII. The discharge will take place under the waterline of the LII, and be choked to provide an average retention time of 24 hrs in the detention basin (Cathy Begley, pers. comm., DLS). The average discharge rate can be estimated by the filled volume of the detention pond (4,450 m^3) divided by the retention time (i.e. estimated at 24 hrs). This gives an average discharge rate of approximately 51.5 L/s.

6.2 Mixed water quality downstream of the Liffey Springs stormwater outfall

In an account of contaminant mixing, it has been suggested that a point-source contaminant becomes fully mixed at a distance approximately 100 times the channel width (Rutherford *et al.* 1997). In the case of the LII, where the mean channel width was 5.3 m, this would place the fully-mixed zone 0.53 km downstream, well below the confluence with the LI, and a potentially non-compliant zone (if any) could include therefore include dilution from the LI, and even possibly from Springs Creek further downstream. The PNRRP provides a different definition for the mixing or non-compliance zone of a distance $D = \sqrt{W} \times 25$, where W = the channel width in metres. This expression provides a much shorter mixing zone of 57 m, based on a mean width of 5.1 m (see Section 5.1). Under this definition, the non-compliance zone does not extend to the confluence of the LI and LII.

Therefore, based on the PNRRP definition, we have calculated mixed contaminant concentrations based on mixing in the LII alone, using flow-weighted mean concentrations based on the average discharge from the ponds (i.e. 51.5 L/s) divided by the sum of the baseflow of the LII (i.e. 183 L/s) and the pond discharge (i.e. 183

L/s plus 51.5 L/s). It was considered reasonable to use the LII baseflow as a mixing volume, because treated stormwater discharge may occur sometime after a rain event, and after any flow increase in the LII had subsided.

Table 6 summarises the expected mixed concentration of a range of contaminants in the LII, assuming effective stormwater contaminant reduction outlined in Table 5, and full mixing in the LII. Because there is no urban stormwater entering the LII upstream of the proposed Liffey Springs discharge, and the close vicinity of the springhead, we have assumed that the metal concentrations are negligible. However, we have recent data on a range of rural contaminants from the LII (Table 3), in addition to those collected by ECan (Appendix I). Median values for these contaminants have been factored into Table 6. Downstream of the stormwater discharge point, further mixing will occur at the confluence of the LI and LII, when the LII will receive a significant inflow of stormwater contaminants from the township of Lincoln.

Table 6. Estimated concentrations of stormwater contaminants when mixed with LII waters.

Contaminant	**Estimated mixed with LII waters (g/m^3) unless otherwise specified**	**Comments**
Faecal coliforms	1152 fcu/100 ml	Flow-weighted mean value, which is much higher than the PNRRP figure of 100 fcu/100 ml.
Dissolved oxygen	100 % saturation	LII baseflow was DO saturated, as will be the detention pond.
Event-mediated change in temperature[6]	**Increase** of approximately 1.5 °C	Estimate based on an estimated maximum temperature difference of 7°C between the LII waters and detention pond water.
Seasonal temperature range[5]	9.8 °C – 17.4 °C	LII temperature range probably moderated by groundwater source. LI measured range is 11.3 – 15.9 (Appendix I I), which is probably similar to that in the LII.
Event-mediated change in pH	0	LII was circum-neutral (Table 1), as was the lower LI (Appendix II), and urban stormwater (Mosley & Peake 2001).
Suspended sediment	9.1-17.1-36.8 gm/m^3	Median SS in LI was 7.5 mg/L (gm/m^3) (Appendix I). It was expected that the SS level in the LII was similar.
Event-mediated change in visual clarity[8]	% black disc visual range reduction (33%-67 %)	The term visual clarity is not defined in the PNRRP. Examination of the distribution of black disc clarity data (Davies-Colley & Close 1990), would indicate that for a moderately clear river, like the headwaters of the LI and LII (Appendix II), black disk clarity range would be about 1.8 m. At low mixed sediment concentrations (9.1 g/m^3), black disc visual range may reduce to 1.2 m, and under heavy sediment inputs (i.e. 36.8 g/m^3), black disc visual range may reduce to 0.6 m. These are estimates obtained graphically from (Davies-Colley & Close 1990), so are only approximations. However, real-world changes will vary with the actual sediment inputs into the stormwater treatment chain, actual detention time, and the sediment particle size.

Table 6 cotd.		
Event-mediated colour change[9]	5 Munsell unit change	The relationship between clarity change and colour change (i.e. Munsell hue) is weak (Davies-Colley & Close 1990). A graphical estimate indicates a possible change of approximately 5 Munsell units.
Event-mediated change in inorganic nitrogen	Approx. 0.9 mg/L **decrease** to 3.29-3.32-3.37 mg/L	Recent LII value at baseflow was 4.2 mg/L, ECan median value for the LI was 6.34 mg/L (Appendix I). Thus, based on recent LII values, mixed stormwater discharge may **decrease** concentration.
Event-mediated change in dissolved reactive phosphorous	Approx. 0.04 mg/L **decrease** to 0.01 mg/L **increase**. Expected mixed concentrations 0.020- 0.022-0.026 mg/L	Median LI level was 0.024 mg/L (ECan data, Appendix I). The expected DRP in untreated stormwater ranges from lower than this, to markedly higher. However, mixed treated DRP concentration will not differ substantially from original levels.
Total ammonia	26.4-35.5-53.6 mg/m^3 (0.026-0.036-0.054 mg/L)	Flow-weighted average, based on EMC stormwater concentrations (Williamson 1993), treatment, and measured background value (Table 1). PNRNP maximum is 100 mg/m^3.
Dissolved organic carbon	Expected stormwater concentrations are unknown, but LII background level is 3 mg/L or 3 g/m^3	The LII record already exceeded the PNRRP trigger level of 1 gm/m^3 (Table 1). but this may reduce downstream of the LI confluence.
Total hydrocarbons	0.2 - 1.0 g/m^3	Assumed a baseflow of 0 hydrocarbons, and no effective stormwater treatment of expected EMC values of 1-5 gm/m^3 (Williamson 1993). The assumption of no treatment is conservative, light hydrocarbons will oxidise during detention, and residuals can be both microbially decomposed, and broken down by sunlight (Auckland Regional Council 2003).
Lead[3]	5.3-9.7-16.7 mg/m^3	Assumed the LII headwaters have no residual heavy metal contamination.
Zinc[3]	7.9-22.8-70.3 mg/m^3	Assumed the LII headwaters have no residual heavy metal contamination.
Copper[3]	1.3-3.5-9.7 mg/m^3	Assumed the LII headwaters have no residual heavy metal contamination.
Algal mats	No change expected	No algal mats are present, and none expected due to no expected increase in nutrient levels.
Filamentous algae	None observed, and no change expected	No algal mats are present, and none expected due to no expected increase in nutrient levels.
Emergent macrophytes	No increase expected	Williamson (1993) states "Few problems of nutrient enrichment from urban runoff alone have been reported in New Zealand." Macrophyte growth is unlikely to increase because due to no expected increase in nutrient concentration. Luxuriant macrophyte growth is already present in sunlit reaches, but growth could become light-limited with the development of the riparian buffer strip.

Table 6 cotd.		
Substrate embeddedness		Substrate has no coarse substrate particles, and is already 100% embedded.
Toxicants	Not expected to be exceeded.	Trace metals in stormwater will be bound to particles, and will settle out. No industrial inputs in proposed stormwater discharge.
Conspicuous oil or grease films		Oil spills are expected to be trapped by gully traps and other devices. Landuse has no carparks.

6.3 Environmental Impacts of stormwater discharge

Overall, the impacts of the stormwater discharge are expected to be minor, although some expected water quality parameters exceed the PNRRP figures even without stormwater input. These parameters include dissolved organic carbon with a LII level of 3 g/m^3, three times higher than the PNRRP trigger of 1 gm/m^3 for class LOWLAND waterways. Winter water temperatures in the headwaters of the spring-fed LII may naturally exceed 11 ^{0}C due to lack of exposure to cold winter air. A minimum of 11.3 ^{o}C, was recorded in June 1998.

Dissolved reactive phosphorous (DRP) is not considered likely to change significantly, with a decrease in concentration at low stormwater inputs, and only a possible slight increase (0.01 mg/L) should DRP values in the stormwater become very high. Natural background DRP levels in the LI already exceed PNRRP levels for class LOWLAND streams (i.e. 0.002 mg/L), and LII levels are expected to be similar.

Inorganic nitrogen (NH_4 + NO_3 + NO_2) levels in the upper LII were higher (4.22 mg/L, Table 1) than average EMC stormwater concentrations from urban catchments (ca. 0.9 mg/L) (Williamson 1993). With some detention pond treatment prior to discharge into the LII, mixed inorganic nitrogen concentrations in the river will decline slightly.

Water clarity is not defined in the definition section of the PNRRP. We have expressed clarity as an approximate reduction in visual range of black disc distance (Davies-Colley & Close 1990). How this relates to the reduction in water clarity in the context of the plan is unclear. Certainly bottom visibility will be retained during most storm events, but some turbidity could be expected depending on the stormwater detention time, and the size of the suspended particles. Water colour is unlikely to vary significantly, although the effect of suspended sediment on colour is very approximate (Davies-Colley & Close 1990).

The identified fauna is commonly found in spring-fed waterways in Canterbury with reasonable water quality and stable banks. None of the recorded species are rare either regionally or nationally. The invertebrate fauna was representative of a lowland scheme, with a MCI index (soft-bottom) value (67.6, Table 3) indicating fair stream health. However, the index did not include koura, as the identified individual was captured well upstream of the proposed stormwater discharge site, and invertebrate collection site. The individual MCI score for koura is mid-range, and would not have greatly affected the combined MCI value. The amphipod *Paracalliope fluviatilis* has been a test organism for some common urban stormwater contaminants, and a summary of the results of these trials are provided in Table 7 (*data from* Hickey 2000). This invertebrate has proved to be more sensitive than the snail *Potamopyrgus antipodarum*, and an order of magnitude more sensitive than any of the fish species, which is discussed further below.

Table 7. Summary of EC_{50} values for the freshwater amphipod *Paracalliope fluviatilis* shaded) and the common bully *Gobiomorphus cotidianus* (unshaded).

Toxicant	pH	EC_{50} (mg/L)x 10^{-2}	Testing period (hrs)	Expected contaminant concentration* (mg/L)x10^{-2}
Cu	7.8	6.1	48	0.13-0.35-0.97
Zn	7.8	58	48	0.79-2.3-7.03
NH_3	7.6	1450	48	2.6-3.6-5.4
Zn		148**	96	See above
NH_3	7.5	8230	96	See above

* from Table 6
** water hardness corrected value

Table 7 indicates that the highest expected concentrations of specified contaminants from the Liffey Springs outfall remain well under the EC_{50} values. However comparing EC_{50} values against expected values is not a conservative test because there is increasing evidence that chronic low-levels of contaminants can cause insidious changes in organisms over long timeframes (i.e. months), and a concentration level which kills 50% of the organisms is not environmentally acceptable. Unfortunately there is little experimental data to detect chronic low-level effects (e.g. effects on reproduction), mainly because of the difficulty in holding sensitive animals under experimental conditions for long periods. There is some test data on a small freshwater bivalve (*Sphaerium*) and the mayfly *Deleatidium*, which were held for 60 days, neither of which appear to be present in the upper LII. However, in the context of episodic stormwater discharges which have duration of days, or possibly a week during wet periods, acute tests based on several days of exposure to contaminants may be more relevant to the environmental scenario experienced than enduring months of continuous contaminant exposure. A pragmatic point of view is that the exposure times for the acute tests may be more relevant to that expected for episodic stormwater discharges, although expected mixed concentrations should be an order of magnitude lower than EC_{50} values. Within the constraints of available data on contaminant loadings, and its impact on the resident fauna, this is the situation in this receiving environment. *Paracalliope* is closely related to species in North America that have also been subject to ecotoxicology studies, and it would appear this species is likely to become a useful environmental indicator species for monitoring in the future.

The one koura caught during this survey was well upstream of the proposed stormwater discharge point, and the absence of other captured individuals despite significant fish pressure indicates that they are naturally scarce in the LII. This could be due to large eels which would predate on them, and possibly trout when present, as koura lack effective escape behaviour when confronted with trout (Shave *et al.* 1994). Koura appear sensitive to disturbance, especially bank dredging/erosion, and flood flows (Parkyn & Collier 2004), and in my experience are frequently encountered in

Canterbury's spring-fed lowland streams possessing stable banks and at least moderate water quality. There is no ecotoxicology data on the koura, although they are known from catchments which receive significant treated stormwater inflows, for example koura are still present in good numbers in Cashmere Stream downstream of the detention basin for the Aidenfield sub-division three years after the discharge was consented (McMurtrie & Taylor 2006). Cashmere stream was also subject to episodic high suspended sediment levels due to stock access, and channel maintenance activities (Taylor 2003). Koura are not, or infrequently, found in waterways which receive large inputs of untreated stormwater, and chronic effects from a range of deleterious agents are suspected, but to date these agents have not been elucidated.

Ecotoxicology data for freshwater fish is incomplete, although there is Zn, and NH_4 testing data available for the common bully which was identified from the mixing zone, and these data are presented in Table 7. The common bully is considered the 3rd most sensitive species tested, after common smelt and rainbow trout (Hickey 2000). Some test data exists on the sensitivity of juvenile common bully to suspended sediment in respect to inhibition of feeding (Rowe & Dean 1998). This indicated that common bullies are not highly sensitive to suspended sediment, and although feeding rates did decline in turbid water, the decline in feeding rate was not statistically significant. Like many native fish, common bullies are known to feed after dark (McDowall 1990). Generally, testing within the New Zealand fauna has indicated that all fish are far less sensitive to contaminants than invertebrates.

In summary, there is no evidence that the addition of episodic treated stormwater into the LII headwaters will be detrimental to environmental values. The most sensitive organism present in the mixing zone for which reliable stormwater contaminant test is available is a freshwater amphipod. Examination of available information indicates that the expected concentration from the stormwater discharge will not cause deleterious effects to this sensitive organism.

It is intended that this waterway will be subject to a riparian planting program (David Hobbs, pers. comm., Broadfield Estates Ltd.) which is likely to directly benefit the invertebrate and fish communities. The importance of riparian planting to the aquatic ecology has been demonstrated on many occasions, including in highly urbanised and pastoral settings (Collier & Scarsbrook 2000; McMurtrie & Taylor 2003; Quinn 2000). While it is beyond the brief of this report to discuss the details here, we consider it likely that the environmental benefits will outweigh any potential detrimental impacts of the proposed stormwater discharge.

7 Acknowledgements

We thank EOS Ecology for indentifying the aquatic invertebrates. Hill Laboratories analysed the water samples. All maps are subject to Crown Copyright.

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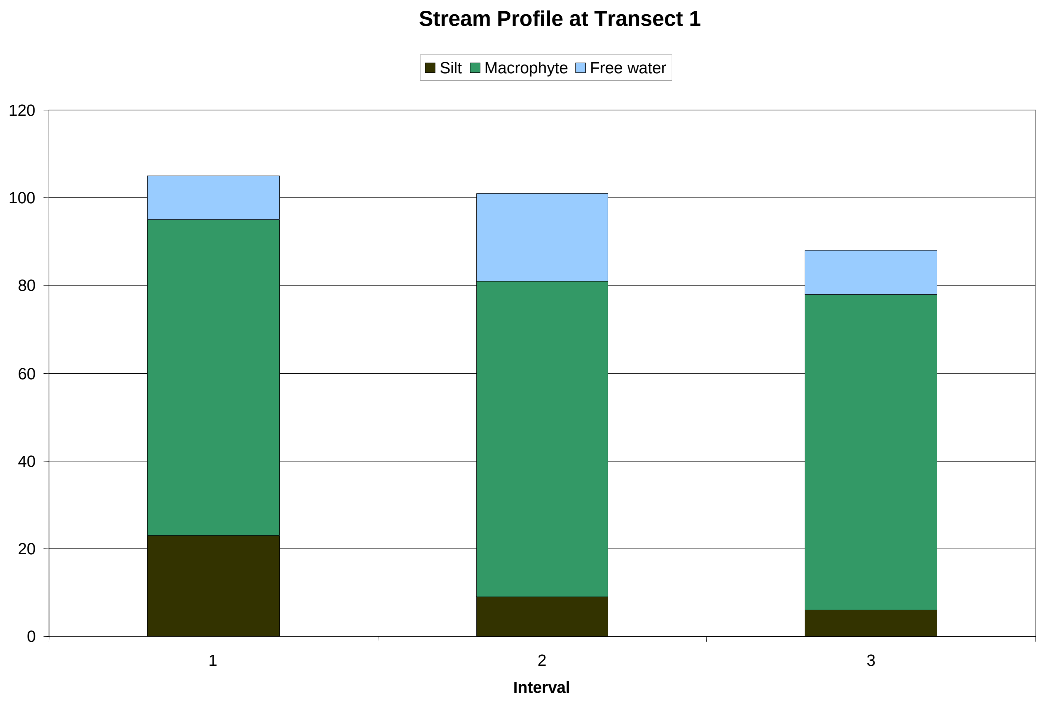
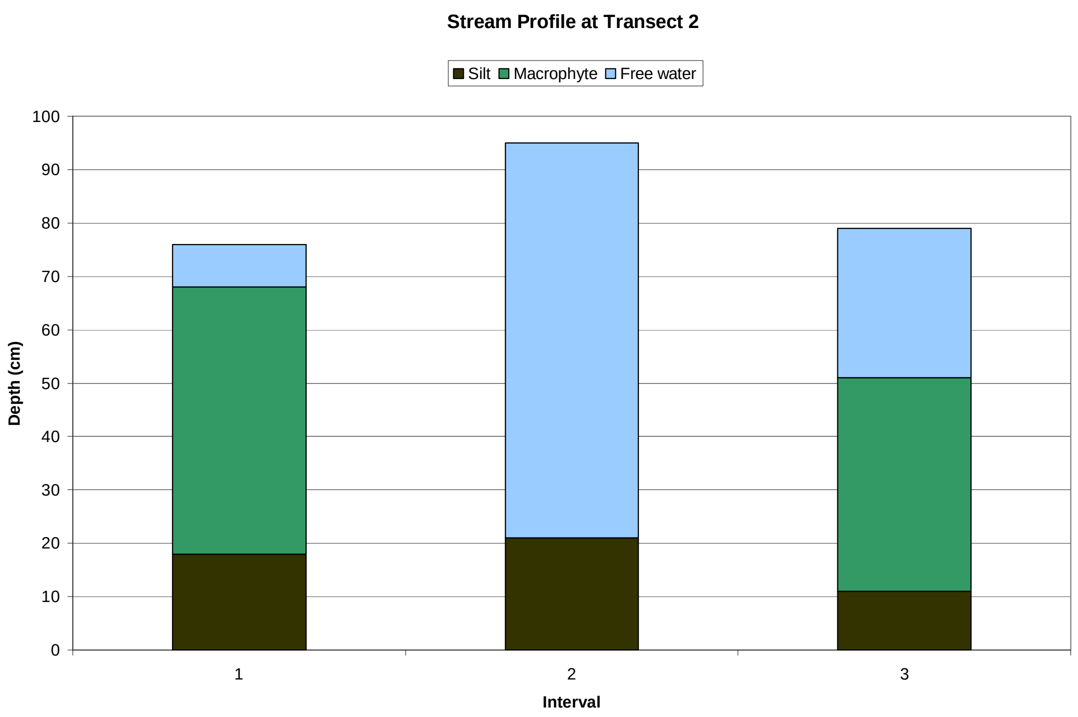
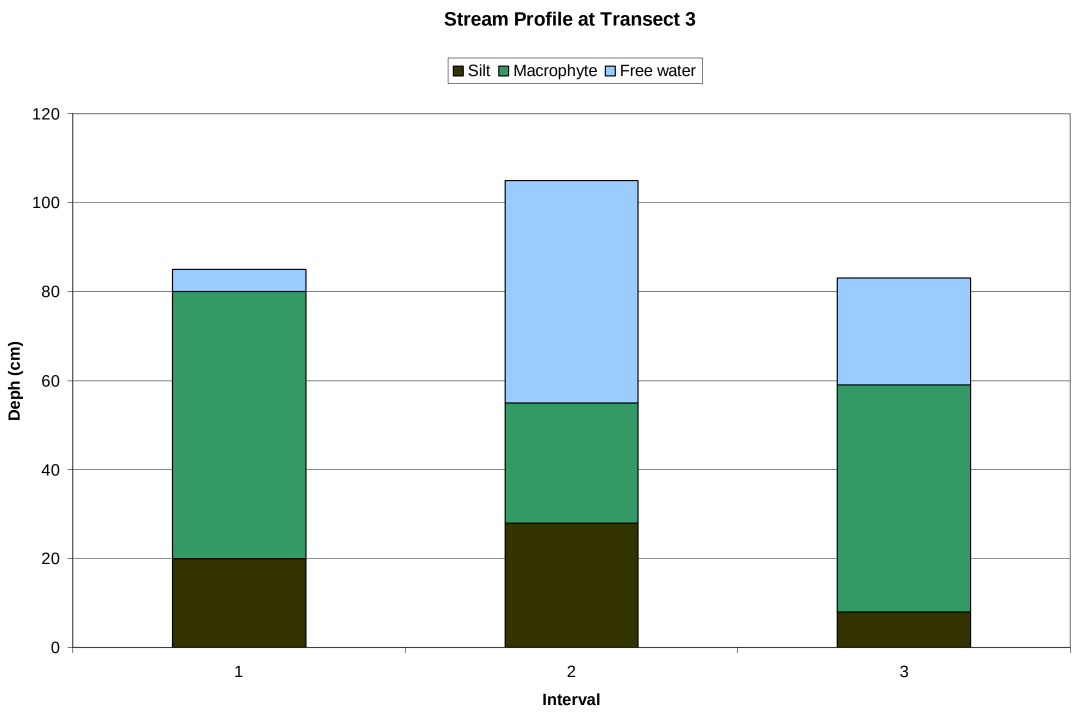
9 Appendix I



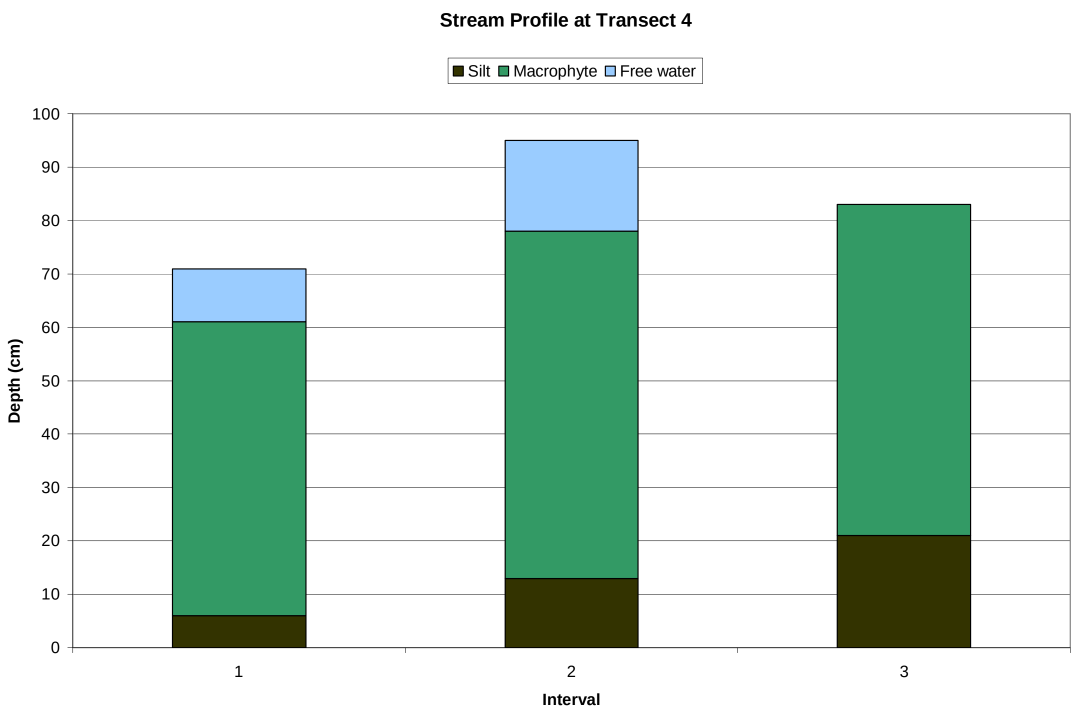
A. Bar chart showing depth (in centimetres) of free-flowing water, macrophyte cover and silt at three equal intervals across the L11 stream at transect 1.



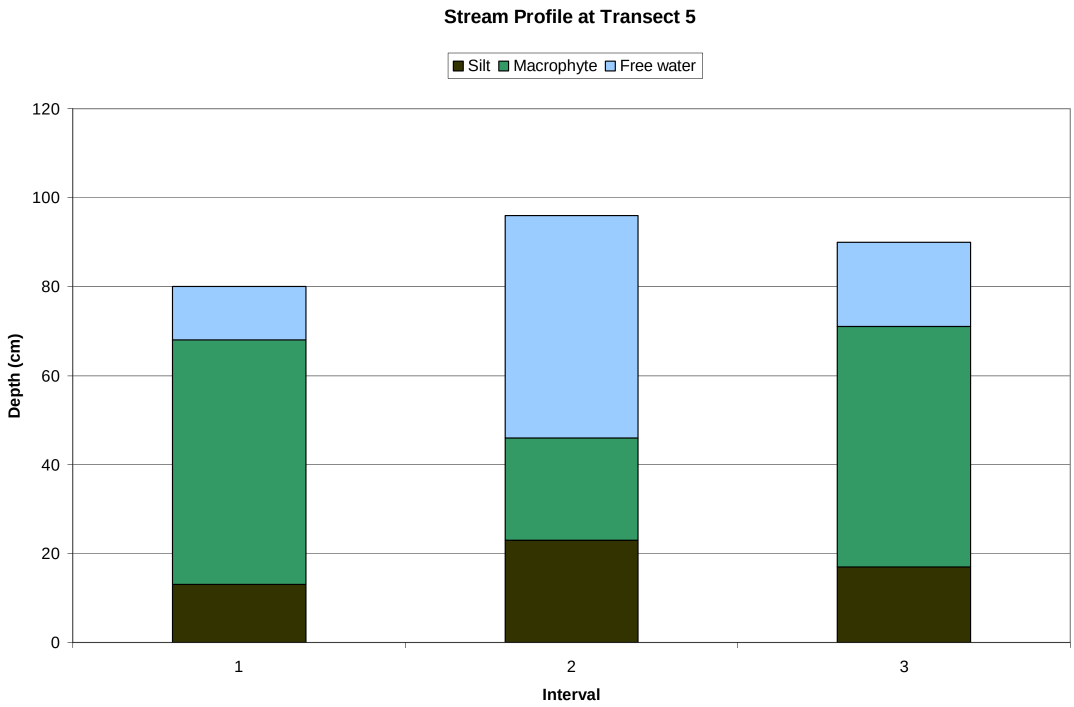
B. Bar chart showing depth of free-flowing water, macrophyte cover and silt at three equal intervals across the L11 stream at transect 2.



C. Bar chart showing depth of free-flowing water, macrophyte cover and silt at three equal intervals across the L11 stream at transect 3.



D. Bar chart showing depth of free-flowing water, macrophyte cover and silt at three equal intervals across the L11 stream at transect 4.



E. Bar chart showing depth of free-flowing water, macrophyte cover and silt at three equal intervals across the L11 stream at transect 5.

10 Appendix II

a) Water quality data from ECan lower LI monitoring site, CRC300884

Date	Dissolved Oxygen mg/L	Faecal Coliforms n/100mL	Total Suspended Solids mg/L	Water Temperature °C	pH	Turbidity NTU	Ammonia Nitrogen mg/L	Dissolved Reactive Phosphorus mg/L	Nitrate + Nitrite Nitrogen mg/L	Total Nitrogen mg/L	Total Phosphorus mg/L
11-Mar-87	7.9	235	0	13.1							
31-Mar-87	8.2	75	5	12.9							
4-Aug-87	8.9	100	52	11.7	6.9						
3-Dec-87	9.4	370	7	13.5	7.1						
24-Mar-88	7.7		0	12.1		2					
23-Jun-88	8.7	1500	26	11.3							
11-Jan-93		630	13	15.9			0.057	0.022	5.9	6.2	0.03
26-Apr-93	9.1	300	8	11.4			0.14	0.026	6.6	7.5	0.045
Medians	**8.7**	**300**	**7.5**	**12.5**	**7**	**2**	**0.0985**	**0.024**	**6.25**	**6.85**	**0.0375**

AEL