

# **Seven day mean annual low flow mapping in the Kaikoura area**

Report No. U02/82



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## **Executive Summary**

This report is in two parts:

Part A of this investigation attempts to estimate a Seven-day Mean Annual Low Flow (7DMALF) for streams and creeks in the Kaikoura area. These are calculated to assist the expert panel process. This information is essential for the development of the Natural Resource Regional Plan (NRRP), Water and Land Chapters.

Flow measurements at 17 locations were naturalised with regard to upstream abstractions. The 17 tertiary sites were further normalised with longer-term primary sites. A 7DMALF for each site was then calculated using regression equations. The majority of gauging sites show a good relationship with at least one of the primary sites.

As part of the larger project to map the 7DMALF's for the entire Canterbury region, Part B discusses the methods, results and limitations of the mapping 7-day low flows in the Kaikoura area.



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## 1 Introduction

The water found in the streams in the Kaikoura area are used for domestic, stock water and irrigation purposes. Given that these waters also retain instream and recreational values, specific management is required to ensure all of the given needs are met.

The purpose of this project is to determine estimates of the “natural” low flows of the streams in the Kaikoura area, from spot gaugings and recorded flows.

Part A will discuss those sites required for Expert Panel analysis, while Part B will discuss more sites, which are only used for mapping 7-Day Mean Annual Low Flow in the Kaikoura area. Some of the sites where 7DMALF's were calculated for the Expert panel work are also used as part of the mapping.

Maps showing lines of equal specific mean flow and equal specific 7-day mean annual low flow have been produced in accordance with the outputs of project EMR027504.

Such flow mapping is one way in which to provide information about catchments for which there is little or no data. It uses the principles of establishing a regression relationship, between a catchment with only spot gauging (with no recorded flow data) and a nearby catchment for which there is good flow record. This method recognises that although catchments are within the same region, they may recede differently, as defined by the regression, due to their specific physical characteristics. These variations in flow data quantify the effects of the physical differences between catchments, which are the basis to regional/classification type approaches to surface water mapping.

The information found in this report is essential for the development of the Water Chapter of the Natural Resource Regional Plan (NRRP) which will specify rules regarding minimum flows and flow allocation.

## 2 Methodology

A 7-Day Annual Low Flow (7DALF) is calculated as the lowest flow recorded over seven consecutive days in a single year. These annual values are then averaged over the recorded period to give the 7DMALF for that stream/river. However, this is only accurate for long term monitoring sites, so for those sites where we have limited spot gaugings (tertiary sites) correlation with recorder sites (primary sites) was required. Linear regression were carried out to ascertain tertiary site flow characteristics from similar primary sites. These regression equations are then used to estimate 7DMALF's for each tertiary site.

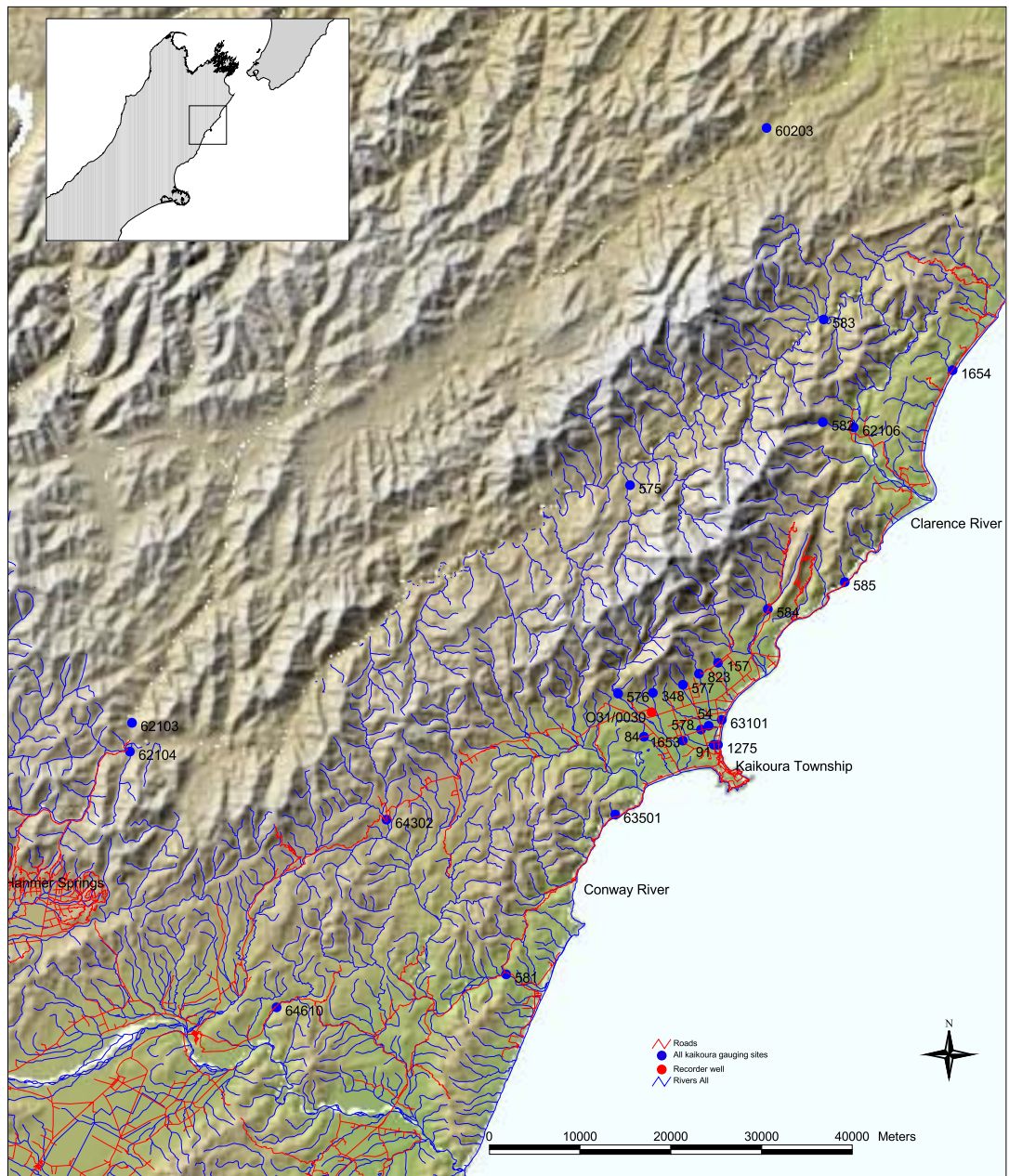
The values calculated using the above method formed the basis of the 7DMALF isohyetal map for Kaikoura. Specific yield values were plotted in the middle of the catchment area, contours drawn accordingly, integrated and adjusted until generated flows matched those at known points. Annual rainfall contours and the Mean flow map (constructed for the area in 1999) were used to aid in drawing the lines of equal specific discharge.

## 2.1 Sites included in this investigation

26 sites in total have been included in this investigation. These sites are listed in Table 2.1 while a map of site locations is shown in Figure 2.1.

**Table 2.1 List of all the sites included in this investigation, including those used as primary and tertiary sites for Part A and Part B.**

Site Number	Name	Site	Map Reference	Contributes to
62103	Acheron River	Clarence	N31:071-703	Clarence River
60203	Awatere River	Awapiri	P29:707-299	Pacific Ocean
62106	Clarence River	Glen Alton	P30:794-999	Clarence River
584	Clinton River	Clinton Bridge	P31:708-817	Puhi Puhi River
581	Conway River	No.1 SHB	O32:446-451	Pacific Ocean
64302	Conway River	No.70 SH	O31:326-606	Pacific Ocean
1654	Deadman Stream	At SH1	P30:983-056	Pacific Ocean
575	Dubious River	At Island -2km US of Clarence	O30:570-941	Clarence River
84	Ewelme Stream	Quarry Road	O31:584-689	Pacific Ocean
348	Floodgate Creek	D/S Boyd Take	O31:593-733	Kowhai River
582	George Stream	Boulder Gorge	P30:763-004	Clarence River
157	Harnetts Creek	Grange Road	O31:658-763	Pacific Ocean
576	Kowhai River	Gorge	O31:558-732	Pacific Ocean
577	Luke Creek	Rush Property	O31:624-737	Middle Creek
54	Lyell Creek	Left Branch - Mackle Property	O31:649-700	Pacific Ocean
578	Lyell Creek	Mill Road-Mt Fyff Rd Bge (dairy)	O31:641-696	Pacific Ocean
1275	Lyell Creek	D/S Warren Confluence	O31:658-680	Pacific Ocean
583	Mead Stream	At Clarence confluence	P30:764-107	Clarence River
63101	Middle Creek	No. 1 SHB	O31:660-707	Pacific Ocean
585	Ohau Stream	At Railway Bridge	P31:785-844	Pacific Ocean
63501	Rosymorn	Weir	O31:555-611	Pacific Ocean
64610	Stanton River	Chedder Valley	N32:216-418	Waiau River
62104	The Ribble	At Airstrip	N31:069-674	Clarence River
2261	Waimangarara River	200m D/S Rock Weir	O31:636-759	Pacific Ocean
91	Warren Creek	Rorrissons Road Bridge (U/S Lyell conf)	O31:654-681	Lyell Creek
1653	Warren Creek	Red Swamp Road	O31:623-685	Lyell Creek



**Figure 2.1 Sites used in this investigation**

## 2.2 Naturalising River Flows

Surface water consented abstractions, and hydraulically connected groundwater takes, were added back to all sites, to produce the “Natural” 7- day Mean Annual Low Flows (7DMALF), for each stream, and creek, to reflect low flows under natural conditions.

However, precise reconstruction of natural flows is impossible due to the changes in the natural system that have occurred. These include (but not limited to):

- Changes to natural drainage systems,

- Draining of wetlands,
- Groundwater irrigation and domestic abstractions,
- Kaikoura town water supply,
- Stockwater takes.

After assessing the water source and location of each consented take, 14 surface water consents and 1 divert water consent were found to be above the gauging sites and therefore assessed for affects on stream flow. Those consents located downstream of the gauging sites were not added back and would not affect the gauged flows.

Only one groundwater consent (for two bores) was included in this investigation. These bores are very shallow and were considered, in the Consent Audit, to be connected to surface flows and do have a minimum flow attached. The remaining groundwater consents appear to be pumping from deeper confined aquifers which are not considered to be directly connected to surface water or were found to be downstream of the gauging site.

However a number of assumptions were also required:

- That the irrigation season runs from 1 October to 30 April, and consented abstractions were only added back for this period. This was done with the exception of the Waimangarara River where the Kaikoura District Council has a consented take for the Kaikoura town supply. The actual records were used for this purpose.
- During the irrigation season only 50% of consented takes are actually used (Sanders, 1998). Therefore, for surface abstractions, only 50% of the consented amount was added back to the stream flows. This is only an estimation used in this case as no actual data was available.
- It was assumed that when flows were less than the minimum flow at the time of the gauging there would be no surface takes from that stream. Consented abstractions for that stream were not added back during low flow periods.
- For purposes of estimating low flows, it was preferred that flows in the dataset were less than mean flows, which for Middle Creek, is approximately  $600 \text{ l s}^{-1}$ , and Rosy Morn,  $28 \text{ l s}^{-1}$ . For statistically correct regression at least eight pairs of data is required. When data was removed above mean flows for both these sites, the number of concurrent flows for many sites dropped below the necessary eight. For this reason the flows were cut off, above the mean flow for Middle Creek at  $1000 \text{ l s}^{-1}$  and Rosy Morn at  $40 \text{ l s}^{-1}$ .

### 3 Primary and Secondary Sites

A hydrological normal was required for primary sites used for estimating a 7DMALF (or 7DMALL- 7-day Mean Annual Low Level for the well) for all streams in the Kaikoura area. This was calculated using reference stations with long term records. Table 3.1, shows the primary sites used in this investigation and available data from each. Descriptions of the method used follows.

**Table 3.1 Primary and Secondary Sites used in the Kaikoura analysis and the normalised MALF's**

Site Number	Name	Site	Map Reference	Catchment Area (km <sup>2</sup> )	Estimated MALF
<b>Primary</b>					
63501	Rosy Morn	Weir	O31:555-611	1.7	3.54 l s <sup>-1</sup>
64610	Stanton	Cheddar Valley	N32:216-418	41.89	12.73 l s <sup>-1</sup>
62103	Acheron	Clarence	N31:071-703	972	4,681 l s <sup>-1</sup>
2346001	O31/0030	TJ Boyd well	031:591-713	NA	-9.04 mbgl
<b>Secondary</b>					
63101	Middle Creek	No. 1 SHB	O31:660-707	20.58	239 l s <sup>-1</sup>
62104	The Ribble	At Airstrip	N31:069-674	20.74	193 l s <sup>-1</sup>
60203	Awatere	Awapiri	P29:707-299	608	3,078 l s <sup>-1</sup>

l s<sup>-1</sup> = litres per second

mbgl = metres below ground level

#### 3.1 Rosy Morn at Weir

Rosy Morn has a catchment size of only 1.7 km<sup>2</sup> and has a mean flow of only 28 l s<sup>-1</sup>, but has a valuable flow record of 22 years. This is short of the appropriate 30 years used for normalising, however the coastal Kaikoura region is devoid of hydrological records. With a total of 22 years of usable 7DALF's, it was considered sufficient to cover a number of droughts and floods. This catchment drains a steep, forested, south facing area approximately 13km south of the Kaikoura Township.

From the 22 years of available record, an estimate of a 7DMALF is 3.45 l s<sup>-1</sup>.

#### 3.2 Stanton River at Cheddar Valley

The Stanton River is an inland catchment, which drains the south-eastern slopes of Mt Cookson (865m), eventually draining into the Waiau River approximately 10km downstream of the Waiau township. This site has been run by NIWA for the last 33 years, and with only 3 short gaps in the record, this considered very valuable.

From the 33 years of data a 7DMALF was estimated at 12.7 l s<sup>-1</sup>.

### 3.3 Acheron at Clarence

The Acheron River drains a large (972 km<sup>2</sup>) SW facing catchment located in the Marlborough Region, but flows over the boundary into North Canterbury and feeds the Clarence River. This site has also been run by NIWA from mid 1958 till the present, and with a valuable long-term record of 40 years.

From the 40 years of data a 7DMALF was estimated at 4,681 l s<sup>-1</sup>.

### 3.4 Well O31/0030 at Postmans Road

Groundwater levels have been measured sporadically in well O31/0030, since 1950, and monthly since 1986, while a groundwater level recorder has been in place since 1994. A total of 619 additional manual measurements have been taken from this well.

Due to the shallow depth of this well (9.1m) it is considered that levels are likely to be affected by flows in Floodgate Creek, the Kowhai River and rainfall events. It is considered highly unlikely that this well would be affected by other groundwater takes, as there are no consented takes upstream and the closest consent downstream of this well is at least 4km away.

To create a 30-year record, the data was simply interpolated between measurements. From this a complete 30-year record was created which resulted in a normalised 7-day Mean Annual Low Level (7DMALL) was estimated at -9.04 metres below ground level (*mbgl*).

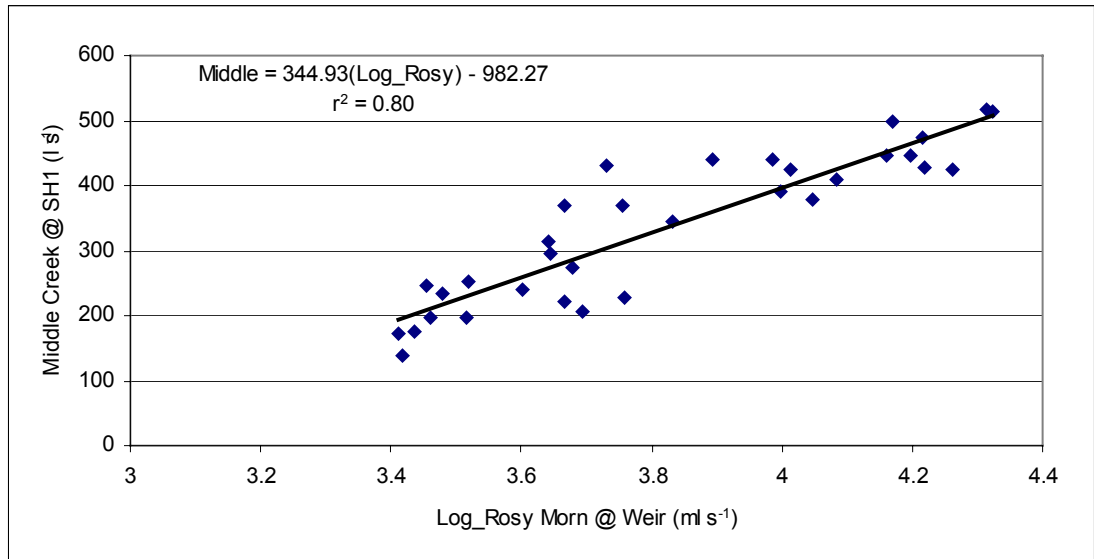
### 3.5 Middle Creek at State Highway 1 Bridge

The Department of Conservation identified Middle Creek as having value as a habitat for native species such as the Torrentfish (Ngai Tahu Taonga species), and long-finned eels. Middle Creek has also been identified as having instream values such as being a trout fishery and spawning.

The Marlborough Catchment Board (MCB) opened a gauging station on Middle Creek at Beach Road in 1980. This site was subsequently closed in 1987. Environment Canterbury resited the station at the State Highway 1 Bridge on the 21 May 1998. A recent data audit carried out by Smith (2002) stated that the data recorded between 1980 and 1987 was not to ECan standards. This was due to the low frequency of gaugings carried during this period, which in turn were insufficient to accurately determine rating changes, resulting in rated flows differing from actual gauged flows by more than  $\pm 8\%$  for most gaugings (Smith, 2002).

Therefore only the data since 1998 was used in this investigation. With only 4 complete years of record, Middle Creek required normalising (hence labelled a Secondary Site) before further analysis with tertiary sites.

After attempting a number of simpler methods, and due to the short record available, the best result was found using non-linear regression, between instantaneous flow in Middle Creek and daily mean recorded flow at Rosy Morn. The resulting  $r^2$  of 0.80, shows a good relationship between these two sites. The non-linear regression equation is seen in Figure 3.1 below. From this, a normalised 7DMALF for Middle Creek was estimated at  $239 \pm 24$  l s<sup>-1</sup>.

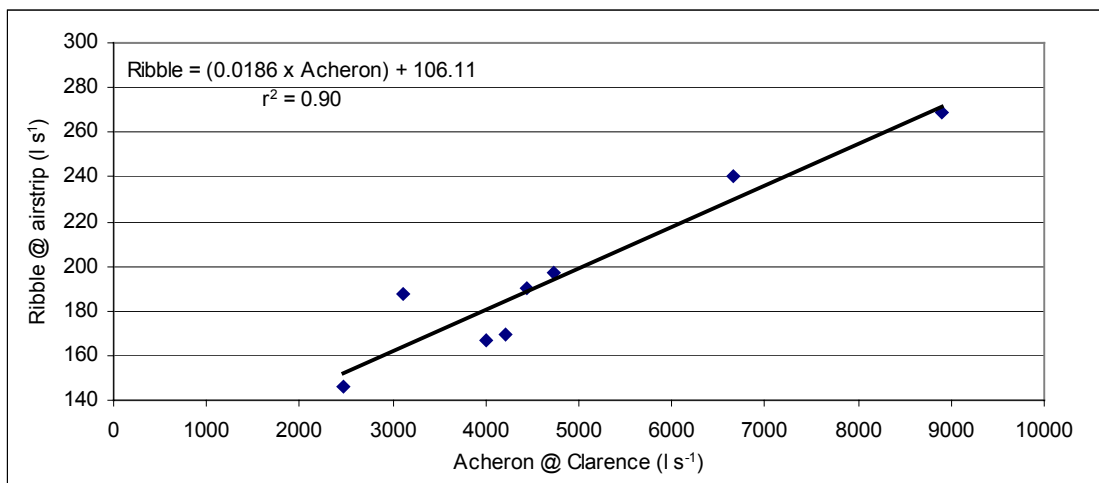


**Figure 3.1 Gaugings for Middle Creek compared with daily mean recorded flow at Rosy Morn.**

### 3.6 The Ribble at Airstrip

NIWA operated a recorder site on The Ribble for only 10 years, between 1971 and 1981. This site is located inland and feeds the Clarence River just upstream of where the Acheron River joins the Clarence River. The 10-year record and more recent gaugings have assisted this investigation.

To estimate a long term 7DMALF for this site normalising was required (hence labelled a Secondary Site). This was done by comparing the available 7DALF's with those from the long-term recorder on the Acheron. The resulting  $r^2$  of 0.90 shows a very good relationship and hence a 7DMALF was calculated at  $193 \pm 15 \text{ l s}^{-1}$ .

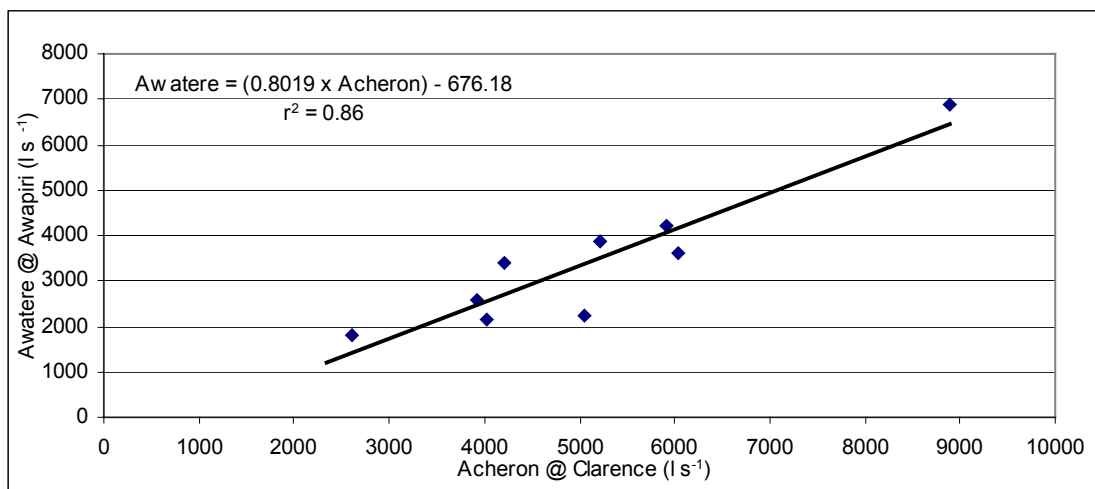


**Figure 3.2 Available 7DALF's from the Ribble compared to those from the Acheron River.**

### 3.7 Awatere River at Awapiri

The Awatere River is another site within the Marlborough region used in this investigation. This site has had a recorder located since 1977, however there appears to be some long periods of missing record, leaving only 11 years of usable data. Some year's lowest flows were also removed as they occurred during winter months and which are not relevant to this study, and would have been affected by winter freezing in the mountains.

As there is only 11 years of reliable data, normalising was required. This was also done by comparing the available 7DALF's with those on the Acheron. The resulting  $r^2$  of 0.86 shows another very good relationship and a 7DMALF was calculated from this relationship at  $3,078 \pm 654 \text{ l s}^{-1}$ .



**Figure 3.3 Available 7DALF's from the Awatere compared to those from the Acheron River.**

## 4 Part A Results:

### 7DMALF Calculations for Expert Panel Tertiary Sites

Regression equations were used to estimate 7DMALF's for the tertiary sites in the Kaikoura area. Table 4.1 below shows all the streams with the regression results. Further analysis follows in proceeding sections. Figure 4.1 shows the location of these sites.

**Table 4.1: Regression results and calculated 7DMALF's.**

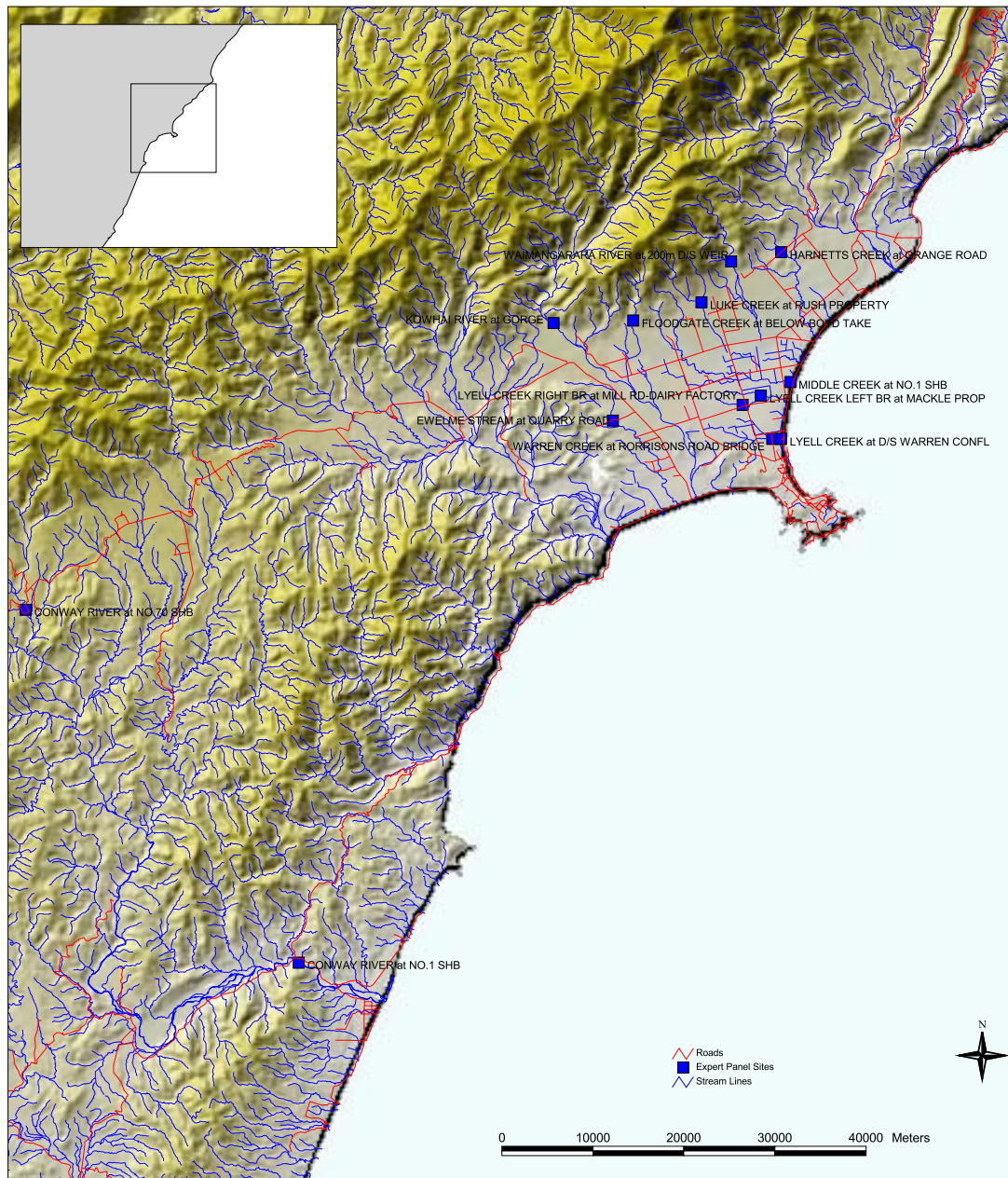
Site Number	Stream	Site	Adjusted $r^2$	SE	Equation	Estimated 7DMALF (litres per second)
64302	Conway River	No.70 SH	0.79	234	$y=(1.86xStanton)+522.026$	$546 \pm 197$
581	Conway River	No.1 SHB	0.95	392	$y=(12.57xStanton)+910.6$	$1071 \pm 421$
84	Ewelme Stream	Quarry Road	0.78	22.9	$y=(0.1596xMiddle)+15.226$	$53 \pm 37$
348	Floodgate Creek	D/S Boyd Take	0.79	25.9	$y=(33.639xO31/0030)+348.163$	$44 \pm 28$
157	Harnetts Creek	Grange Road	0.94	2	$y=(0.029xMiddle)-2.625$	$4 \pm 24$
576	Kowhai River	Gorge	0.79	288.8	$y=(3.453xStanton)+646.131$	$690 \pm 310$
577	Luke Creek	Rush Property	0.91	3.2	$y=(0.037xMiddle)-4.15$	$5 \pm 24$
1275	Lyell Creek	D/S Warren Confluence	0.76	74	$y=(0.509xMiddle)+298.017$	$420 \pm 118$
578	Lyell Creek	Mill Road-Mt Fyffe Rd Bge (dairy)	0.82	3.9	$y=(0.032xMiddle)+17.785$	$25 \pm 25$
54	Lyell Creek	Left Branch - Mackle Property				$34^*$
63101	Middle Creek	No. 1 SHB	0.8	50	$y=(344.93xLog\_Rosy)-982.27$	$239 \pm 24$
2261	Waimangarara River	200m D/S Rock Weir	0.99	23.3	$y=(0.31xMiddle)+8.9177$	$83 \pm 25$
91	Warren Creek	Rorrissons Road Bridge (U/S Lyell conf)	0.74	71.6	$y=(132.509xO31/0030)+1476.528$	$279 \pm 92$

Notes:

Adjusted  $r^2$  = Coefficient of determination

SE = Standard Error of estimate from regression

\* = Estimation of MALF through correlation with Right Branch – assumed to be 35% greater.



**Figure 4.1 Sites to be visited by the Expert Panel.**

### 4.1 Conway River (two sites)

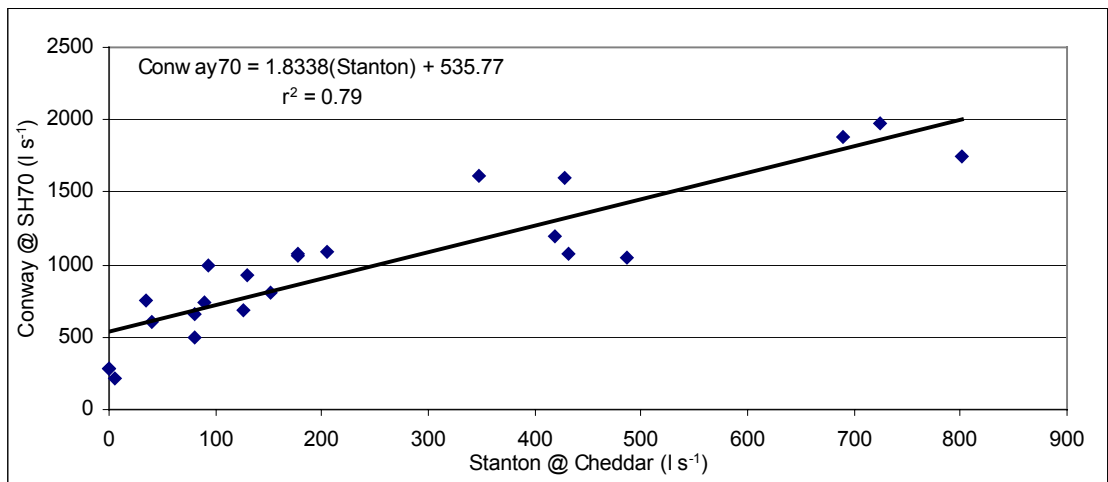
The Conway River is known to have species such as common and upland bullies, inanga, common river galaxias, black flounder, and brown trout. Trout spawning is known to occur in the upper reaches of the Conway river (Source: Survey of freshwater fisheries in the Kaikoura area, and the Freshwater Fisheries Database).

The Conway River at State Highway 70 only had a flow recorder from March 1998 until February 2000. Gaugings from the Conway were compared with the daily mean flow recorded on the Stanton River using a linear regression and found to have a close relationship. The regression result gave an  $r^2$  (coefficient of determination) of 0.79.

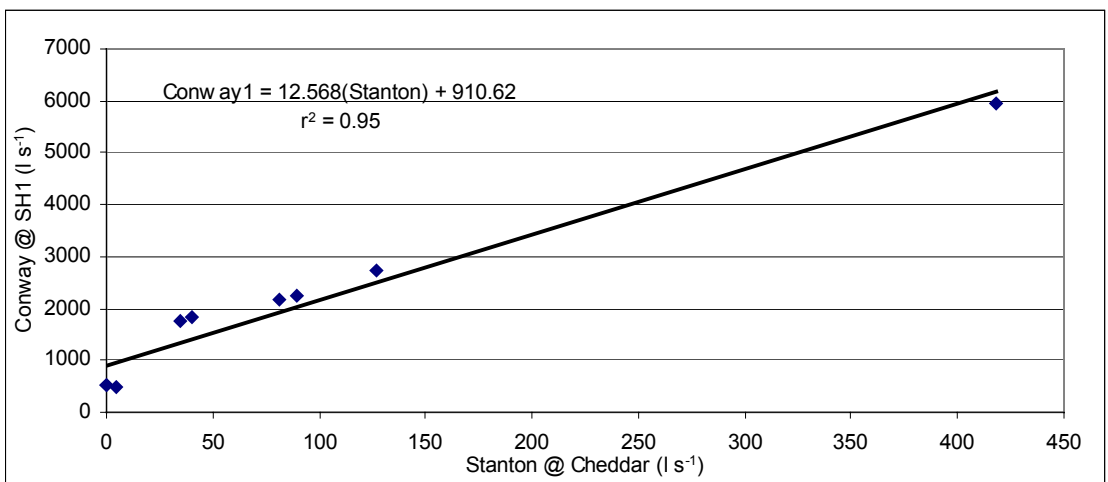
The linear regression equation is shown on Figure 4.2A, which gives a 7DMALF for the Conway at SH70 of approximately  $546 \pm 197 \text{ l s}^{-1}$ .

The Conway at State Highway 1 also had a recorder for a short time between 1955 and 1967. This sites gaugings also correlated very well with the Stanton River flow. This regression resulted in an  $r^2$  of 0.81 (as seen in Figure 4.2B), giving an estimation of a 7DMALF on the Conway at SH1 of  $1071 \pm 421 \text{ l s}^{-1}$ .

A)



B)

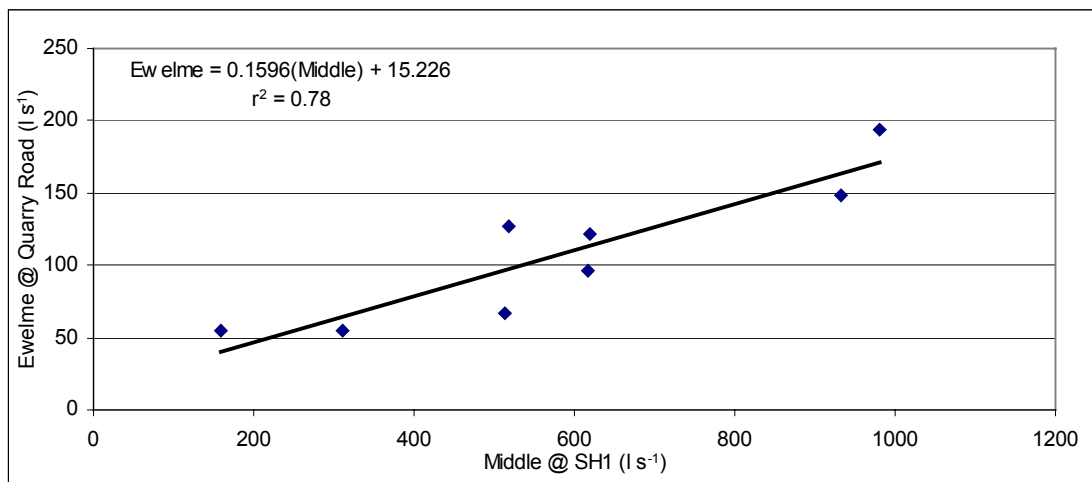


**Figure 4.2 Gaugings for Conway River at SH70 (A) and SH1 (B) compared with daily mean flows on the Stanton River**

## 4.2 Ewelme Stream at Quarry Road

Short and long finned eels, and common bullies were identified in this stream.

The correlation between flows at this site and those measured at Middle Creek, resulted in an  $r^2$  of 0.78. From this a 7DMALF was calculated at  $53 \pm 37 \text{ l s}^{-1}$  (Figure 4.3)

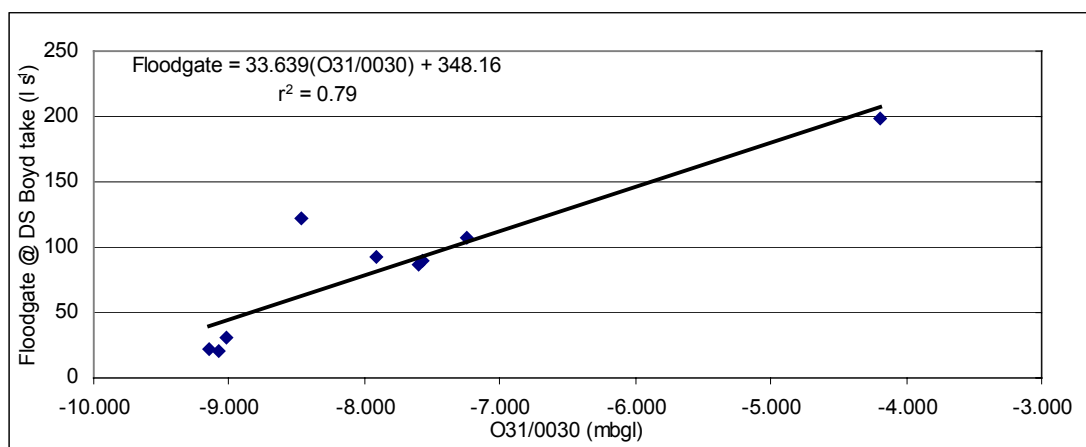


**Figure 4.3 Gaugings for Ewelme Stream compared with daily mean flows recorded on Middle Creek (concurrent gaugings used where available).**

## 4.3 Floodgate Creek at DS Boyd Take

Floodgate Creek was not identified as having any significant fisheries value, primarily because this creek has only subsurface flow in some reaches for a large percent of the time. Floodgate Creek is also relatively steep and bouldery for the majority of its course. Water is taken from this creek and used for irrigation and domestic purposes and therefore requires a visit from the Expert Panel.

This creek also appears to have a better correlation with a nearby groundwater well, O31/0030 ( $r^2 = 0.79$ , shown in Figure 4.4) than with Middle Creek. A 7DMALF was therefore calculated at  $44 \pm 28 \text{ l s}^{-1}$  from O31/0030 (TJ Boyd well).

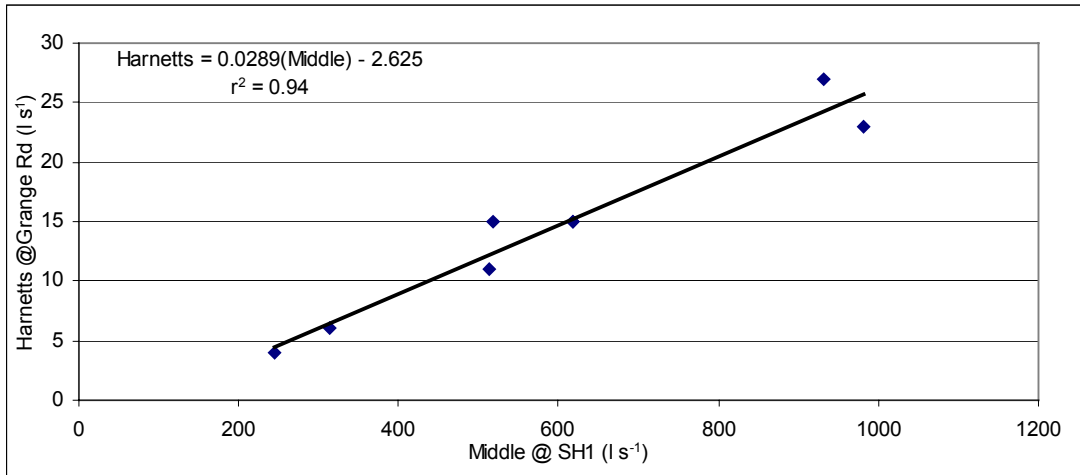


**Figure 4.4 Gaugings for Floodgate Creek compared to daily mean recorded water levels in well O31/0030.**

### 4.4 Harnetts Creek at Grange Road

Harnetts Creek at Grange Road site drains a very small (1.4km<sup>2</sup>) catchment, which was dry when the Freshwater Fishery Survey was carried out. It was assumed that due to the low flows recorded in this stream and the fact that it regularly goes dry there would be very little instream habitat.

As expected Harnetts Creek flows, correlate very well ( $r^2 = 0.94$ ) with those measured at Middle Creek. This relationship can be seen in Figure 4.5. A 7DMALF was calculated from this relationship at  $4 \pm 24 \text{ l s}^{-1}$ .

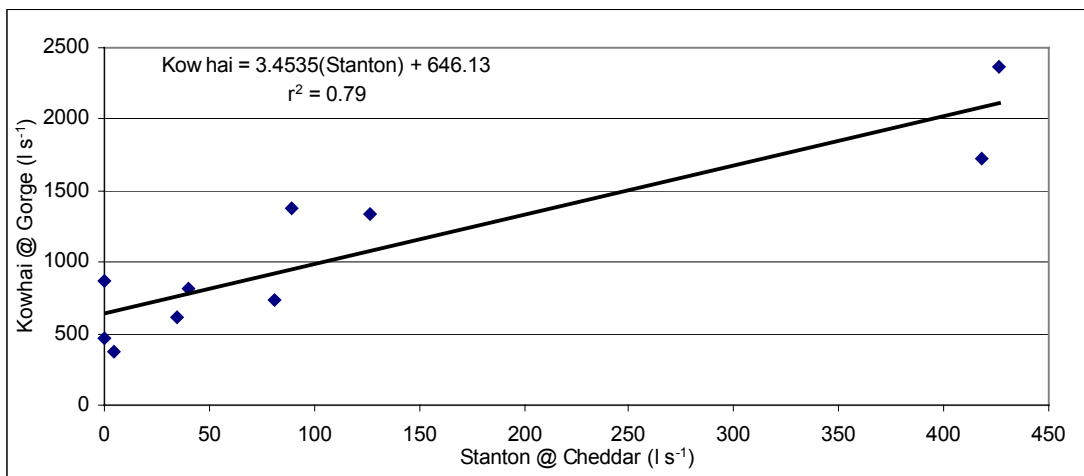


**Figure 4.5 Gaugings for Harnetts Creek compared with daily mean flows recorded on Middle Creek (concurrent gaugings used where available).**

### 4.5 Kowhai River at Gorge

The Kowhai River supports a native fishery, including torrentfish, common river galaxias, short- and long-finned eels, and upland bullies.

Given the nature of the river it was expected that flows in the Kowhai and those measured in the Conway at SH70 would correlate well, so therefore the same primary site was used here. With an  $r^2$  of 0.79 (as seen in Figure 4.6), a 7DMALF was calculated, from a correlation between Stanton flows and Kowhai River flows, at  $690 \pm 310 \text{ l s}^{-1}$  for the Kowhai at Gorge site.

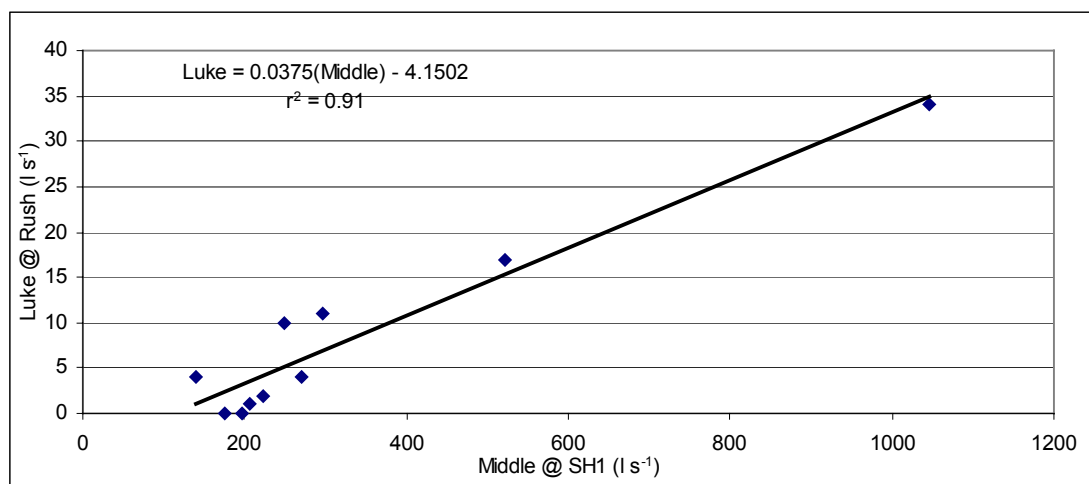


**Figure 4.6 Gaugings for the Kowhai River compared with daily mean flows recorded on the Stanton River.**

## 4.6 Luke Creek at Rush Property

No fish have been identified within Luke Creek with in the Survey of freshwater fisheries in the Kaikoura area (as defined by DoC). Luke Creek is also known to only flow subsurface in its lower reaches.

Flows in Luke Creek correlate well ( $r^2$  of 0.91, shown in Figure 4.7) with Middle Creek flows. An estimated 7DMALF of  $5 \pm 24 \text{ l s}^{-1}$  resulted.



**Figure 4.7** Gaugings for Luke Creek compared with daily mean flows recorded on Middle Creek (concurrent gaugings used where available).

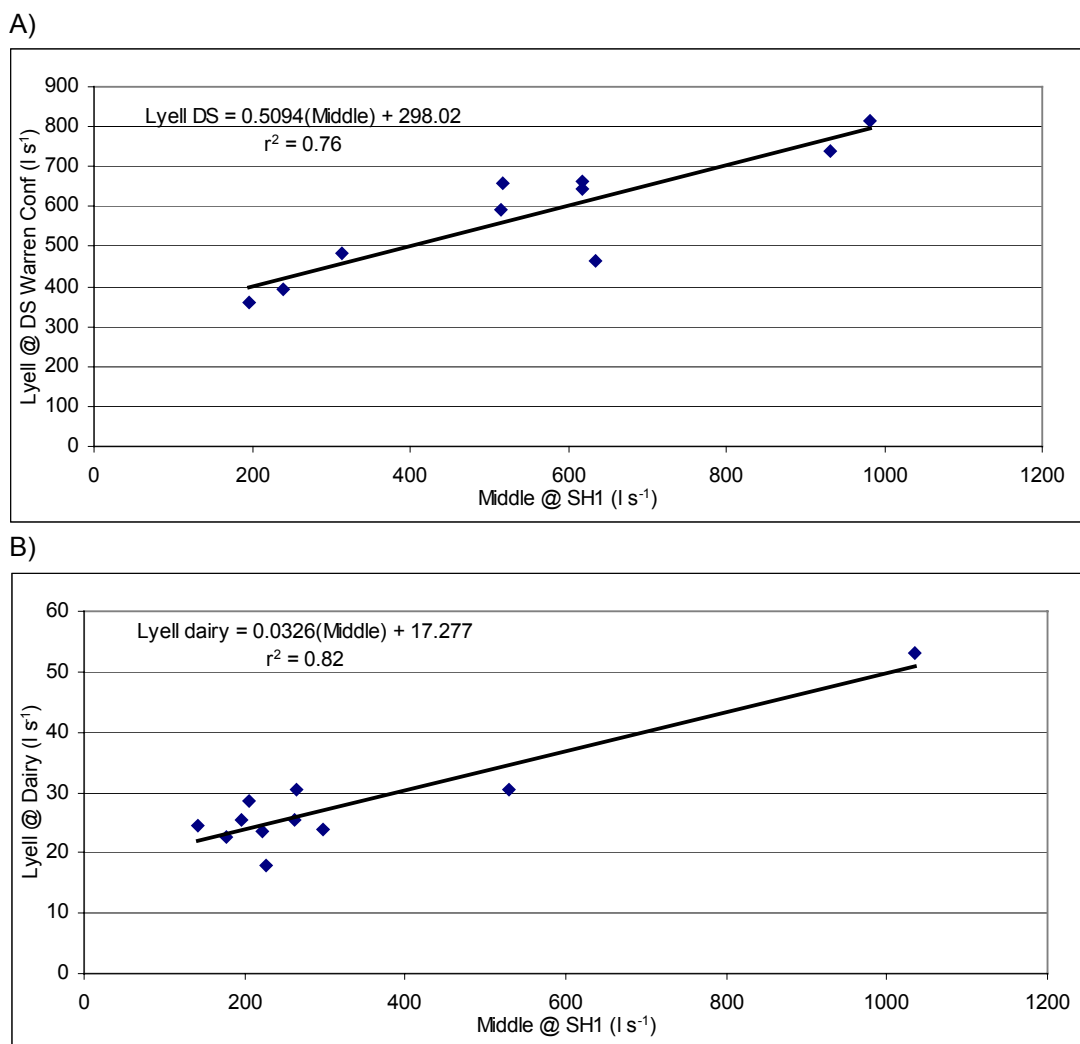
## 4.7 Lyell Creek (three sites)

Three sites on Lyell Creek have been identified as critical in this investigation: Main Stem at downstream of Warren Confluence, right branch at the dairy factory, and the left branch at the Mackle property. Short and long finned eels, brown trout, various bullies and black flounder are common in most reaches of Lyell Creek.

Lyell Creek at DS Warren Confluence shows a good relationship with Middle Creek flow data, with an  $r^2$  of 0.76 (Figure 4.8A). This relationship gives a calculated 7DMALF of  $420 \pm 118 \text{ l s}^{-1}$  at this site.

The Right Branch of Lyell Creek at Dairy Factory also shows a good relationship with Middle Creek ( $r^2 = 0.82$ ), (Figure 4.8B). A 7DMALF for this site was calculated at  $25 \pm 25 \text{ l s}^{-1}$ .

The Left Branch of Lyell Creek appears to have only 4 gaugings on ECan's gaugings database, however after searching through an old consent report a series of gaugings carried out on both branches were found. This data shows that as a general trend this branch has on average 35% more water than the right branch. From this a 7DMALF was estimated at 35% greater than that estimation for the Right Branch, which gives  $34 \text{ l s}^{-1}$  for the Left Branch.

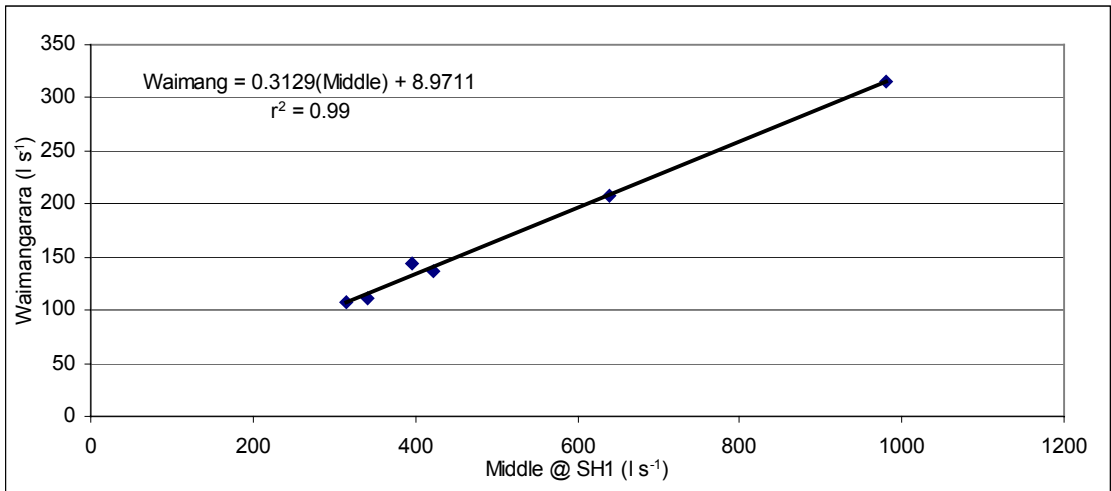


**Figure 4.8** Gaugings for Lyell Creek (2 sites – A and B) compared with daily mean flows recorded on Middle Creek (concurrent gaugings used where available).

### 4.8 Waimangarara River at 200m DS Rock Weir

The Waimangarara River is similar to Floodgate Creek in a number of respects; steep, bouldery nature, large portion flows subsurface and no fish have been identified in the upper reaches (above Harnetts Road).

Flows measured in the Waimangarara River however do correlate ( $r^2 = 0.99$ ), (Figure 4.9) with flows in Middle Creek. A 7DMALF was calculated at  $83 \pm 25 \text{ l s}^{-1}$ . Eight gaugings were completed on the Waimangarara however one of these was removed from further analysis as the flow in Middle Creek was greater than  $1,000 \text{ l s}^{-1}$ .



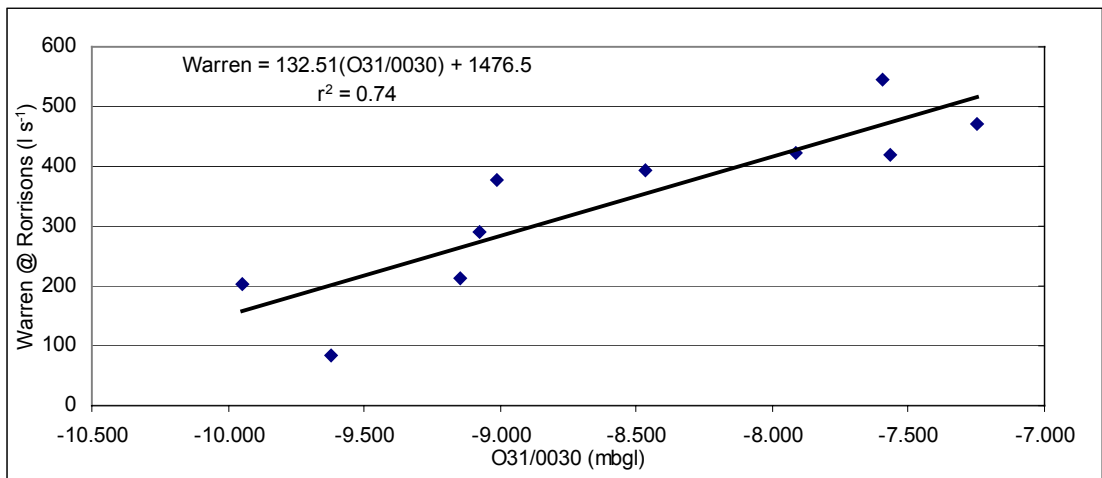
**Figure 4.9 Gaugings for Waimangarara compared with daily mean flows recorded on Middle Creek (concurrent gaugings used where available)**

### 4.9 Warren Creek at Rorrison's Road Bridge (U/S Lyell Confluence)

Short and long finned eels, brown trout, common bullies and inanga are also common in this tributary of Lyell Creek.

This creek appears to have a good correlation with a nearby groundwater well, O31/0030, where the  $r^2 = 0.74$ , (Figure 4.10), from which a 7DMALF was calculated at  $279 \pm 92 \text{ l s}^{-1}$ .

Another site on Warren's Creek, at Red Swamp Road, has a number of gaugings from previous analysis but it was assumed that a MALF was not required. There are no consents above this site and this site is not found in any consent conditions to act as a minimum flow site.



**Figure 4.10 Gaugings for Warren Creek compared to daily mean water levels in well O31/0030**

## 5 Part B Results:

### 7DMALF Calculations of the remaining Tertiary Sites used for mapping purposes

Regression equations were also used to estimate 7DMALF's for tertiary streams in the extended Kaikoura area. The table below shows the results from the remaining tertiary sites.

**Table 5.1 Regression results and calculated 7DMALF's.**

Site Number	Name	Site	adjusted $r^2$	Equation	Estimated MALF (litres per second)
62106	Clarence	Glenalton	0.87	$y=(7.022*\text{Clarence@Jollies})-4188.4$	19,391*
584	Clinton River	Clinton Bridge	0.79	$y=(0.593*\text{Stanton})+102.333$	110
1654	Deadman Stream	At SH1	0.28	-	0
575	Dubious	At Island (2km upstm of Clar conf.)	0.91	$y=(1.572*\text{Ribble})-7.759$	296
582	George Stream	Boulder Gorge	0.73	$y=(0.124*\text{Ribble})+46.854$	71
583	Mead	At Clarence confluence	0.8	$y=(0.037*\text{Awatere})+95.647$	210
585	Ohau Stream	At Railway Bridge	0.54	$y=(7.323*\text{Rosy})+7.657$	34

\* It should be noted that the Clarence at the Glen Alton site has two different estimates of a 7DMALF. The above figure of 19,391  $\text{l s}^{-1}$ , was estimated using all available flow data and comparing it with the Clarence at the Jollies site. The figure seen below in Table 5.2 was estimated for the sole purposes of calculating a Specific Discharge for only the area below the confluence with the Acheron. Hence, for this calculation data for the Acheron and the Clarence at Jollies was subtracted from the Clarence at Glen Alton data before the analysis.

These estimates and some of those estimated in Part A, were then divided by the catchment area above the gauging site, to express the estimates as a yield, in litres per second per square kilometre. Table 5.2 gives these estimates, which are the basis for the flow contours, produced when mapping.

The numbers in Table 5.2 formed the basis of the 7DMALF isohydral map for the Kaikoura area (Figure 5.1). The contours will be stored in GIS and are produced as a hard copy map here. Specific yield values were plotted in the middle of the catchment area, contours drawn accordingly, integrated and adjusted until the above-generated flows matched those at known points. The 7DMALF values calculated by the map can also be seen in Table 5.2. The values calculated by the map all come within 5% of the original 7DMALF's calculated using regression with primary sites.

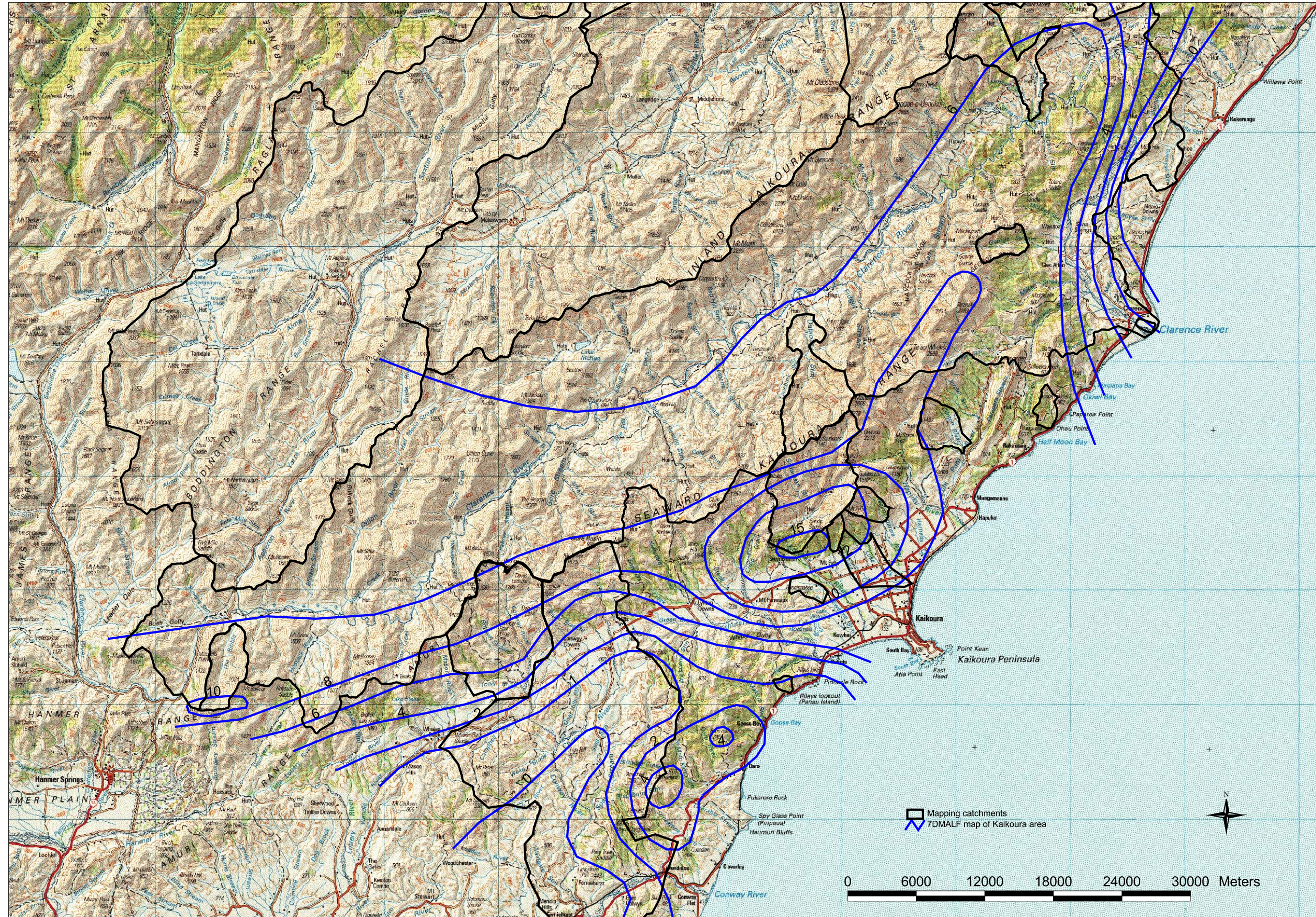


Figure 5.1 7DMALF map for the Kaikoura area

**Table 5.2 Estimates of catchment yields for those catchments used in and calculated from the 7DMALF Isohyd Map (Figure 5.1).**

Site Number	Name	Site	Catchment Area (km <sup>2</sup> )	Estimated MALF (litres per second)	Specific Discharge (l/s/ km <sup>2</sup> )	Calc 7DMALF from map (litres per second)
62106	Clarence	Glenalton	1872	12,204	6.52	12,166*
584	Clinton River	Clinton Bridge	14.14	110	7.77	110.0
64302	Conway River	No.70 SH	79.36	546	6.88	544.0
581	Conway River	No.1 SHB	473.97	1,071	2.26	1,110.0
1654	Deadman Stream	At SH1	18.62	0	0.00	0.0
575	Dubious	At Island (2km upstm of Clar conf.)	42.92	296	6.90	309.0
84	Ewelme Stream	Quarry Road	4.54	53	11.76	50.6
348	Floodgate Creek	D/S Boyd Take	3.24	44	13.60	45.6
582	George Stream	Boulder Gorge	9.74	71	7.27	68.0
576	Kowhai River	Gorge	59.95	690	11.51	663.0
583	Mead	At Clarence confluence	37.47	210	5.59	214.0
63101	Middle Creek	No. 1 SHB	20.58	239	11.61	231.0
585	Ohau Stream	At Railway Bridge	5.09	34	6.60	32.7
63501	Rosymorn	Weir	1.7	4	2.08	3.5
62104	The Ribble	At Airstrip	20.74	193	9.32	191.8
2261	Waimangarara River	200m D/S Rock Weir	7.4	83	11.22	87.0

\* This estimate of MALF for the Clarence at Glenalton only includes the area below the confluence with the Acheron. Data for the Acheron and the Clarence at Jollies was subtracted from the Clarence at Glen Alton data before the analysis.

**Note:**

Not all sites seen in Part A were considered to be suitable for mapping low flows:

- Lyell Creek and including Warren Creek (calculated specific discharge of 41.1 l/s/km<sup>2</sup> for site at DS Warren Confluence) is almost completely groundwater fed so not appropriate for mapping catchment specific yield.
- Streams at the base of Mt Fyffe loose water rapidly to the groundwater system:
  - ⇒ Harnetts Creek at Grange Road (Specific capacity of 3.14 l/s/km<sup>2</sup>) and Luke Creek at Rush Property (Specific capacity of 1 l/s/km<sup>2</sup>) both appear to have been gauged too low in the catchment to give a full representation of the total catchment resource for mapping purposes.

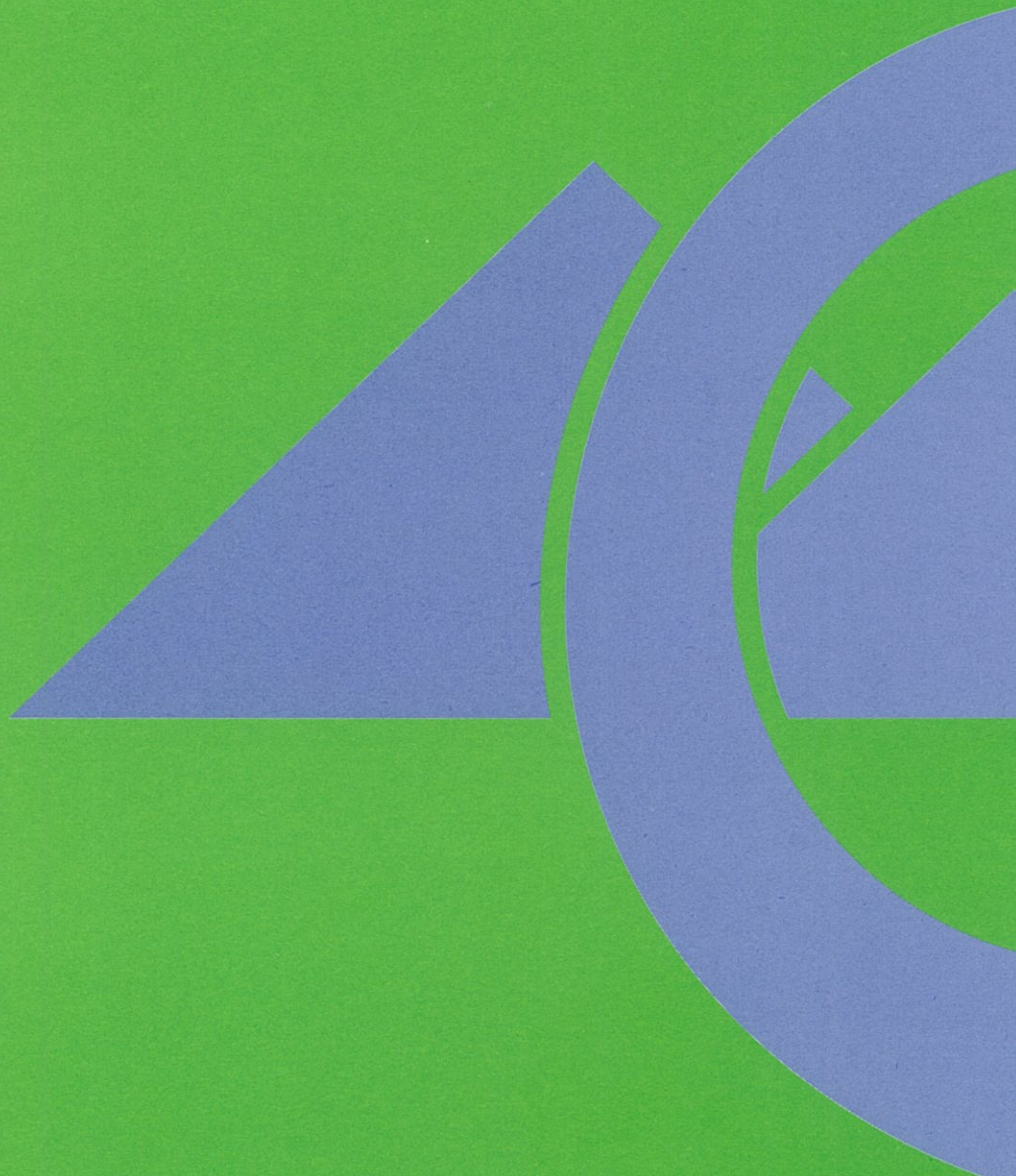
## **6 Conclusions**

Natural seven-day Mean Annual Low Flows have now been estimated for expert panel analysis on selected streams, rivers and creeks that drain the Kaikoura area. These were then combined with several other sites in the extended Kaikoura area and used to create a map of 7DMALF's isohyds.

It is understood that two new flow recorder sites are planned for the Kaikoura area; one for Lyell Creek and one for Luke Creek. Sites for these are currently being discussed, however it is likely that the Lyell Creek site would be the lowest site at Downstream Warren Confluence. The site for Luke Creek is still under investigation but it is suggested that the site be upstream of the location discussed to allow monitoring of the full resource.

## **7 References**

Smith, E. (2002) Data Audit for the Middle Creek at State Highway 1 Bridge, Site no. 63101, 1980-2002. Environment Canterbury Report, U02/48.



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