

# **Ashburton River Low Flow Regime**

**Report No. U01/26**



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Prepared by

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## **Executive Summary**

Water has been drawn from the Ashburton River since the early 1870's. It is now a highly allocated river. This report attempts to establish what the natural flow regime would be without abstractions. Along the way it seeks to determine whether the North Branch of the Ashburton River would go dry under natural conditions. Low flow gauging work carried out to determine low flow requirements in various reaches and tributaries is also reported on.

The key findings of this report include:

1. Ashburton River is a complex system and an understanding of its operation requires knowledge of surface and groundwater flow dynamics. This is further complicated by water abstractions.
2. The natural mean flow at State Highway One is  $30 \text{ m}^3 \text{ s}^{-1}$  some  $13 \text{ m}^3 \text{ s}^{-1}$  greater than the mean flow recorded over the past 5 years
3. Ashburton River is the most highly modified river in New Zealand with 60% of the mean flow allocated for abstraction.
4. The natural 7 day mean annual low flow (7DMALF) is 400% higher than the current low flow experienced today.
5. The North Branch would not go dry under natural conditions, but with high abstractive use it is dry for sustained periods.



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## 1 Introduction

Little is known about the present low flow regime of the Ashburton River (Figure 1.1). The river is highly modified with surface takes and groundwater takes totalling some  $18.2 \text{ m}^3 \text{ s}^{-1}$  (60% of the mean flow of  $30 \text{ m}^3 \text{ s}^{-1}$ ).

There is a need first of all to determine what the natural flow regime would be without any artificial abstraction. This involves assessing total actual abstractions as opposed to that authorised by resource consents. Details of the occurrence of abstraction are also required. The sustained period of no flow in the North Branch of the Ashburton River is a particular issue.

This information is essential for the development of the Water Chapter of the Natural Resources Regional Plan which will specify, amongst other matters, rules regarding minimum flows and flow allocation for the Ashburton River.

The analysis complements earlier work by Scarf (1983) and Young (1992) which dealt with rainfall and river flows respectively. For background on catchment properties and description see Scarf (1983) and Young (1992).

## 2 Analysis and Results

Three studies were undertaken: construction of natural flow time series at various locations; estimation of losses and gains on the South and North Branches and main stem during summer low flow conditions; and the recent history of flow changes in the North Branch.

Data was obtained from recorders located on the North and South Branches, concurrent gaugings down the river reaches and groundwater level recordings (Figure 2.1, Table 2.1).

### 2.1 Natural River Flows

Precise reconstruction of natural river flows is impossible owing to changes to the natural system that have occurred. These include:

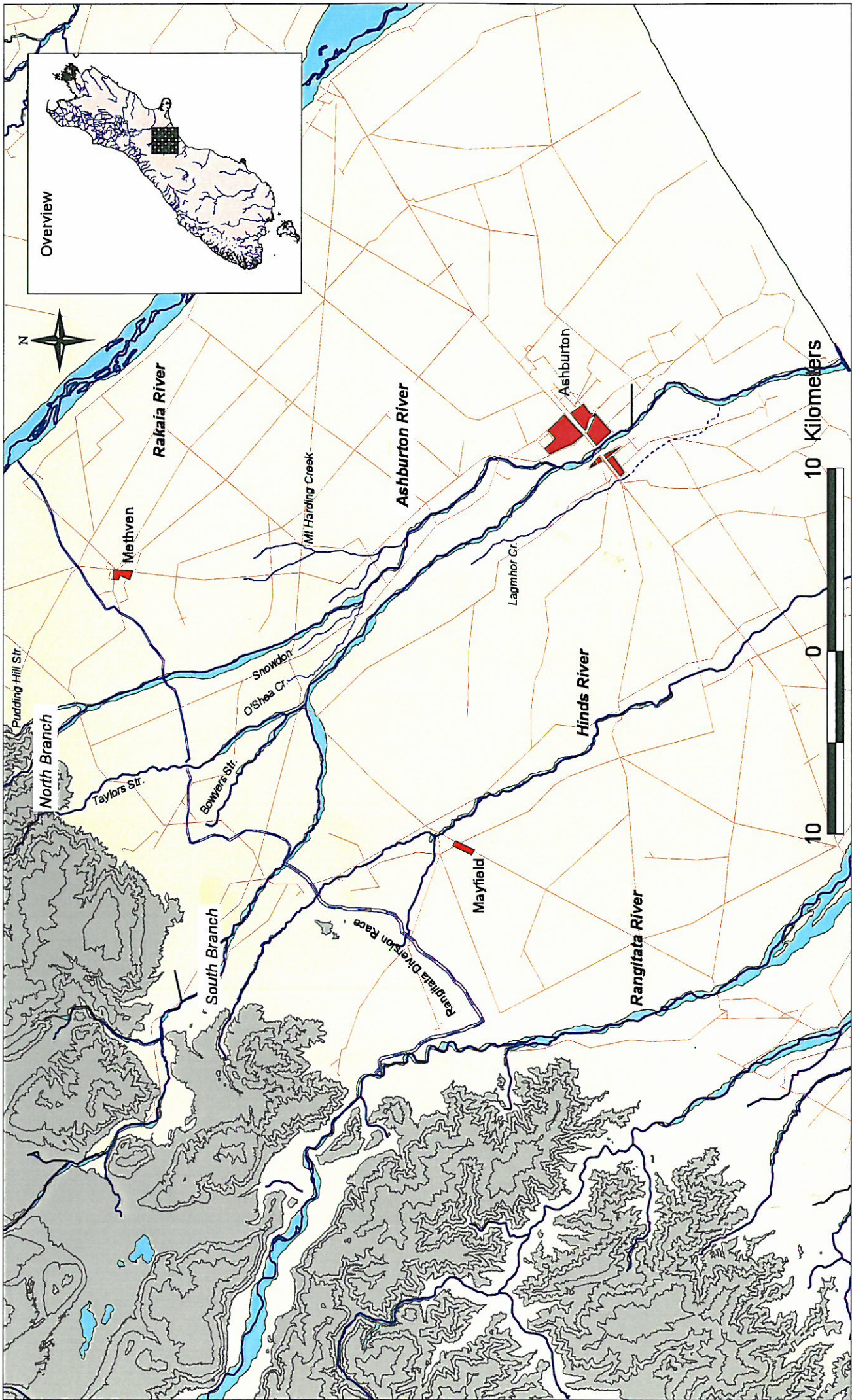
- stockwater takes
- surface irrigation takes (Rangitata Diversion Race (RDR) takes sometimes include power generation)
- groundwater irrigation and domestic takes
- draining of wetlands
- possible recharge to the groundwater system from border dyke irrigation
- lateral bywash from the RDR and Greenstreet Irrigation Scheme back to the river
- willow plantings
- narrowing of river channels for flood protection works
- stockwater re-entering the river

The above all effect the surface water flows as well as the groundwater system that is recharged by, or discharges into, the river (Figure 2.1).

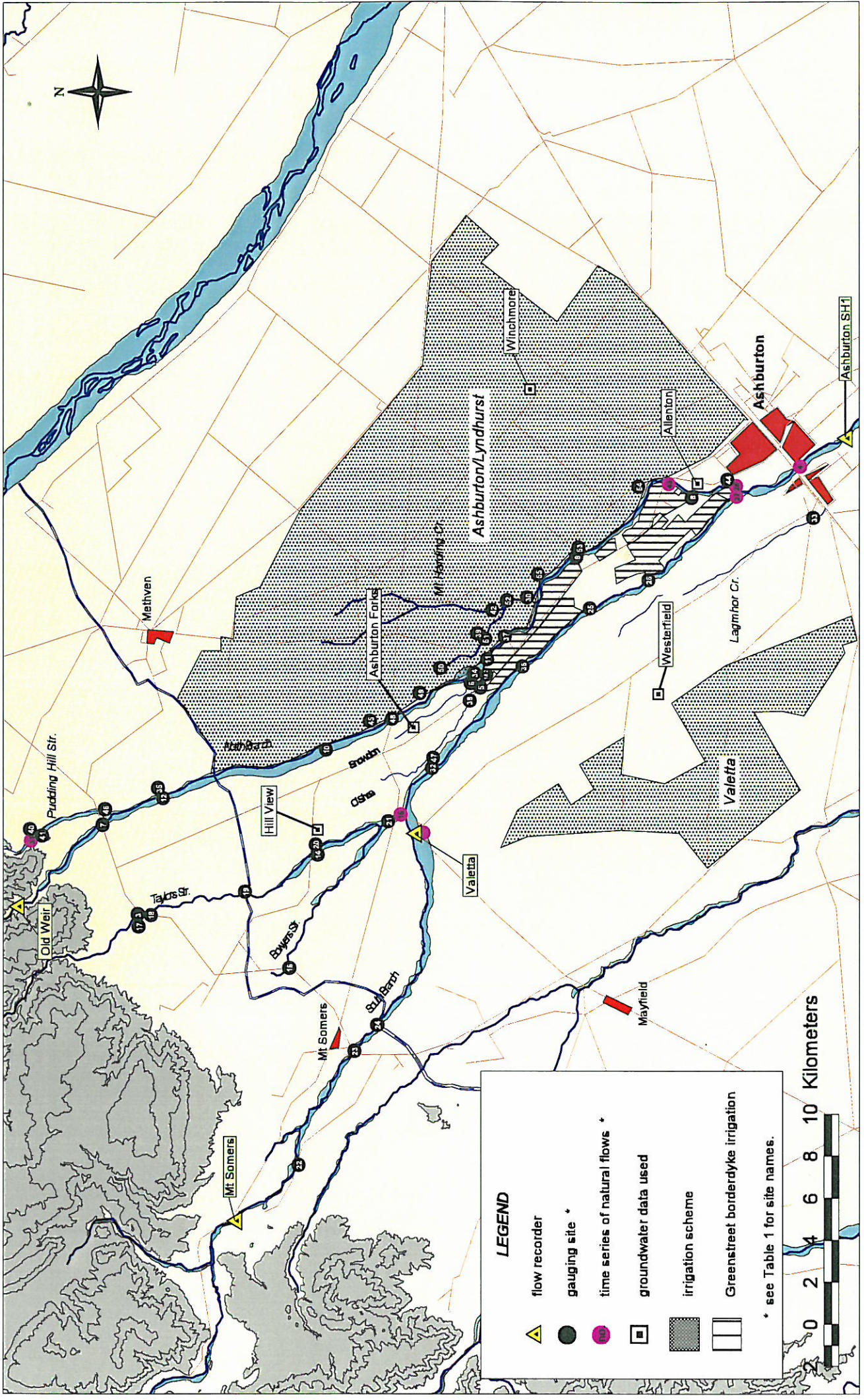
A precise analysis would require:

- waterlevel recorders at all potential minimum flow locations
- monitoring of groundwater levels in all the various groundwater systems
- records of volumes of border dyke irrigation applied spatially and in time over the total area
- all surface water stockwater and irrigation takes monitored on a daily basis
- all groundwater domestic and irrigation takes monitored
- monitoring of irrigation scheme and stockwater bywash back to the river







The cost of these measurements is well beyond the funding capability of Environment Canterbury, so a less rigorous method was employed to estimate natural flows.



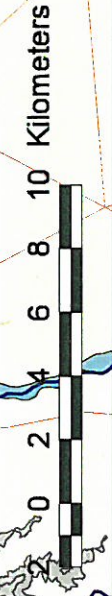
**Figure 1.1: Location Map of Study Area**



**LEGEND**

-  flow recorder
-  gauging site \*
-  time series of natural flows \*
-  groundwater data used
-  irrigation scheme
-  Greenstreet borderdyke irrigation

\* see Table 1 for site names.



**Figure 2.1: Location of Hydrological Sites**

Table 2.1 List of Gauging Sites (refer Figure 2.1)

Gauging Site Reference No.	Gauging Site	Map Reference	Gauging Site Reference No.	Gauging Site	Map Reference
1	Greenstreet Irr Scheme @ Main Race	K36:988140	29	Ashburton River @ Above Lagoon (2km u/s)	L37:138856
2	Main Race @ Staffgauge (m)	K36:988140	30	Mt Harding Creek @ Aitkens Road	K36:026118
3	Taylor's Stream @ No. 72 SH	K36:873307	31	Pudding Hill Stream @ Above ADC Race	K36:908358
4	Ashburton River @ No.1 SHB	K37:087990	32	Greenstreet Irr Scheme @ Below Sth Ashburton Intake	K36:944165
5	Osheas Creek @ Above Greenstreet Pond	K36:983143	33	Lagmor Creek @ Frasers Road	K37:062982
6	Snowdons Creek @ Above Greenstreet Pond	K36:984143	34	Osheas Creek @ Bywash to Nth Ashburton	K36:985143
7	Nth Ashburton @ SH72	K36:915325	35	Methven Auxiliary @ Nth Ashburton	K36:932296
8	Spring Stream @ Fawles Crossing Rd	K37:073040	36	Sth Ashburton River @ Shearers Road	K36:991122
9	Nth Ashburton @ Ollivers Road	K37:045097	37	Nth Ashburton @ Shearers Road	K36:005130
10	Nth Ashburton @ Flemings Road	K36:951217	38	Osheas Creek @ Ashburton/Slaveley Road	K36:976148
11	Nth Ashburton @ Above Osheas Confl	K36:994140	39	Winchmore Main Race Take @ Mt Harding Creek	K36:009143
12	North Ashburton @ Below Methven Auxiliary	K36:930298	40	ADC W/Race @ Pudding Hill Stream	K36:908359
13	Ashburton @ Smalls Rd	L37:123890	41	Pudding Hill Stream @ Below ADC Race	K36:908358
14	Taylor's Stream @ Roxburgh Bridge	K36:902222	42	Mt Harding Creek @ Rakaia Gorge Rd	K36:016136
15	Taylor's Stream @ Above Sth Ashburton Confluence	K36:920179	43	Nth Ashburton @ Digbys Bridge	K37:079051
16	Bowyers Stream @ No. 72 SH	K36:847236	44	RDR Coniston Race @ Nth Ashburton	K37:077022
17	ADC @ Durrans Tce Stock W/Race	K36:873307	45	RDR Waste Race @ Lateral 1A	K36:966194
18	ADC @ Bushside Stock W/Race	K36:873301	46	Pudding Hill Stream @ Nth Ashburton Confluence	K36:920321
19	ADC @ Goughs Crossing Stock W/Race	K36:883257	47	Greenstreet Irr Scheme @ Below Shutoff Gate	K36:947165
20	Alford Station @ Irrigation Intake	K36:904222	48	North Ashburton @ Thompsons Track	K36:965185
21	Frank MacAtamney @ Irrigation Intake	K36:917189	49	RDR Waste Race @ Lateral 1B	K36:978172
22	Lincoln W/Race @ Intake	K36:754232	50	RDR Waste Race @ Lateral 2	K36:992162
23	Sth Ashburton River @ No.72 SH	K36:807203	51	RDR Waste Race @ Lateral 3	K36:005141
24	RDR Intake @ Sth Ashburton Siphon	K36:820193	52	RDR Waste Race @ Lateral 5	K36:022130
25	Sth Ashburton River @ Ollivers Road	K37:019090	53	RDR Waste Race @ Lateral 8	K37:046095
26	Sth Ashburton River @ Blacks Road	K37:033063	54	RDR Waste Race @ Lateral 9	K37:077066
27	Sth Ashburton River @ Above Confluence	K37:074017	55	RDR Waste Race @ Lateral 7	K36:035116
28	Nth Ashburton River @ Above Confluence	K37:076020			

Flow Recorder Site (also gauging site)	Map Reference
North Ashburton River @ Old Weir	K36:876366
South Ashburton River @ Mt Somers	K36:726261
South Ashburton River @ Valetta Bridge	K36:915174
Ashburton River @ No.1 SHB (Recorder)	K37:099967

Groundwater data used	Map Reference
Winchmore	K36:959173
Ashburton Forks	K36:913221
Hill View	K37:978057
Westerfield	
Allenton	

\*The method involved measuring concurrent river flows at various locations for a range of summer flows, coupled with spot measurements of stockwater takes and major irrigation takes. A data set of surface water and groundwater consented takes between the selected river locations was compiled.

Two assumptions were made about how to treat irrigation takes. Firstly it was assumed that the irrigation season ran from 1 September to 30 April and that outside those dates no irrigation water was abstracted. Secondly that during the irrigation season 55% of the takes were being exercised. These assumptions cut out the enormous task of measuring all takes, but add uncertainty to the analysis. The 55% factor was applied to 20% of the takes by volume, as 80 % of the consented take were actually measured by spot gaugings. There is some basis for selecting 55% as follows. Sanders (1998) looked at the 1997/98 summer for Ashburton District (between the Rakaia and Rangitata Rivers) and compared the estimated groundwater pumpage for irrigation to the consented allocation, for a 120 day or half irrigation season. Results showed that on a regional scale the estimated total abstraction for the whole season was equal to 55% of the volume that would be pumped in 120 days if all the consented takes were using their maximum allocation.

Daily time series of natural flows were derived using linear regression from primary flow recorder stations and in some cases multiple linear regression using groundwater levels.

During measurement of concurrent gaugings automatic groundwater recorders were installed at four locations (Hillview, Ashburton Forks, Westerfield and Allenton Nurseries). However only data from Hillview was used (Figure 2.1).

For the construction of natural flows using groundwater levels, historic monthly groundwater readings were used and interpolated for each day. This procedure also contributes errors to the analysis. Figure 2.2 displays a sensitivity plot of Hillview monthly readings interpolated as daily values with the actual recorded

values plotted in bold. This example shows that the interpolated values are very similar to the recorded but it may be coincidental, with monthly readings occurring just before major changes in waterlevel.

Stream depletion affects of groundwater abstraction takes, as assessed by Pattle Delamore (1997), were used in the analysis.

### **2.1.1 Natural flow record for the South Branch at Valetta.**

The equation used to estimate natural flow at Valetta flow was:

$$\text{Natural flow at Valetta} = \text{Gauged flow at Valetta} + \text{Abstractions} \quad (1)$$

Equation 1 applies to gauging runs undertaken on particular days when the flow was steady.

Essential to these calculations is the measured RDR abstraction from the South Ashburton. This was gauged on all concurrent gauging runs. The Ashburton District Council (ADC) Lincoln stockwater race was not gauged during all runs. Rather an average of previous gaugings ( $1243 \text{ l s}^{-1}$ ) was adopted. Other takes amounted to  $133 \text{ l s}^{-1}$  during the non-irrigation season and  $257 \text{ l s}^{-1}$  during the irrigation season.

The 55% of consented take assumption was adopted if the Ashburton River was under restriction or not (during the investigation runs, the river was never in full restriction). It is unknown if farmers adhere to restrictions associated with the stepped minimum flows. It is assumed that the 55% of take rule of thumb goes some way to account for this uncertainty. However, the Ashburton flow can be manipulated by RDR to maintain flows just above a restriction level thus benefiting RDR and allowing other irrigators the opportunity to continue.

Once a data set of natural flows for Valetta was compiled these were regressed with the flows measured at the

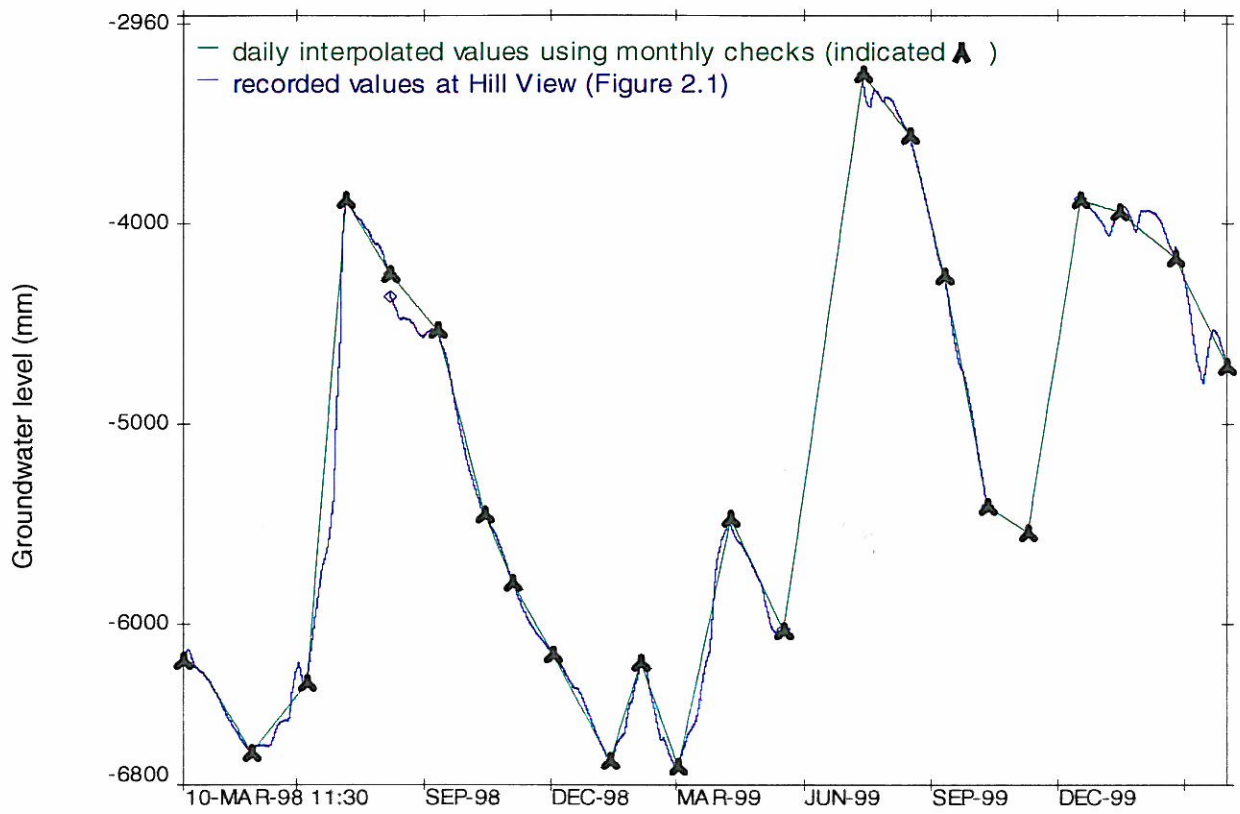


Figure 2.2: Monthly groundwater levels interpolated to daily values, compared to recorded levels.

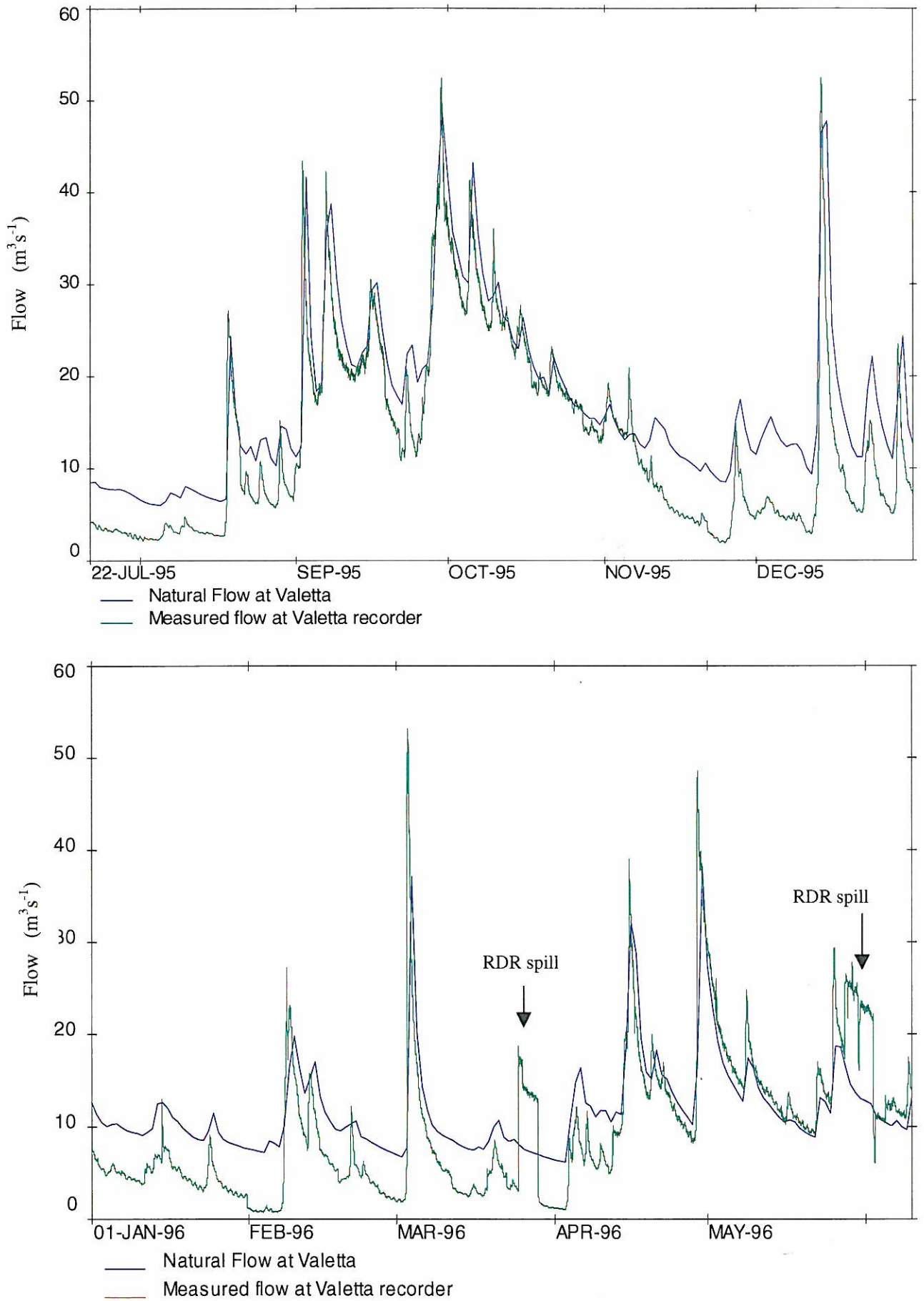


Figure 2.3 Constructed natural flows (daily means) for the South Ashburton at Valetta compared to recorded flows.

Mt Somers recorder for the same day. There are some inflows from tributaries such as Woolshed Creek and losses to groundwater in the reach between the RDR intake and the Valetta Bridge. These are explained by the linear regression equation :

$$\text{Natural flow at Valetta (l s}^{-1}\text{)} = 0.946 \times \text{Recorded Flow at Mt Somers (l s}^{-1}\text{)} - 133 \quad (2)$$

The number of values in the data set was 12, and the coefficient of determination ( $r^2$ ) was 0.94 with a standard error of  $\pm 427 \text{ l s}^{-1}$ .

Tests of the synthetic natural flow compared to a recorder at Valetta are shown in Figure 2.3 for the period 1-8-1995 to 1-8-1996. The period of reduced flow of the recorded compared to the natural are due to RDR and Lincoln takes. Otherwise in winter the natural record matches closely to that actually recorded. Unusual rises occur in the record owing to RDR releases into the South Ashburton on 3 occasions when the recorded flow well exceeded the natural flow record (John Young, pers comm).

### 2.1.2 Natural flow record for Taylors Stream at the South Ashburton confluence

The equation used to estimate natural flow in Taylors Stream was:

$$\text{Natural flow of Taylors Stream at South Ashburton confluence} = \text{Gauged flow at Taylors Stream at South Ashburton confluence} + \text{Abstractions} \quad (3)$$

The procedure as described above was used to derive a data set of natural flows for Taylors Stream. The majority of takes were measured during the concurrent gauging runs. These included the three ADC stockwater takes (Durrans, Bushside, and Goughs) and the large irrigation takes of Allen and Cocks. In fact takes not gauged only totalled  $20 \text{ l s}^{-1}$ . Therefore the 55% assumption was not exercised over a large flow. It was discovered after the gaugings were complete that Mr Cocks had a bywash race back to the South Ashburton

downstream of the gauging location. Mr Cocks assured the writer that it was never used during recent summers when the data set was compiled.

The total measured takes were added to the residual flow measured at the confluence with the South Ashburton to produce a natural flow record (assuming there would be minimal losses to groundwater, see section 2.2). The resulting dataset was correlated with primary recorder sites.

However the regressions showed Bowyers and Taylors Stream flows correlated better with North Branch flows and a groundwater well nearby at Hillview. It is clear that Taylors and Bowyers behave similarly to the North Branch owing to their aspect and correlate less with the South Branch because of a higher predominance of NW rainfall in the South Branch headwaters.

The linear regression equation is:

$$\text{Natural flow of Taylors at South Ashburton confluence (l s}^{-1}\text{)} = 0.272 \times \text{North Branch recorded flow (l s}^{-1}\text{)} + 0.708 \times \text{Hillview level (mm)} + 4063 \quad (4)$$

The number of values in the data set was 17, and the coefficient of determination ( $r^2$ ) was 0.84 with a standard error of  $\pm 508 \text{ l s}^{-1}$ .

The poor correlation may owe to differing geology, volcanic bedrock of a portion of the Bowyers and Taylors catchments as opposed to the mainly greywacke North Branch.

The regression analysis provides a daily time series at this location, and is not valid when flows are high. As future analysis will concentrate on flows at or below the mean flow, the calibration range of the above regression, another relationship was developed for high flows. This relied on the estimates of mean annual flood provided by Pearson (1996). These estimates are, for Taylors and Bowyers at the South Ashburton confluence,  $130 \text{ m}^3 \text{ s}^{-1}$  and for North Ashburton at Old Weir,  $206 \text{ m}^3 \text{ s}^{-1}$ . A straight line

relationship was assumed between the mean flow for both sites and the mean annual flood.

The equation used to estimate Taylors stream flow when above mean flow is :

$$\text{Natural flow of Taylors at South Ashburton confluence ( l s}^{-1}\text{) = 0.643 x North Branch recorded flow ( l s}^{-1}\text{) - 2487} \quad (5)$$

### 2.1.3 Natural flow record for the South Ashburton at North Branch confluence

The methodology for deriving a natural flow data set for the South Branch is different from the analysis for Valleta and Taylors. When the concurrent gaugings were done the flows at Valleta and Taylors were heavily modified. Thus the losses or gains down the south branch monitored for those actual flows did not represent an elevated flow when the takes above Valleta or Taylors are included. Accordingly the actual measured flows at Taylors and Valetta were used as the starting flows.

The resulting (semi) natural flow dataset consisted of gauged flows at the confluence with the North Branch with the takes (Valleta /Taylors confluence to Nth confluence) added, correlated with the total gauged flows of Valleta and Taylors at the top of this reach.

The resulting regression equation is:

$$\text{Natural flow South Ashburton at North branch confluence ( l s}^{-1}\text{) = 1.237 x (Valleta +Taylors) ( l s}^{-1}\text{) + 2570} \quad (6)$$

The number of values in the data set was 10, and the coefficient of determination ( $r^2$ ) was 0.98 with a standard error of  $\pm 504 \text{ l s}^{-1}$ .

To calculate a daily record the combined Valetta and Taylors daily flows were applied to the above equation.

### 2.1.4 Natural flow record for the North Ashburton at South Branch confluence

The methodology for deriving a natural flow data set for the North Branch is different from the analysis for the South Branch.

Essential to the calculations are the measured takes by ADC from Pudding Hill Stream, Methven Auxilary from the main channel and Winchmore Main from Mt Harding Creek. These are all essentially takes from the North Ashburton, and were gauged on all concurrent gauging runs.

The major irrigation take from the ponded water of O'Shea and Snowden Creeks for the Greenstreet Irrigation Scheme was calculated from concurrent gaugings of the take from the South Ashburton, the combined Greenstreet irrigation intake (as South Branch water is added to O'Shea) and residual flow to the North Branch. Other irrigation takes were treated as described previously while other stockwater takes were assumed to be taken at the rate consented. It was discovered that the  $226 \text{ l s}^{-1}$  ADC stockwater take at Rawles Crossing has never having been exercised).

Furthermore, the main bywash channel Lateral 6 from the RDR irrigation scheme was gauged at Coniston. The other various bywash channels from the RDR and Greenstreet irrigation schemes were not measured as irrigation managers gave assurances they were very rarely used, and if flowing the flows would be small. Two concurrent runs in late December 1999 and at the end of February 2000 did include bywash channels as this was a wetter summer than previous ones, and many of the bywash channels were flowing.

To form a data set of natural daily flows at the South branch confluence all takes upstream were added to the residual flow measured, and bywash discharges were subtracted as they are unnatural recharges e.g. Rangitata River water.

**2.1.4.1 Complexities of the North Branch flows: points of discussion.**

- First is the logic of adding all takes back to the residual flow found at the South Branch confluence (losses and gains down the North Branch will be discussed in Section 2.2.

This assumes all abstracted water from the water resource system of the North Branch would reappear at the confluence with the South Branch.

As discussed in section 2.2 the North Ashburton is supporting (especially in summer) two linked water resource systems, a groundwater system and a surface flow in the river channel (winter concurrent gauging showed gains from the groundwater system to the surface flows). Therefore to add all takes to the residual flow is not totally correct as some of this surface flow without abstractions, may actually be lost to the groundwater system. Unfortunately, of the many wells in this vicinity none have been measured consistently. A recorded well installed for this study unfortunately malfunctioned at critical periods.

The inability to model these responses does detract from the accuracy of producing a natural flow record for this location. A crude analysis given in Section 2.3.7 endeavours to explain the groundwater /surface water loss/ gain relationship, but it is not conclusive enough to produce a usable model.

- Second is the problem of adding back the Pudding Hill ADC take. It could be considered that as the lower reaches of Pudding Hill are dry for much of the summer, it would not contribute to the North Ashburton flow. This statement is actually incorrect, because if there is no surface flow one cannot assume there is no subsurface flow and no contribution to the water resource.

Furthermore there are losses to the south (towards the South Branch) below the RDR syphon. Some of these losses may return as surface

flows in Snowden and O'Shea Creeks.

In addition it is considered there are losses to groundwater to the east of the North Branch below Thompsons Track (see CRC, R92 (36), p 112). Thus the North Branch is maintaining a groundwater resource to the south and east as well as endeavouring to maintain a surface flow in the river. So any surface or subsurface flow that would contribute to the lower reaches groundwater or surface water system is in fact part of the North Branch water resource. A take from Pudding Hill stream does have an influence on the residual flow at the confluence.

- Third, the natural inputs such as O'Shea or Mt Harding Creek did not need to be added to the system as their inputs naturally occur within the system. This is consistent with the logic for Woolshed Creek on the South Branch. If their inflows were required as an input to the model, then daily flows are necessary. These are unavailable so no precision is lost.
- Fourth, it is believed that any localised raised groundwater level caused by the border dyke irrigation schemes would tend to flow away from the river during the summer and so not enhance the river flows.
- Fifth, the natural flow at the confluence of the North and South Branches was never actually measured. The relationships for the regression model were always biased towards low flows. The resulting model output is therefore not reliable for higher flows. Thus flows above mean will be less reliable. (Fortunately this analysis is more concerned with lower flows).
- Sixth, with the incomplete measurements of groundwater which would affect flows at the confluence, there is a high possibility the regression model will be coarse.

**2.1.4.2 Formation of natural daily flows**

Once a data set of natural flows for the North Branch at the confluence was compiled they were regressed with the flows measured at the Old Weir recorder for the same day.

The linear regression equation was:

$\text{Natural flow North Ashburton at South branch confluence (l s}^{-1}\text{)} = 0.517 \times \text{Old Weir (l s}^{-1}\text{)} + 2084 \quad (7)$
--

The number of values in the data set was 17, and the coefficient of determination ( $r^2$ ) was .74 with a standard error of  $\pm 431 \text{ l s}^{-1}$ .

This is a crude relationship given an  $r^2$  of .74.

As the intention of the regression analysis is to provide a daily time series at this location, this relationship is not valid when flows are high. Although the analysis for Plan development will concentrate on flows at or below the mean flow, which is in the calibration range of the above regression, another relationship was developed for high flows. This relied on estimates of the mean annual flood provided by Pearson (1996) for North Branch at the South Ashburton confluence of  $235 \text{ m}^3 \text{ s}^{-1}$  and for North Ashburton at Old Weir,  $206 \text{ m}^3 \text{ s}^{-1}$ . A straight line relationship was assumed between the mean flow for both sites and the mean annual flood.

The equation used to estimate North Branch flow when above mean flow is :

$\text{Natural flow of North Branch at South Ashburton confluence (l s}^{-1}\text{)} = 1.164 \times \text{North Branch recorded flow (l s}^{-1}\text{)} - 4845 \quad (8)$
---

**2.1.5 Natural flow record for the Ashburton at State Highway One**

The methodology for deriving a natural flow data set for the Ashburton at SH1 is similar to the South Branch at the confluence. When the concurrent gaugings were done the flows at South

and North Branch confluences were heavily modified. Therefore the losses or gains down the South and North Branches monitored for those actual flows did not represent an elevated flow when the takes above the South and North confluences were included. Accordingly the actual measured flows at the South Branch confluence and North Branch confluence were used as the starting flows.

The resulting (semi) natural flow dataset consisted of gauged flows at the SH1 with the takes (South /North confluence to SH1) added, correlated with the actual gauged flows of South Branch at the confluence and North Branch at the confluence.

The resulting linear regression equation is:

$\text{Natural flow Ashburton at SH1 (l s}^{-1}\text{)} = 1.049 \times (\text{South at Conf} + \text{North at Conf}) (\text{l s}^{-1}\text{)} + 82 \quad (9)$
---

The number of values in the data set was 13, and the coefficient of determination ( $r^2$ ) was 0.99 with a standard error of  $\pm 459 \text{ l s}^{-1}$ .

To calculate a daily record the combined South Branch at confluence and North Branch at confluence daily flows were applied to the above equation.

**2.1.6 Natural flow record for the North Ashburton at Digbys Bridge**

As the flow at Digbys Bridge appears to be the most modified of any reach on the Ashburton an analysis was included that derives a natural time series record for this location.

The methodology for deriving a natural flow data set for the Digbys Bridge is different from other analysis. When the concurrent gaugings were done the flows on the North Branch at Digbys Bridge and South Branch confluence were heavily modified. Therefore the river system characteristics of losses or gains down the North Branch monitored for those actual flows did not represent an elevated flow when the takes above Digbys bridge were

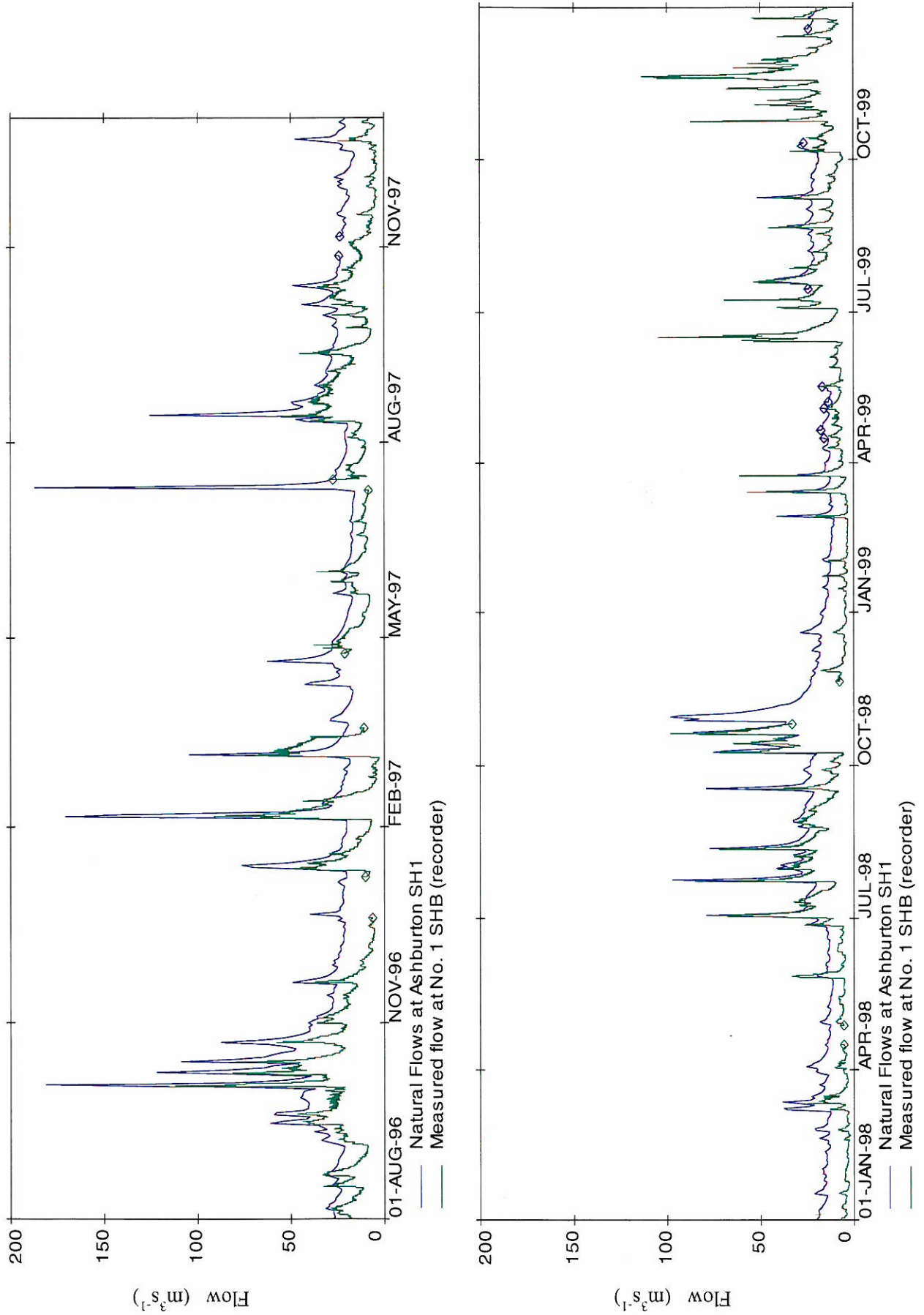


Figure 2.4: Constructed natural flow (daily means) for the Ashburton River at State Highway One, compared to recorded flows.

included. Thus the actual measured flows at Digbys Bridge and South Branch confluence were used as the starting flows.

173 l s<sup>-1</sup>.

This analysis was dependent on the record constructed for the North Branch at South Branch confluence described in 2.1.4.

### 2.1.8 Results

All regressions are listed in Table 2.2. Statistics of natural flow time series appear in Table 2.3.

The resulting linear regression equation is:

$$\text{Natural flow at Digbys Bridge (l s}^{-1}\text{)} = 0.982 \times \text{Natural flow at South Branch confluence (l s}^{-1}\text{)} - 441 \quad (10)$$

The number of values in the data set was 9, and the coefficient of determination ( $r^2$ ) was 0.99 with a standard error of  $\pm 151$  l s<sup>-1</sup>.

## 2.2 Losses and gains during summer low flow conditions

Losses from the North Branch to the surrounding groundwater systems and gains to the South Branch are important for the understanding of Ashburton River water resources.

### 2.1.7 Natural flow record for Pudding Hill Stream above ADC intake

This applies to gauging runs undertaken on particular days when the flow was steady.

Summer 1999/2000 losses and gains were calculated by comparing two runs of concurrent gaugings down the main Ashburton River and the major tributaries - Taylors Stream, South Branch, and North Branch. Consideration of takes was also included in the analysis.

The resulting linear regression equation is:

$$\text{Natural flow at above ADC intake (l s}^{-1}\text{)} = 0.330 \times \text{Selwyn at Whitecliffs Daily Mean Flow (l s}^{-1}\text{)} + 174 \quad (11)$$

The number of values in the data set was 53, and the coefficient of determination ( $r^2$ ) was 0.75 with a standard error of  $\pm$

Many other runs of concurrent gaugings have been completed historically. However there is uncertainty as to the measurement of bywash flows. The above two runs include bywash measurements. Historical runs on Taylors, Bowyers and the South Branch above Valetta were included in the analysis as bywash was not an issue.

**Table 2.2 Regression**

Regression equations	Adjusted $r^2$	Standard Error l s <sup>-1</sup>	Number of values
South Ashburton at Valetta = (Mt Somers x 0.946) - 133	.94	427	12
Taylors = (Old Weir x 0.272) + (Hillview x 0.708) + 4063	.84	508	17
South Branch at Nth Confl = (Valetta + Taylors) x 1.237 + 2570	.98	504	10
North Branch at Sth Confl = (Old Weir x 0.517) + 2084	.74	431	17
SH1 = (Sth Branch at Confl + Nth Branch at Confl) x 1.049 + 82	.99	459	13
Digby's Bridge = (Nth Branch at Confl x 0.982) - 441	.99	151	9
Pudding Hill = (Selwyn at Whitecliffs x 0.33) + 174	.75	172	53

Table 2.3 Flow statistics for recorded and natural time series data

Flow sites	Recorded period	Natural period	Mean flow	Median flow	7DMALF	Monthly Mean Flows											
						January	February	March	April	May	June	July	August	September	October	November	December
South Ashburton at Mt Somers	28/4/1967 - 1/1/2000	28/4/1967 - 1/1/2000	11.16	9.09	4.65	9.95	8.36	8.68	8.83	8.19	9.38	9.58	12.07	14.32	16.6	14.78	12.25
South Ashburton at Valetta	21/7/1995 - 1/1/2000	7/5/1982 - 1/1/2000	7.48	4.6	0.89	4.04	6.34	5.74	6.55	7.4	7.03	11.27	9.96	10.89	15.88	5.18	4.87
Taylor's Stream at South Ashburton confluence		7/5/1982 - 1/1/2000	10.52	8.59	4.48	9.44	8.09	9.17	7.84	7.59	8.48	8.94	12.33	12.61	16.85	12.73	11.91
		7/5/1982 - 1/1/2000	4.05	2.9	1.05	2.29	2.43	3.42	2.49	2.55	3.23	3.55	5.32	4.89	8.36	5.82	4.23
South Ashburton at Nth confluence		7/5/1982 - 1/1/2000	20.59	16.76	9.72	17.08	15.57	18.15	15.35	15.13	17.06	18.02	24.39	24.22	33.72	25.51	22.53
North Branch at Old Weir	6/5/1982 - 1/1/2000	6/5/1982 - 1/1/2000	8.86	6.54	3.02	6.02	5.88	7.14	5.72	6.5	7.64	7.76	9.82	10.79	15.82	12.41	9.66
North Ashburton at Sth confluence		7/5/1982 - 1/1/2000	7.98	5.57	3.69	5.3	5.83	7.47	5.49	5.65	6.75	6.86	9.6	8.91	14.92	10.86	8.25
North Branch at Digbys Bge		7/5/1982 - 1/1/2000	7.39	5.03	3.18	4.76	5.28	6.89	4.88	5.1	6.18	6.3	7.9	8.31	14.21	10.22	7.66
Ashburton at SH1	21/6/1996 - 1/1/2000	7/5/1982 - 1/1/2000	16.7	12.41	3.88	9.65	9.89	8.21	7.34	10.55	13.48	24.47	21.82	17.87	27.61	22.41	10.7
		7/5/1982 - 1/1/2000	30.05	23.48	14.23	23.55	22.53	26.96	21.53	21.87	25.06	26.18	32.94	34.83	51.11	38.24	32.37
O'Shea and Snowdon			1.19														
MI Harding Stream			> 1,000 est														
Lagmhor Creek			0.2 est														
Pudding Hill above ADC intake		27/5/1964 - 1/1/2000	1.27	0.88	0.44	0.78	0.82	1.05	1.11	1.11	1.33	1.63	1.77	1.75	1.63	1.19	1

All flows in cumecs m3 s-1

Numbers in bold are natural flows

Numbers unbolded are recorded flows

7 day mean annual low flow (7DMALF)

Natural period 7/5/1982 - 1/1/2000 is the constructed natural time series

Table 2.4 Comparison of flow statistics with previous analyses

River / Stream	Location	flow statistic	Scarff 1983	Scarff 1999	Young 1992	This report
Taylors	near confluence with the South Branch	mean	5.2	2.9	5.35	4.05
		median		2.1	3.4	2.9
		7DMALF	1.4	1	0.4	1.05
South Branch	above confluence with the North Branch	mean			15.9	20.59
		median			13.1	16.76
		7DMALF			6.3	8.98
South Branch	Valetta bridge	mean	12.8	12.6	10.1	10.52
		median		9.4	7.6	8.59
		7DMALF	5.6	4.7	3.6	4.48
North Branch	above confluence with the South Branch	mean		9.9	6.8	7.98
		median		7.2	5	5.57
		7DMALF		3.2	1.8	3.69
Pudding Hill	above Ashburton District Council abstraction	mean			1.87	1.27
		median			1.23	0.88
		7DMALF			0.46	0.44
Mt Harding Creek		mean		1		> 1.0
Osheas		mean		1		1.19
Ashburton	State Highway One	mean	27.6	29		30.05
		median		21		23.48
		7DMALF	10.8	10		14.23

7DMALF is 7 day mean annual low flow

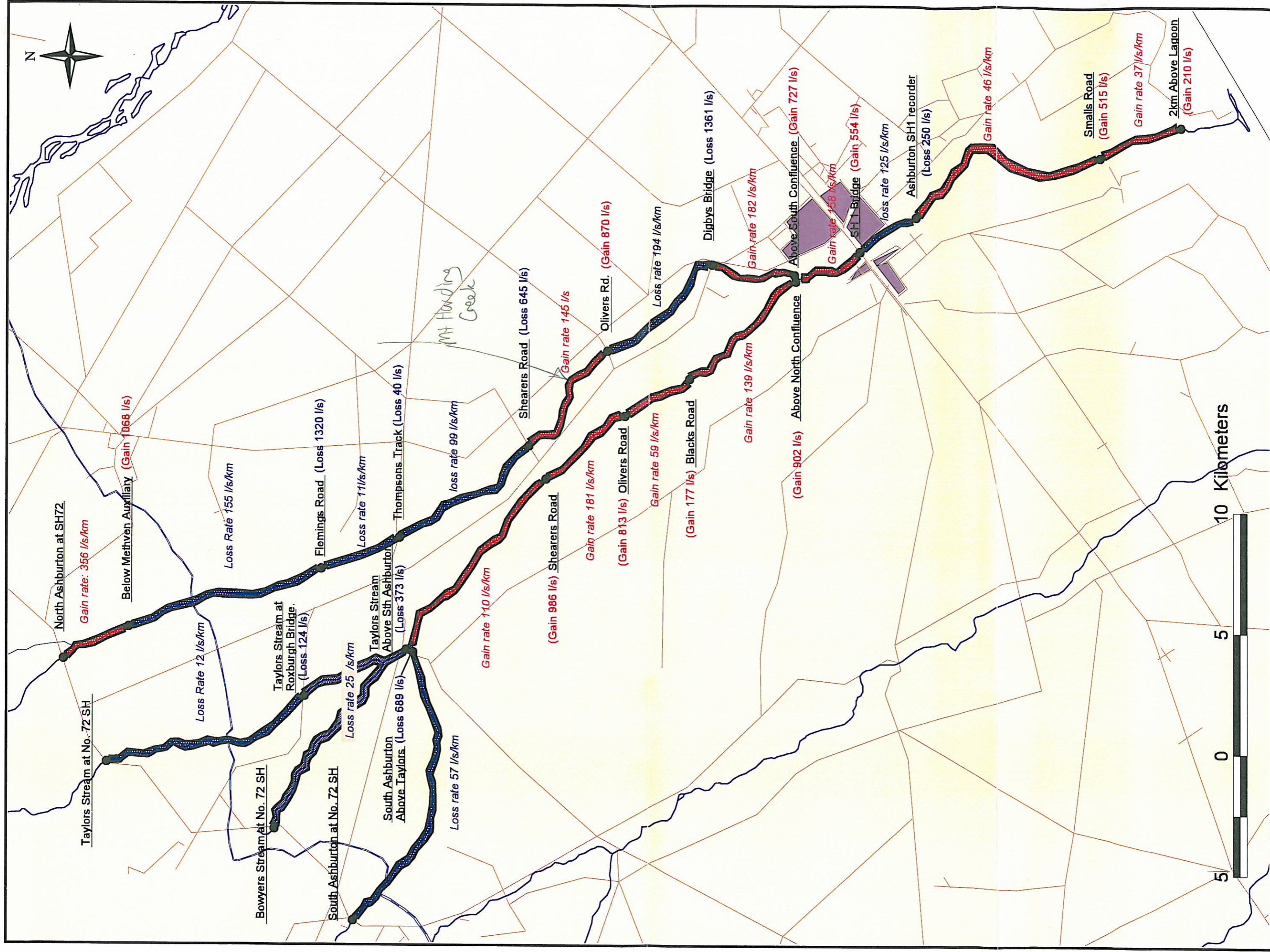


Figure 2.5: Flow Losses and Gains in the Main Tributaries

The results are described using units of loss or gain rate to the river channel, per kilometre of reach ( $l\ s^{-1}\ km^{-1}$ ). (Figure 2.5)

### **2.2.1 South Branch**

The general trend for the tributaries was a gradual loss from Taylors, Bowyers and the South Branch to their confluence, totalling  $1.2\ m^3\ s^{-1}$ . There was a general gain from these confluences down to the confluence with the North Branch, with a total gain over the reach of  $2.9\ m^3\ s^{-1}$ .

Some of the gains could be attributed to upstream losses from the South Branch, Bowyers and Taylors (above their confluences) re-entering the lower reaches. Some gains may derive from Greenstreet Irrigation Scheme seepage. However the majority of gains come from groundwater identified in a spring zone by Aitchison-Earl (2000). Further gains are attributed to losses from the North Branch as described below.

### **2.2.2 North Branch**

The North Branch gains as it emerges from the gorge. The source is mostly subsurface flows from Pudding Hill stream. From the Methven Auxillary downstream to Fleming Road there is a significant loss of  $1.3\ m^3\ s^{-1}$ . This loss becomes underflow into an old river channel heading towards the South Branch and the headwaters of O'Shea and Snowden Creeks.

From Fleming Road to Thompsons Track the losses are insignificant; this is a region of spring flow activity (Aitchison-Earl 2000). From Thompsons Track to Shearer's Crossing (below the O'Shea and Snowden inflow) there remains a loss, but from Shearers Crossing to Ollivers Road there is a gain, mainly from Mt Harding stream inflows. Also, from Ollivers to Digbys Bridge there are major losses from the channel.

The total North Branch losses between the Gorge and the confluence with the South Branch are estimated to be  $0.7\ m^3\ s^{-1}$ . One must remember that the survey was carried out in summer when the flows were relatively low. Furthermore, there may be losses where gains were calculated, e.g., the gain between

Shearers and Ollivers created by one inflow (Mt Harding Creek). There will be bed losses occurring as well, but because there was an overall increase, the reach is represented by a gain. Moreover, the slight gain from Digbys Bridge to the South Branch confluence could be sourced from upstream losses re-entering the stream.

The  $0.7\ m^3\ s^{-1}$  loss monitored above recharges the groundwater system to the east of the North Branch and contributes to gains in the South Branch.

Flow measurements to ascertain the dataset for natural flows in the North Branch at South Branch confluence are displayed in Figure 2.6, compared to the losses or gains over the North Branch full reach. This scatter displays natural conditions with abstractions added back to the river (refer to section 2.1.4.1). The crude relationship implies that with increased flows at the Old Weir, losses at the South Branch confluence are high. In contrast when low flows occur at the Old Weir, losses are small or gains may result.

From Table 2.3 a crude estimate of losses to this system at mean flow can be estimated by adding the mean flows of contributing tributaries to the North Branch and subtracting the mean flow at the confluence with the South Branch. Assuming upstream losses continue at the same rates (identified in summer 1999/2000) the losses to the east (below Ollivers Road) are estimated to be in the order of  $2\ m^3\ s^{-1}$ . The highly modified flows experienced today suggest this groundwater resource would not receive these inflows continuously (1999/2000 summer supplied only  $1.3\ m^3\ s^{-1}$ ). This may explain the long periods of no surface flows experienced in the lower reaches of the North Branch.

### **2.2.3 Ashburton Main Stem**

From the confluences of the North and South Branches to the mouth there is a gradual gain to the main stem, estimated to be  $1\ m^3\ s^{-1}$ .

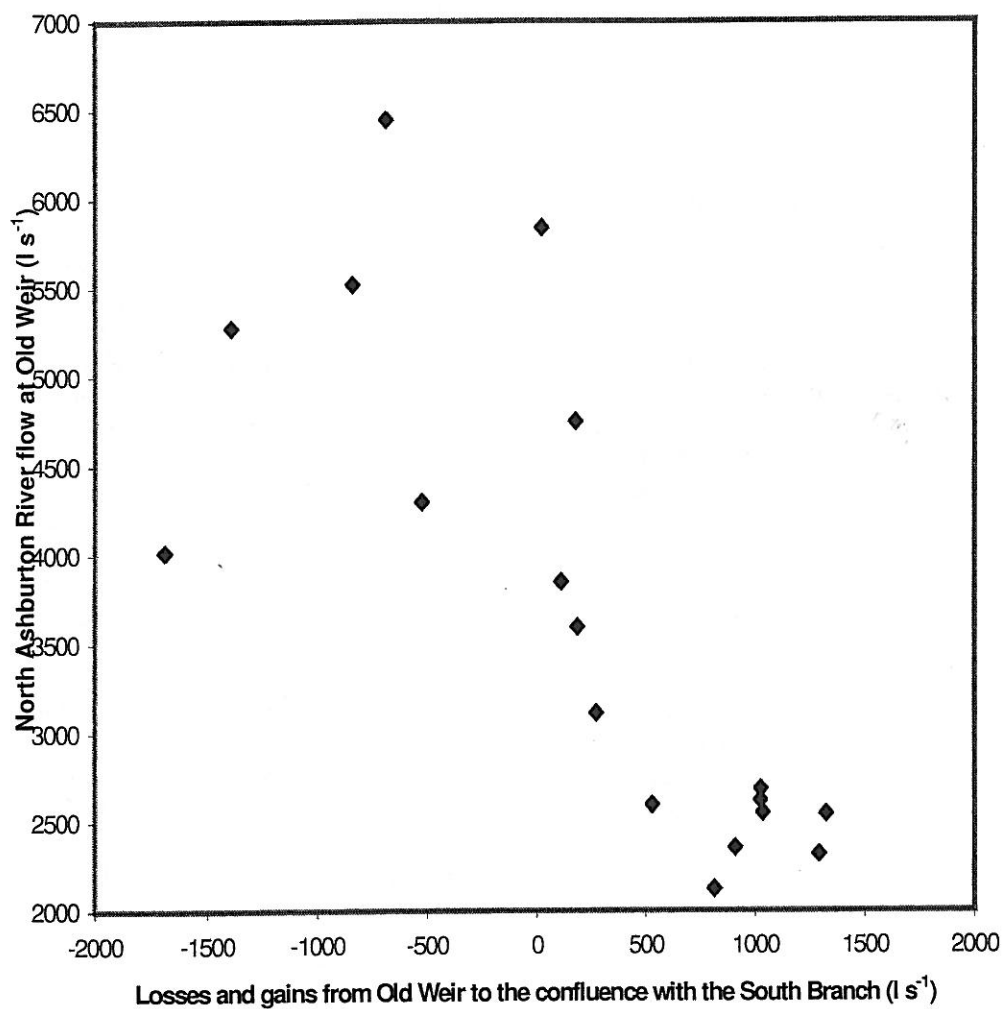


Figure 2.6 North Ashburton River losses and gains over the full reach compared to flows measured at Old Weir

## 2.2.4 Net losses and gains

Overall during the summer low flows of 1999/2000 the South Branch and its tributaries from SH 72 to the confluence with the North Branch displayed a gain of approximately  $1.7 \text{ m}^3 \text{ s}^{-1}$ . The North Branch had a net loss of  $0.7 \text{ m}^3 \text{ s}^{-1}$ , while at the Lagoon the Ashburton River flows have increased by  $1 \text{ m}^3 \text{ s}^{-1}$  to have an overall net gain of over  $2.0 \text{ m}^3 \text{ s}^{-1}$ .

## 2.3 North Branch flows

### 2.3.1 Background

There is evidence to suggest that the North Branch of the Ashburton used to flow all year round at Digbys Bridge. Recently (since the 1980s) the river can be dry for up to 6 months of the year during late Spring through to Autumn.

Britten (1991) in discussing stockwater said "The North Ashburton itself could be an uncertain source. When it dried up completely in the summer of 1890/91 Mr Baxter (County Engineer) tapped the South Ashburton, sending water into the North Branch through O'Shea Creek at the narrow part of the forks".

Furthermore newspaper headlines of the time noted.

- (4.2.1890) Extremely low flow in the Ashburton
- (8.2.1890) Hottest day North Branch of the Ashburton completely dry.
- (21.4.1890) Long drought and scarce feed.
- (25.6.1891) Serious water shortage.

Even in 1890 there was considerable stockwater abstraction from the North Branch. Listed below are the known abstractions (Leadley, 1952):

- Pudding Hill February 1881
- Mill race February 1873
- Methven auxillary 1880s
- Winchmore Main (Fairton to Seafield) 1880s
- Winchmore Estate 1870s

Assuming these takes were the same as the consented rates, they would total  $2.5 \text{ m}^3 \text{ s}^{-1}$ . (No estimate was assessed for the Winchmore Estate take.) These abstractions equal the total flow coming through the gorge at times of extremely low flow, which raises the question as to whether the North Branch in 1890 with no abstraction would have gone dry.

The evidence is somewhat sketchy as to when the North Branch first went dry in recent decades. During the last 20 years many locals have grown accustomed to the river going dry, and some consider it always did.

The first time Tom Goodwin (retired Regional Council Overseer, (River Works) from 1951-1998) saw the river dry at Digbys bridge was in 1966. This was as a result of Crum Brothers digging a hole in the river channel about 2 km upstream near Wakelin Road. Approximately 7 cusecs (200 litres) seeped down this hole.

Athol Shearer has farmed to the east of the North Ashburton at Shearers Road for many years, and his father had farmed there since 1908. To his knowledge the river never used to go dry. He first noticed it dry in 1969 at Shearers Road crossing. Tom Goodwin first saw parts of Blands reach dry in 1968 above Shearers Crossing.

Refer to Appendix 1 for further anecdotal information.

Rainfall recorded at Methven was below average for 8 of the 10 years from 1960 through to 1969, which may explain the low flows witnessed in 1968 and 1969. There are other factors described below that may have contributed.

Earliest concurrent gaugings during the drought from 1971 to 1974 down the North Branch have shown there were flows at Digbys Bridge, the lowest being only  $41 \text{ l s}^{-1}$  on 15 February 1971. All 3 years of 1971, 1972 and 1973 were well below average rainfall at Methven (according to a long term raingauge 1892-2000).

The following discussion and analysis compares the conditions in 1971-74 when

reliable flows did occur at Digbys bridge (from the evidence provided thus far) and those unreliable flows today at Digbys bridge.

**There are many changes that may have decreased the river flows.** Some relevant questions are:

- Has the rate of consented abstractions for stockwater and irrigation increased?
- Has the climate changed with less rainfall and therefore less flows?
- Blands reach bed level is now 2m higher, are we losing water there?
- What do the willows use?
- What's the RDR management view on the river going dry?
- What were the river channel natural flow losses anyway? How do groundwater levels affect them?
- Are groundwater levels in the vicinity now at lower levels than they were historically?
- What has been the largest impact on the river prior to 1980?
- What effect has the reduction of wetlands caused?
- Has straightening the river removed some sealing clays from the river bed?

These are discussed in order below.

### **2.3.2 Has the rate of consented abstractions for stockwater and irrigation increased?**

Yes, in 1971 the consented takes from above Digbys Bridge amounted to  $3650.2 \text{ l s}^{-1}$ . This is the sum of  $2390 \text{ l s}^{-1}$  for stockwater take and  $1260.2 \text{ l s}^{-1}$  for irrigation. The figures for 1999 are  $5028 \text{ l s}^{-1}$  of which  $2349 \text{ l s}^{-1}$  is stockwater and  $2679 \text{ l s}^{-1}$  is irrigation. The total increase is  $1378 \text{ l s}^{-1}$  while irrigation increased by  $1419 \text{ l s}^{-1}$ . A study has shown (Sanders,

1998) that not all irrigation takes are fully exercised during an irrigation season or even during a drought. A figure of 55 % consented take has been adopted for this study. Therefore the  $1260 \text{ l s}^{-1}$  in 1971 perhaps equated to an actual take of  $693 \text{ l s}^{-1}$  while for 1999,  $2679 \text{ l s}^{-1}$  equates to  $1473 \text{ l s}^{-1}$ . Therefore the probable actual irrigation abstraction increase is  $780 \text{ l s}^{-1}$ .

The stockwater takes are considered to equal the actual allocated flow. From check gaugings they remain fairly constant and close to the consented amount.

So the answer is that stockwater has little change but the irrigation takes have increased effectively by about  $780 \text{ l s}^{-1}$  between 1971 and 1999.

### **2.3.3 Has the climate changed with less rainfall and therefore less flows?**

Tom Goodwin's observation is there were small pockets of snow on Mt Hutt nearly all year historically, with perhaps 2 to 3 weeks with no snow at all. It is vastly different now with many months with no snow at all on Mt Hutt. This contradicts Trevor Chinn (per coms NIWA Snow Line expert) who states the Southern Alps have had above average snowfalls from 1977 to 1998.

To endeavour to recognise any long term trend in rainfall a simple analysis was carried out looking at a concurrent set of rainfall readings for Double Hill representing the Norwest component of rainfall to the North Branch catchment and Methven representing the southerly, southeasterly rainfall in the foothills. Data used was from 1918 to 1999. Annual rainfalls were analysed with concurrent annual mean flows measured at the Old Weir (1982-1999), resulting in an annual mean flow record for the period 1918 to 1999 based on regression.

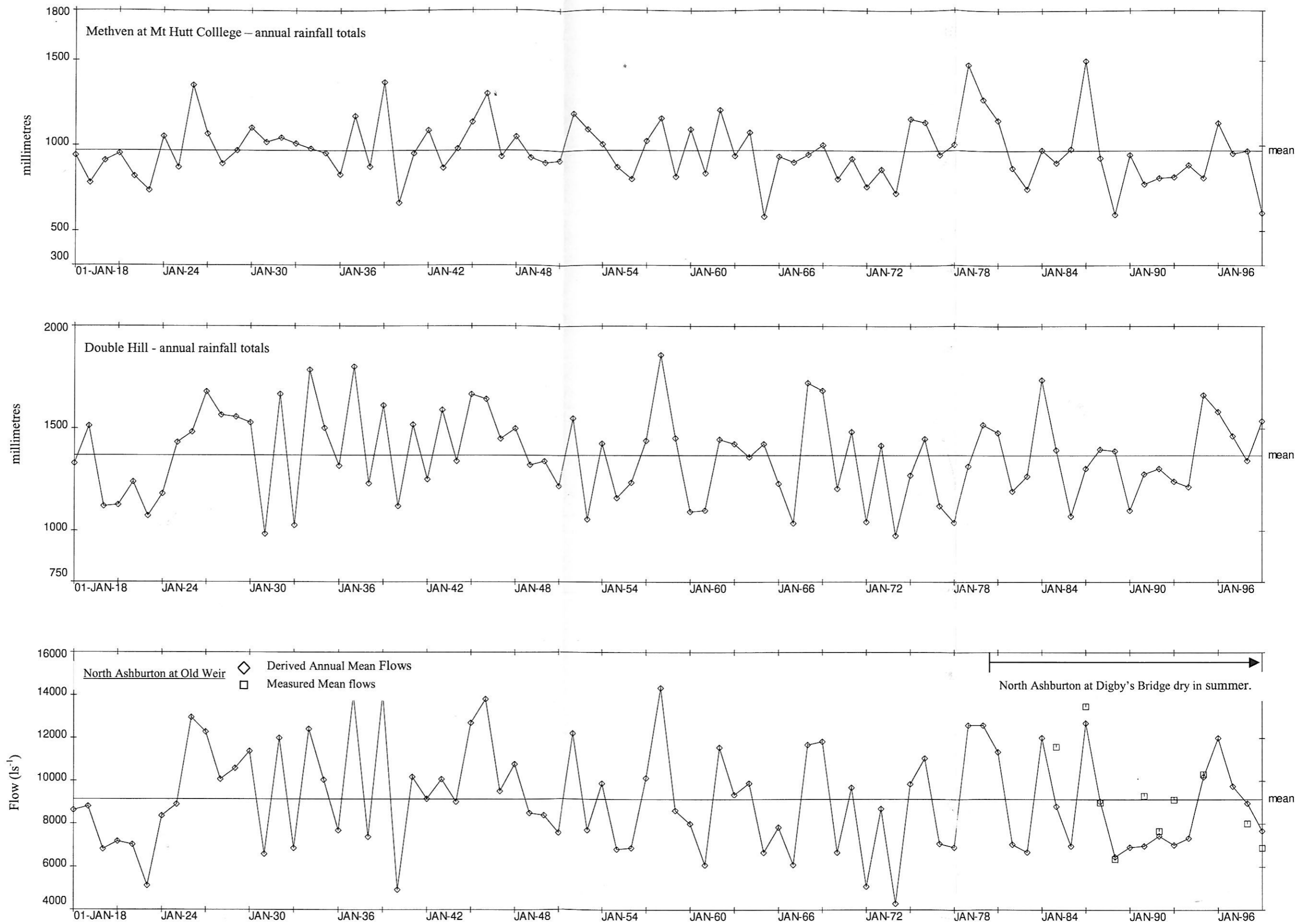


Figure 2.7: Longterm annual rainfall trends, and derived mean annual flow trends for the North Ashburton River.

This record showed that annual mean flows fluctuated considerably but there was no trend of abnormally reduced flows in the last 20 years, or recent low flows that had not occurred historically prior to 1980 (Figure 2.7).

### 2.3.4 Blands reach bed level is now 2m higher, are we losing water there?

There is a school of thought which believes this is the cause of the total loss of water from the North Branch.

Analysis suggests that water is lost today because of the raised bed in Blands Reach and that since the 1960s four processes have contributed to this loss:

- (i) Owing to a raised head, water is lost to the gravels and travels as underflow, eventually moving to the east as groundwater. Some resurfaces in the channel further downstream. There is however an overall increase in surface water lost from the North Branch channel (D Scott pers com).
- (ii) With the higher head of water, there is increased movement laterally into spring fed and groundwater fed streams. This water re-appears to the west in Snowden or O'Shea Creeks or to the east in tributaries of Mt Harding Stream, and then returns into the North Branch (D Scott pers com). Increased flows in O'Shea and Snowden Creeks have been witnessed overtime (S Walkham pers com). However, flows in the North Branch below Blands Reach should be relatively unchanged as these three streams have re-entered the system. A major impediment to this re-entry occurring is the Greenstreet Irrigation Scheme interception of up to  $1200 \text{ l s}^{-1}$  from O'Shea and Snowden creeks.
- (iii) Deepened drains through the Martin property to Mt Harding Creek in 1974,

- (iv) intercepted groundwater destined for the North Branch (J Martin pers com). This made a noticeable reduction in North Branch flows (L Webb pers com)

- (v) The drains dug at the toe of the stopbank in 1980/81 (formally Bland property) released water almost directly (M Bland pers com) from the North Branch into Mt Harding Creek. Although seepage in this area had caused Mr Blands paddocks to be swampy for over 15 years, these drains allowed more direct flow (losses) at an increased rate from the North Branch.

It is difficult to put an estimate on the additional losses of (i), (iii), and (iv) above. A rough estimate of  $500 \text{ l s}^{-1}$  is suggested. The loss from (ii) is during the irrigation season and may be as high as  $1200 \text{ l s}^{-1}$ .

In summary the raised bed level does not seem to be the main reason for the North Branch going totally dry, as much of what may be diverted will be returned to the river via peripheral drains and streams.

### 2.3.5 What do the willows use?

Has there been an increase in willows along the banks?

Tom Goodwin says there were no willows on either bank of the river from Thompsons Track bridge up to the Gorge. This is verified on aerial photos in the early 1950s held by Environment Canterbury. Tom remembers the first time any planting occurred was in 1964 when protection work was carried out to stop the North branch rejoining the South branch via the historic channel. Planting of willow poles below the siphon on the true right bank towards Thompsons Track started in 1964. In November 1968 planting between the gorge and SH72 and further down to the RDR siphon was started. In the beginning thousands of trees were planted on both sides, at a rate on occasions of 1800 per day. Planting stopped in 1988. Environment Canterbury Red Book (Ashburton office) can confirm where and when, (also monthly reports).

Approximately 80,000 trees were planted per year.

Planting below the siphon on the true right bank towards Thompsons track started in September 1971. It is assumed these trees reached maturity in the late 1970s.

An estimate of water uptake by willows was proposed by Meyboom (1964) as 1.82 acre-feet /acre per summer 3 months. Detailed aerial photos were studied to estimate the area in willows above Thompsons Track. The calculated water up take of willows is estimated to be  $150 \text{ l s}^{-1}$  from approximately  $2.1 \text{ km}^2$ .

The area below Thompsons track was not estimated as it has historically been well established in willows on either bank. With bank improvements further willows were planted, but are insignificant in number from what existed historically.

### **2.3.6 What's the RDR management view on North Branch flows?**

John Young provided comment from his experiences with managing the RDR, and his understanding of past management. He believes the North Branch was sustained at higher than natural flows from 1945 to 1973/74 due to a high level of waste from the irrigation scheme into the river. During periods of low demand a maximum spill of  $5.5 \text{ m}^3 \text{ s}^{-1}$  could occur for up to 12 hours. Furthermore there was continuous leakage from the RDR siphon into the Ashburton owing to a sill on the RDR being too low.

From 1945 to 1973/74 utilisation of irrigation schemes was as follows:

Mayfield Hinds	-	25%
Lyndhurst	-	44% (the only scheme to spill into the North Ashburton)
Valetta	-	56%

With the advent of clock automation in 1973/74, irrigation occurred at night and by 1984/85 all schemes were fully utilised

Tom Goodman said spills from the North Branch RDR siphon into the North branch occurred only on a few occasions. Ken Stockdale (head raceman in 1950s -

1960s) and after him Barry Hay and Ross Spicer, used to ring Tom to inform him 24 hours before a spill. These were approximately 8 to 10 cusecs ( $220\text{-}280 \text{ l s}^{-1}$ ) at the most. Any permanent flows would be seepage and small.

The maximum spill possible from the RDR waste laterals is  $6.5 \text{ m}^3 \text{ s}^{-1}$ , consisting of  $3.5 \text{ m}^3 \text{ s}^{-1}$  from combined laterals above Digbys bridge, and the Coniston waste race maximum of  $3 \text{ m}^3 \text{ s}^{-1}$  that joins the North Branch just above the South Branch confluence.

Some of the flow in the waste races was recorded by the raceman at the time. All these records were destroyed when racemen were made redundant after RDR management changed.

No beneficial affect to the North Branch is considered to have occurred as recharge from the Ashburton Lyndhurst irrigation schemes supplied by the RDR. Any release of groundwater from irrigation is presumed to have travelled away from the river. This is consistent with the piezometric map produced by de Joux (1992).

### **2.3.7 What were the river channel natural flow losses? How do groundwater levels affect them? Are groundwater levels in the vicinity now at lower levels than they were historically?**

Natural losses and gains down the length of the North Ashburton were calculated at various sites. Concurrent gauging runs completed in 1972-1973 were repeated in the summer of 1999-2000. Natural losses were calculated by considering all takes and adding these takes to river flows.

Gains from the Gorge to Thompsons track were treated separately from losses between Thompsons track to Digbys Bridge.

Runs of concurrent gaugings in 1972-1973 had, on average, a gain to Thompsons Track of  $278 \text{ l s}^{-1}$  while gaugings in 1999-2000 gave an average loss of  $292 \text{ l s}^{-1}$ . These are crude assumptions as each individual run gave

different results. However the  $570 \text{ l s}^{-1}$  reduction in 1999-2000 may coincide with the calculated  $150 \text{ l s}^{-1}$  reduction in flow proposed for willow uptake in this reach, coupled with raised gravel levels.

Comparisons between Thompsons Track and Digbys bridge show the losses appear to be up on the 1972-1973 runs by approximately  $860 \text{ l s}^{-1}$ . But it is difficult to be certain as this change in trend may be bywash from the RDR not measured in 1972-73. So it could be concluded that the natural losses in this reach may not have changed - excluding the affect of increased consented takes.

Initial assumptions were made that considered little water would be in bywash channels during the dry summer conditions at that time, but when completing the gauging runs in December 1999 and February 2000, our team were required to gauge 5 out of 8 bywash channels. We had earlier been informed by the RDR racemen that they are rarely used and to expect to find water in only a couple of them. This puts doubt on the reliability of earlier runs when no bywash channels were measured. However, during the drought of 1972 to 1974 the waste races may have been dry.

Using all available flow measurements at Thompsons Track and Digbys Bridge variations were compared. Maximum differences were a loss of  $1579 \text{ l s}^{-1}$  when groundwater levels were very low compared with median river flows, and a gain of  $1158 \text{ l s}^{-1}$  with mean groundwater levels and low river flows.

A crude comparison was made between groundwater levels and loss and gain rates in the North Ashburton below Thompsons Track. Unfortunately ground water level recording to the east of the North branch is sparse. A well 12 km away from the river was used only because it spans some of the years of the analysis. This well is situated at the Winchmore research farm. Piezometric contours display the movement of groundwater from the North Ashburton below Thompsons Track in a direction towards the east which includes the Research Station.

This well was read periodically and only those runs between Thompsons track to Digbys Bridge were used when there was a groundwater reading close to the date (in some cases groundwater levels were interpolations between readings). Six runs fit into this category and are displayed in Figure 2.8. There appears to be a relationship. Caution should prevail though, when consideration is given to the distance to Winchmore Research Station, the date of ground water readings versus gauging runs, the unknown bywash (would increase the natural losses and decrease gains), and the affect of local rainfall and local border dyke irrigation influence on the ground water levels at Winchmore.

A further crude comparison was made between river flows and loss and gain rates (Figure 2.9). This indicates a larger loss with higher flows and a gain when flows were low.

From the sparse information shown in Figures 2.8 and 2.9 it is concluded river flows are lost and move away from the river to the east. This is supported by a piezometric map produced by de Joux (1992). If these groundwater levels are high the losses from the river are reduced and in some cases the river flows will increase.

The lack of consistent groundwater information to the east of the North Branch below Thompsons Track and above Digbys Bridge makes description of the levels impossible. All well readings ceased in the 1980s. A groundwater irrigator in the area, Mr I Hood was required to deepen his well to retain a good supply. This is probably the only evidence to date of a declining groundwater system.

It is difficult to draw a firm conclusion from this information. It is possible to suggest that there has been an increasing loss from the channel flows to groundwater between the 1970s and present. With increased abstraction from the river, the supply to the ground water system would be less than historically and ground water

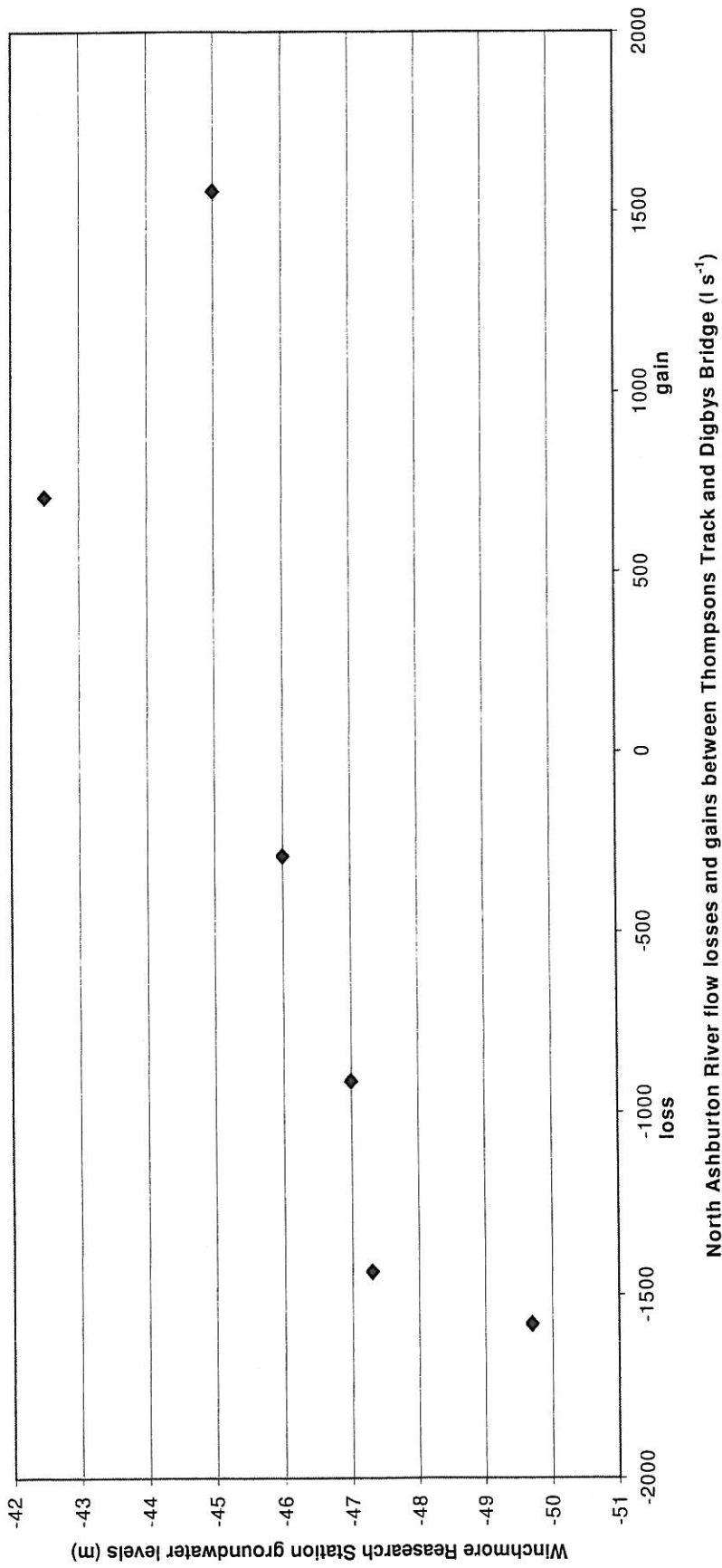


Figure 2.8 North Ashburton River losses and gains over a partial reach compared to groundwater levels measured at Winchmore Research Station

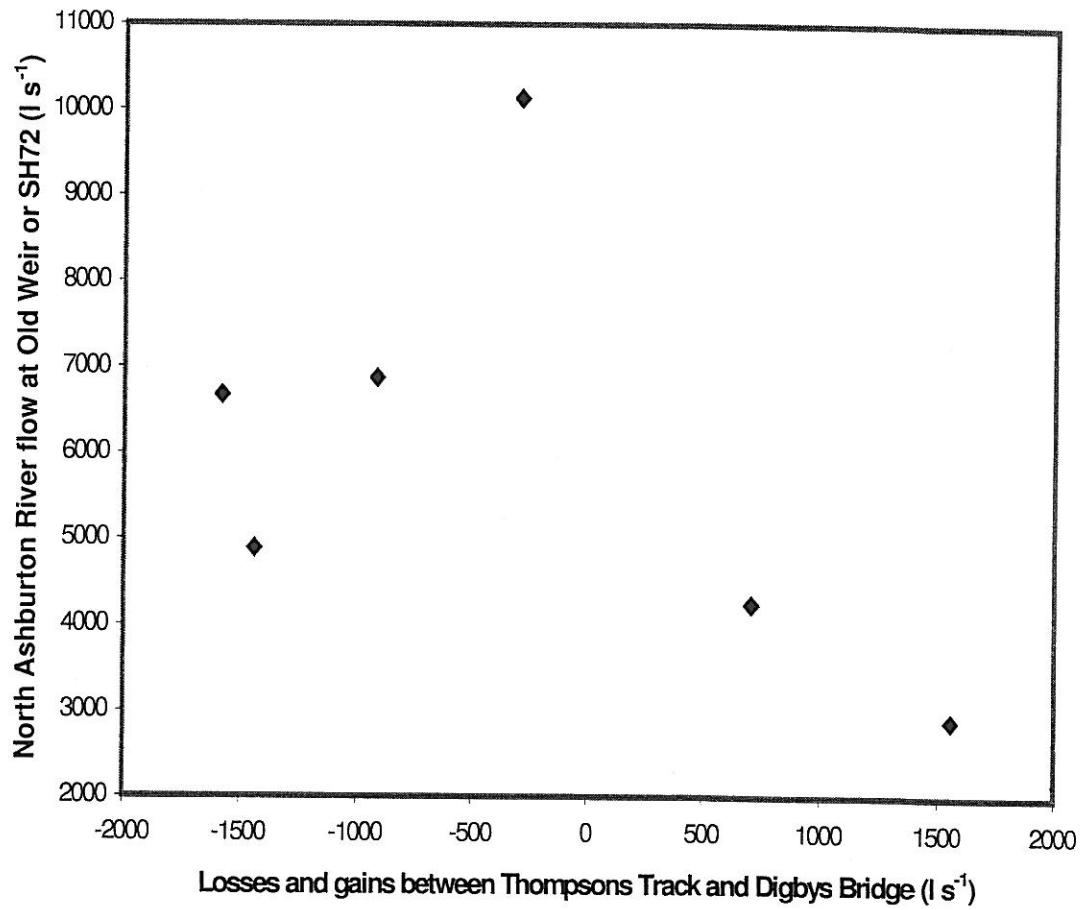


Figure 2.9 North Ashburton River losses and gains over a partial reach compared to flows measured at Old Weir or SH72

levels may become depleted or fall to a lower level more often in summer. Once river flows increase in autumn water is lost to fill the ground water reserve that was not being topped up in summer. This may explain why the North Ashburton has no flow at Digbys Bridge for sustained periods.

### **2.3.8 What was the largest impact on the river prior to 1980?**

The answer is the Greenstreet irrigation scheme take of 1200 l s<sup>-1</sup> from O'Shea. The Greenstreet Scheme was opened in 1975 with some water used. In 1980 the full allotment of water was used and in 1985 all farm border dykes were completed. This scheme draws water from O'Shea and Snowden Creeks which are spring fed, emerging from the area between the North and South Branches, and flow into the North Branch. The abstraction is supplemented by a diversion from the South Branch. The practise of the irrigation scheme has been to shut down the take from the South Branch when restrictions first apply at SH1 and to reduce the take from O'Shea as per the consent. The Greenstreet management observation is that the North Branch is usually dry at the O'Shea confluence before the Scheme is required to reduce its take.

Impacts of the abstraction are displayed on Figure 2.10, where comparison of flows at the Old Weir or SH72 at the top of the plains and the residual measured at Digbys bridge. The lines in blue were measured before the irrigation scheme started while the red are recent measurements when abstractions for Greenstreet occurred. The black line represents the natural losses.

Flows at Digbys bridge with Greenstreet abstractions added back, are displayed on Figure 2.11. The reason the dotted red lines are not parallel with the blue lines could be:

- (i) increase in losses due to the raised gravel at Blands Reach since early 1970s.

- (ii) or RDR bywash was occurring during the gaugings in the 1970s at Digbys bridge.
- (iii) or losses between Thompsons Track and Digbys Bridge have increased.

### **2.3.9 What effect has the reduction of wet lands caused?**

Although this would have the most noticeable affect on runoff in summer it is believed the draining of the wet lands occurred decades before zero flows occurred at Digbys bridge.

The change in delayed runoff with the draining of wet lands in the vicinity of the gorge is unknown but would reduce the baseflows all year round, and most noticeably in summer.

### **2.3.10 Has straightening the river removed some sealing clays from the river bed?**

Some community members believe one of the contributing factors to the North Branch going dry at Digbys Bridge was the straightening of the river, started in 1966. (T Goodwin pers com), as clays which lined the bottom of the bed were cut through allowing water to escape. This affect is difficult to quantify and well may have allowed more losses from the channel to occur, however one must consider the river naturally re-sorts bed material during floods.

### **2.3.11 Conclusions**

- 1 The historical mean flow record developed for the Old Weir site shows that annual mean flows fluctuated considerably but there is no trend of abnormally reduced flows in the last 20 years. (Figure 2.7). However, flows in the lower reaches of the North Branch are much lower than they were historically.

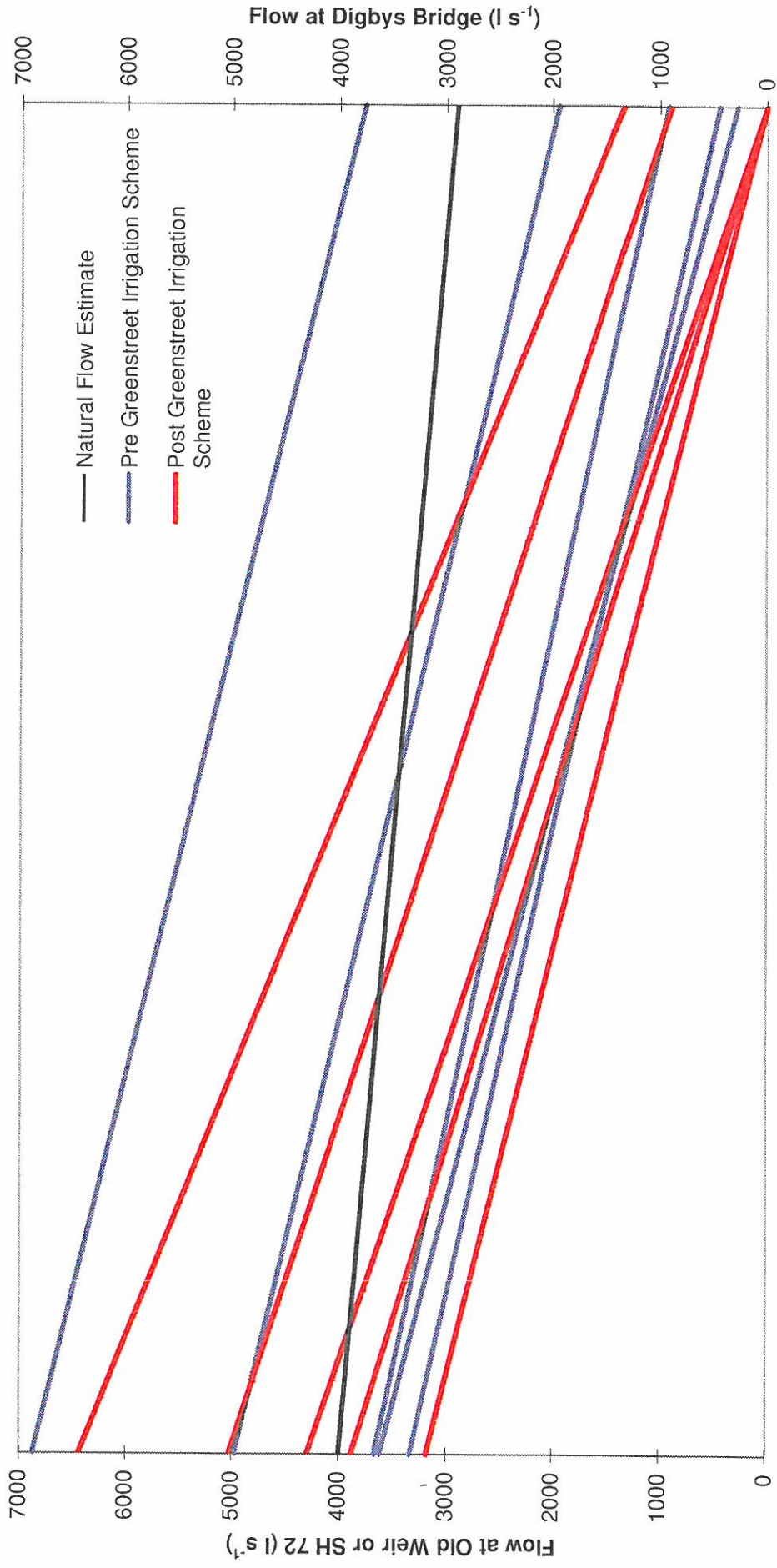


Figure 2.10: Impact of abstraction on flows at Digbys Bridge.

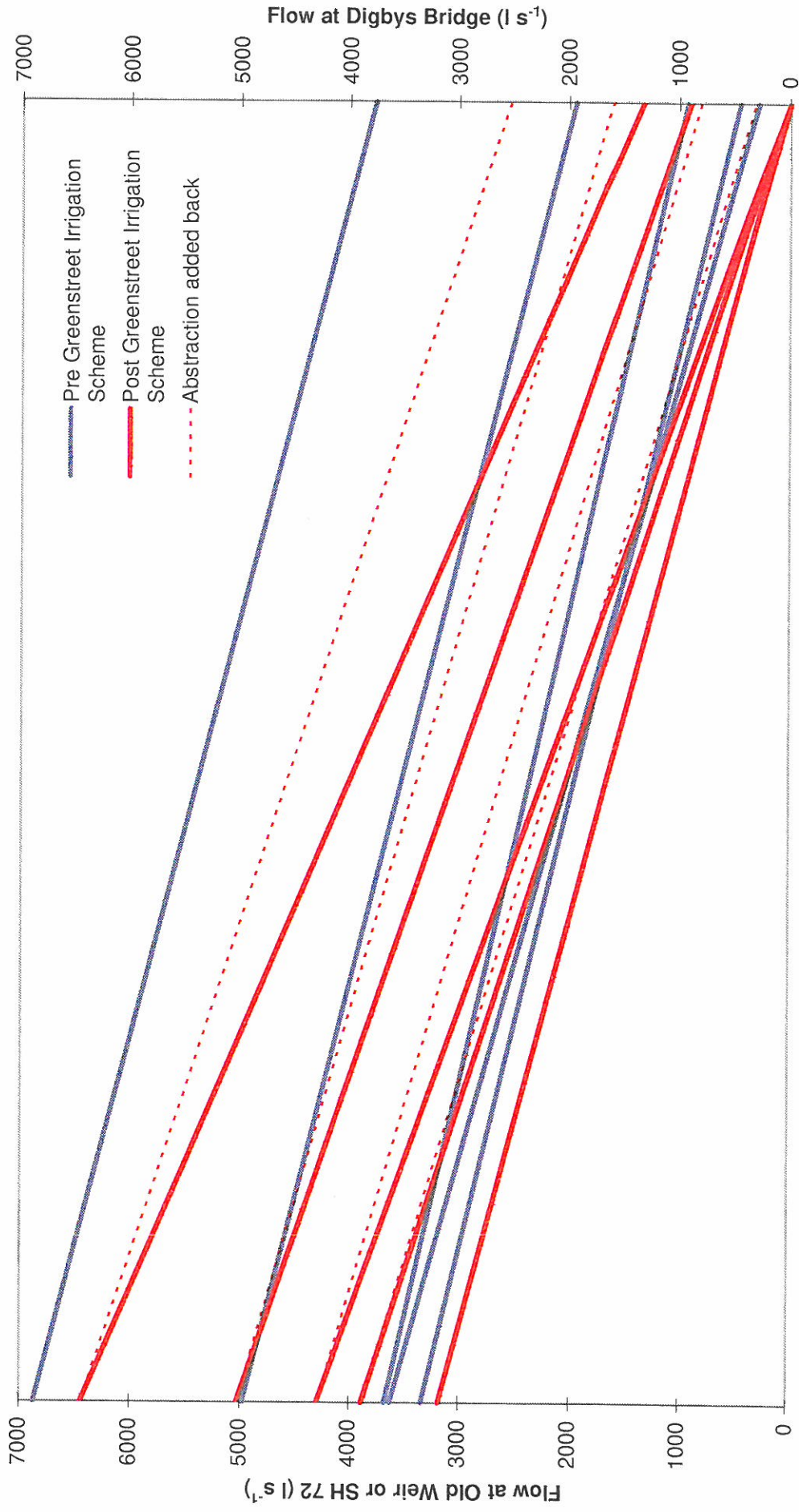


Figure 2.11: Greenstreet abstraction added back at Digbys Bridge

- 2 The North Branch only went dry in 1890 and never ceased flowing until the late 1960s. Observations at Digbys Bridge show there is zero flow for many months at a time. Natural changes do not appear to be responsible for this change.
- 3 By comparing the natural low flows at Digbys Bridge (Table 2.3) to the consented total abstraction of  $5 \text{ m}^3 \text{ s}^{-1}$ , it is evident that the large amount taken from the river is the major reason why the river goes dry.
- 4 The stretch of river extending from below Blands Reach up to the RDR syphon was stopbanked and straightening from 1966 to 1968. It seems coincidental that the North Branch went dry first in parts of Blands reach in 1968. Perhaps some sealing clays were removed.
- 5 Losses due to willows, raised gravel bed, and the reduced groundwater resource to the east also deplete flow from the river during the summer and have all contributed to the zero flows.
- 6 The Greenstreet take of  $1200 \text{ l s}^{-1}$  from O'Shea Creek since 1980 (some of which is diverted from the South Ashburton) was the last action in a series which finally caused the North Branch to go dry.

### 3 Fish Habitat Survey

#### 3.1 Introduction

The purpose of this investigation was to provide information for the development of the Water Chapter of the Natural Resources Regional Plan anticipating that the number of minimum flow locations may increase from one.

Fish habitat surveys were carried out in order to evaluate the fish habitat or fish passage requirements for a selection of fish species. Statistical evaluation of the flows recommended (Jowett 1999) can be assessed using the times series of natural

flow and the actual flow records described in Section 2.

New Zealand Fish and Game (FG) provided expertise on the selection of:

- fish species
- representative reaches
- critical reaches
- type of analysis, either fish habitat or fish passage

The surveys were carried out at 5 locations (Figure 3.1). The majority of the field work was completed by NIWA technical staff trained in the Jowett method of instream flow incremental methodology (IFIM) surveying.

Although the initial calibration and analysis was completed by the writer, Ian Jowett was invited to review the calibration and analysis of flow requirements (Jowett 1999).

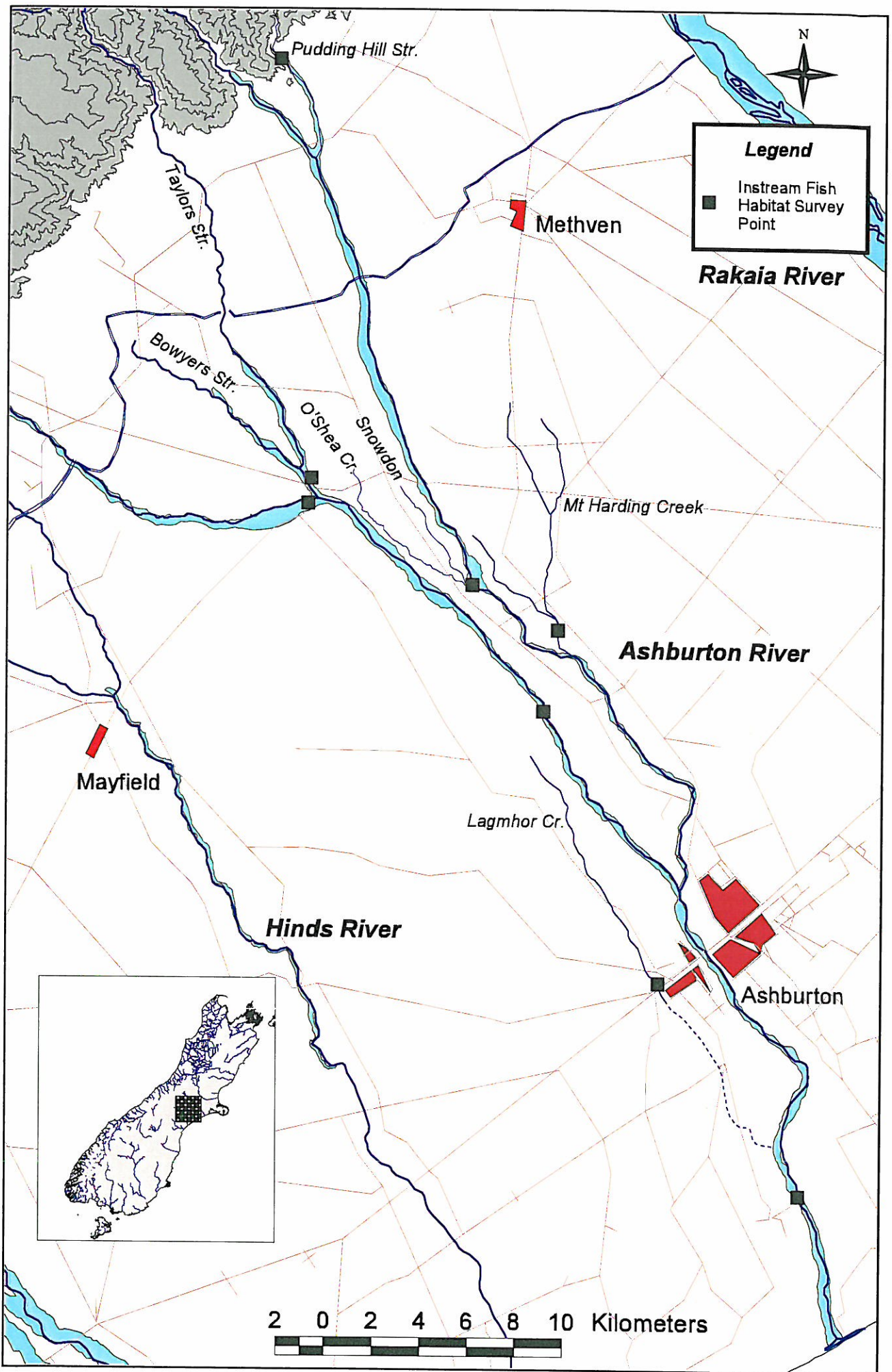
Also Ian Jowett was requested to review earlier surveys on the Ashburton (Jowett 1992) in order to assess a minimum passage flow for salmon.

Results are reported in Jowett (1999). However the rationale for the selection of habitat requirement and the suggested (minimum) flow requirement requires further discussion at selected representative reaches as follows.

#### 3.2 Laghmor Creek at Fraser Road (above Tinwald Golf Club)

This is a highly modified spring fed stream that divides into three streams below this site. It has an insignificant habitat downstream, with poor contact with the Ashburton itself, but the adult trout swim up from the main stem, or survive within the creek.

FG are most interested in the reaches above this location. The range of calibration flows was  $153 \text{ l s}^{-1}$  to  $82 \text{ l s}^{-1}$ . Frank Scarf of FG specified the habitat preference for Brown Trout yearlings. The suggested  $100 \text{ l s}^{-1}$  minimum flow requirement selected is exceeded 95 % of the time (based on spot gaugings measured over a 14 month period).



**Figure 3.1: Location of Instream Fish Habitat Surveys**

### 3.3 Pudding Hill stream

This is a foothills tributary of the North Ashburton River, with headwaters in the Mt Hutt Ski Basin.

Ashburton District Council (ADC) often abstracts all the Pudding Hill flow during summer. This steep braided channel could naturally go dry upstream of its confluence with the North Branch of the Ashburton.

Martin Rutledge and Graeme Crump of the Department of Conservation have identified the presence of native fish species Alpine galaxias, upland bullies, long jawed galaxias, longfin eel, and common bullies.

The suggested  $80 \text{ l s}^{-1}$  is the minimum flow requirement appropriate for these native fish. The  $80 \text{ l s}^{-1}$  has never been measured when monitoring the flow during droughts in 1972, 1973, 1985, 1998, or 1999. The estimated 7 day mean annual low flow for this location is  $435 \text{ l s}^{-1}$ . With a minimum of  $80 \text{ l s}^{-1}$ , some  $355 \text{ l s}^{-1}$  would be available for the abstractors when the stream drops to 7DMALF levels.

### 3.4 Mt Harding Stream at Aitkens Road

Mt Harding Stream is an important stream habitat for trout to retreat to when the North Ashburton River goes dry. Just above this reach the stream divides into many spring fed-streams, where they spawn. The reach chosen was critical for trout passage to the upper spring-fed streams.

The ADC has a stockwater take upstream of this reach of  $566 \text{ l s}^{-1}$ . The recommended minimum flow for trout passage is  $400 \text{ l s}^{-1}$ . The suggested  $400 \text{ l s}^{-1}$  minimum flow requirement is exceeded 67 % of the time (based on spot gaugings measured over a 14 month period).

### 3.5 O'Shea Creek bywash channel to North Ashburton River.

This is another important stream habitat for trout to retreat to when the North Ashburton goes dry. Just above this reach is an irrigation pond which divides upstream into two spring fed streams – O'Shea and Snowdon Creeks where there exists good trout spawning areas. The reach selected is the residual flow channel to the North Ashburton. At the pond, diverted Sth Ashburton water also meets O'Shea water and is diverted into the Greenstreet irrigation scheme. The minimum residual flow required during the irrigation season for this reach is  $50 \text{ l s}^{-1}$ . The suggested flow requirement was  $150 - 200 \text{ l s}^{-1}$  for the habitat requirement of trout passage. From the data available the combined O'Shea and Snowdon Creeks would always exceed  $150 - 200 \text{ l s}^{-1}$ .

### 3.6 Taylors Stream at South Ashburton Confluence.

The reach selected is upstream of Taylors confluence with the Sth Ashburton. Salmon spawn in Bowyers Stream, while in the recent past salmon spawned in Taylors Stream also. However, this has reduced, probably due to the large irrigation takes occurring today. There are less takes from Bowyers Stream and FG are interested in safe guarding passage for salmon to Bowyers Stream. Consequently this was used for the selection of habitat requirements.

The recommended flow requirement is  $2000 \text{ l s}^{-1}$ . From the time series of natural flow constructed for this location this flow would be exceeded 69 % of the time.

An evaluation of spot gaugings conducted mainly in summer, under the current management, suggests this flow would only be exceeded approximately 27% of the time.

### 3.7 Evaluation of 1992 surveys completed on the South Branch at Valetta and Ollivers Road and on the main stem at Wakanui.

Ian Jowett evaluated these surveys for the required habitat of salmon passage. Recommended flows for Wakanui Road on the main stem are  $2000 \text{ l s}^{-1}$ . This would be exceeded 100% of the time under natural or current flow regimes.

Recommended flows for Ollivers Road on the South Branch of  $3000 \text{ l s}^{-1}$  would be exceeded 100% of the time under natural flow conditions. An evaluation of spot gaugings conducted mainly in summer suggests that under the current modified state this flow would be exceeded approximately 64% of the time.

Recommended flows for Valetta on the South Branch of  $2500 \text{ l s}^{-1}$  would be exceeded 100% of the time under natural flow conditions. However, from the recorded data in the modified state this flow would be exceeded 71% of the time.

### 3.8 North Branch of the Ashburton River.

No instream habitat surveys were conducted on the North Branch main stem. This is an oversight. Nevertheless the critical reaches from the Mt Harding confluence down stream to Digbys bridge have an unreliable flow (Section 2.3).

### 3.9 Results

Table 3.1 Study streams, habitat, and suggested flow requirement after Jowett (1999)

STREAM / RIVER	HABITAT REQUIREMENT	SUGGESTED FLOW ( $\text{m}^3\text{s}^{-1}$ )
Laghmor Creek	Brown trout spawning and yearling habitat	0.10
Pudding Hill Stream	Native fish habitat	0.08
Mt Harding Stream	Trout passage	0.40
O'Shea Creek	Trout passage	0.15 – 0.20
Taylor's Stream	Trout and salmon passage	2.0
Ashburton River	Salmon passage	3.0 Olivers Road 2.5 Valetta Bridge 2.0 Wakanui Road

## 4 Further Work

A full piezometric survey is required of the groundwater system to the east of the North Branch to explain the impact of the modified flow on that system, as well as to assess in greater detail how the North Branch flows are affected. It is not clear also at what flow levels the river must be maintained in summer to assure a flow at Digbys Bridge.

Another important question to be answered is what flow conditions are required to stop the South Branch going dry, as happened in 1992.

## 5 Conclusions

- 1 Time series of natural flows have been generated at a number of locations on the Ashburton River and its tributaries. Many assumptions were required owing to the Rivers modified state. However during the field investigation 100% of the river flows were measured and 80% of the abstractions.
- 2 The Ashburton River to State Highway One has a high total abstraction, of  $18.2 \text{ m}^3 \text{ s}^{-1}$  which should be compared with the natural mean flow at State Highway One of some  $30 \text{ m}^3 \text{ s}^{-1}$ . Abstraction is 60% of the mean flow. Recordings since 1996 at SH1 give a mean flow of  $16.7 \text{ m}^3 \text{ s}^{-1}$ . This reduction of  $13 \text{ m}^3 \text{ s}^{-1}$  is larger than the entire South Branch mean flow at Mt Somers.

- 3 The current 7 day mean annual low flow (7DMALF) recorded at SH1 is  $3.88 \text{ m}^3 \text{ s}^{-1}$  whereas the natural 7DMALF is estimated to be  $14.23 \text{ m}^3 \text{ s}^{-1}$ . The abstractions reduce low flows at SH1 by 73%.
  - 4 The North Ashburton River in the vicinity of Digbys bridge would not have gone dry under natural conditions.
  - 5 Factors that have contributed to the North Branch going dry for sustained periods are:
    - consented takes total more than  $5 \text{ m}^3 \text{ s}^{-1}$ , exceeding the natural 7DMALF
    - Greenstreet irrigation take of  $1.2 \text{ m}^3 \text{ s}^{-1}$  fully exercised since 1980
    - straightening and stopbanking 1966-68
    - raised bed level
    - uptake of water for willows (planted mid 1960s and early 1970s)
  - 6 Further work needs to be undertaken to develop a better understanding of the surface / groundwater relationship in the river and particularly in the North Branch.
- 
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## Appendix 1

### Anecdotal information

**Flint Hill** (22 September 1999, farmer, Hills Road, Greenstreet, farmed here since 1955, parents before him back to 1902.)

Greenstreet Creek has never gone dry in that time at Map reference K37:064047. Backspring Creek has only gone dry once, in 1992 at Map reference K37:056041. Greenstreet Scheme started in 1974. The scheme is too large for the available water, he gets water for 48 hours every 18 days. He swam the North Ashburton with his horses during the large flood of 1951.

**Telephone conversation** 17 January 2001. Stewart Walkam requested that Flint be contacted again. Flint recalled riding his pony to Allenton School and crossing the river at Rawles Crossing (First Crossing?) when 5 years old (70 years ago) either 1930 or 1931 and finding the North Branch dry. He also recalled a story of a Land Agent telling the buyer of 40 acres at the point between the confluence of the North and South Ashburton, that the North Branch hardly ever flowed. Three weeks later there was a stream flowing between the house and the long drop.

There were swingbridges at the first and second crossings as the river was quite narrow about a chain wide, with the willows almost touching from either side.

**Tom Goodwin** (22 September 1999, retired Regional Council Overseer of river works from 1951-98).

Tom saw the South Branch dry at Hills Crossing in 1992, it was also dry in 1902 from discussions Tom had with a now deceased Mr Gill who farmed nearby.

The first time Tom saw the North Branch dry was in 1966 at Digbys Bridge. Crum Brothers had a large hole at Waklins Road and about 7 cusecs was disappearing down it. First time he saw it dry in parts of Bland's reach was in 1968.

In his early days there were tussock covered islands and less braiding (more wetlands) above the RDR syphon on the North Branch. All gravel river bed today.

Mill Creek and Wakanui Stream are the same stream, and start behind Coniston.

The old original  $4\text{m}^3\text{ s}^{-1}$  take of the Ashburton District Council for stock water from the South Branch to O'Shea across the North branch and heading towards the Fairton freezing works was never used. The pipes for this purpose through the North Branch stop banks were removed by Tom in 1983.

Spills from the North Branch RDR syphon into the North Branch occurred only on a few occasions. Ken Stockdale (head raceman) in 1950s and 60s and after him Barry Hay and Ross Spicer used to ring Tom to inform him 24 hours before a spill. 8 to 10 cusecs was spilled at the most. Any permanent flows would be seepage and small.

Pudding hill stream supplies about 20% of the flows to the North Branch during a flood.

In 1951 the North Branch broke out towards the South Branch at Orton Green. The channel (below RDR siphon) where the North Branch flowed towards the South Branch was cut off with a retard in the early 1960s. In the vicinity of the siphon in those days there were few fines in the riverbed, compared to today.

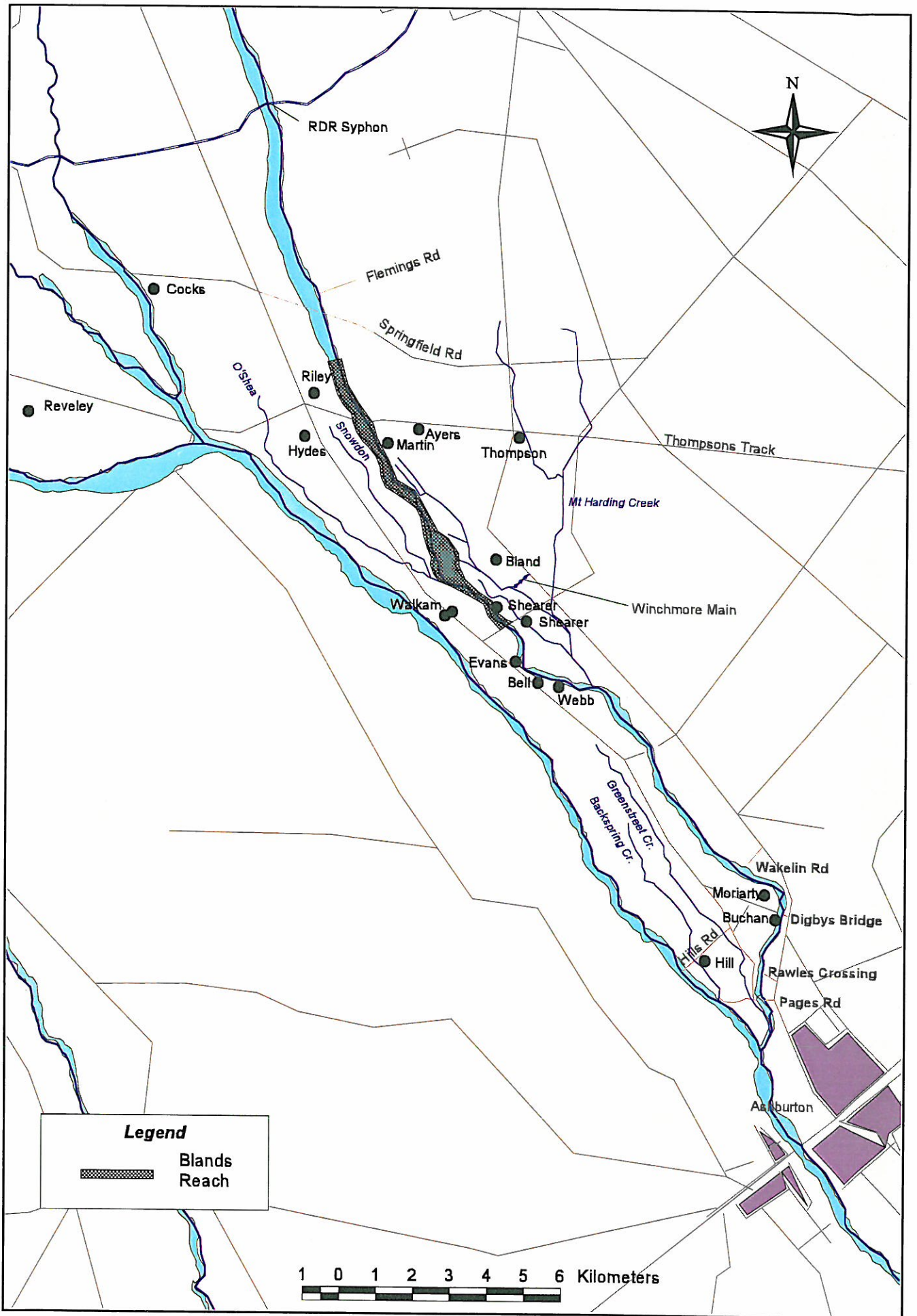


Figure A1.1: Anecdotal Information Location Map

Mt Harding Stream was the old bed of the North Branch at the turn of the century. There are large inflows at about Springfield Road. Some of Mt Harding stream comes from overflows of Pudding Hill Main.

There is a water gallery at the Pudding Hill confluence with the North Branch for Methven Township.

There was snow in small pockets on Mt Hutt for nearly all the year - only 2 to 3 weeks with no snow. Vastly different now, many months with none at all.

**Tom Goodwin 9 March 2000**

Subject was tree planting on the North Branch. Much is written in a little red book that Paul Cornelius of Environment Canterbury operates, even today.

There were no willows on either bank from Thompsons Track Bridge up to the Gorge. This is verified in aerial photos in the early 1950s. The first time any planting occurred was in 1964 when protection work was carried out to stop the North Branch rejoining the South Branch via the historic channel. In November 1968 planting between the Gorge to SH72 and further down to the RDR syphon was started. To begin with thousands of trees were planted on both sides, at a rate on occasions of 1800 per day. Planting stopped in 1988. (Red book to reference where and when, also monthly reports. Approximately 80,000 trees were planted per year).

Planting of willow poles below the syphon on the true right bank towards Thompsons Track started in 1964. In September 1971 one year old hybrid poplars were planted in this reach.

Planting opposite Jim Martin's farm was done in 1980s and the poplars were planted in 1990s.

Through Bland's reach the fairway was first reduced to 80 metres after 1951. Rows were planted around O'Shea Creek in 1960s, but most of old willows in Blands reach were already there.

Large amount of planting was done just above Winchmore Hall Road at Verralls in the 1960s.

In 1960 a large area was planted on the other side of the river opposite Waklins Road. Very little planting was done down towards Digbys Bridge.

**Athol Shearer** (22 September 1999, retired farmer from Orton Green, born in 1919, father arrived to farm this area in 1908).

To the best of his knowledge the North Branch never used to go dry. First time they noticed their swimming hole dry in the North Branch was about 1969. Dry in most summers since then.

Historically the RDR discharged small amounts down the river, once during maintenance they released high flows for 2 to 3 weeks. These flows caused seepage through the banks and increased flows in springs that run through their farm.

**Jim Mitchell** (22 September 1999, retired Assistant Engineer, Ashburton County Council, started in 1973).

The consent (number SCY710051) for  $226 \text{ l s}^{-1}$  near Rawles Crossing was never used.

## *Ashburton River low flow regime*

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Suggested we read Brown's "Ashburton its pioneers and its history 1853-1939" and Leadley's Thesis of 1952 on the history of the stock water race system. He believes the Pudding Hill, Methven Auxiliary and Mt Harding takes have been exercised since about 1900.

The Methven Springfield stockwater race was open until early 1980's and has since been piped.

Jim poses the question – why did the Ashburton District Council want  $4 \text{ m}^3 \text{ s}^{-1}$  from the South Branch for a stockwater race to flow towards Fairton freezing works if the North Branch had a good flow in it? Perhaps the flow although continuous was minimal.

**John Young** (22 September 1999, Company Manager, Rangitata Diversion Race Management Ltd)

Development of the RDR irrigation schemes evolved progressively from 1945 to the mid 1980s. Development of the first of these schemes, Ashburton Lyndhurst commenced in 1945 and by the 1973/74 it was only 44% developed. Irrigation practises in those early days were extremely manual resulting in no irrigation being undertaken over night. This resulted in water being spilt to the North Ashburton over night through the schemes waste races. Development of the Valetta scheme didn't commence until 1955. By the 1973/74 season 56% of the Valetta scheme was developed.

The North Branch was sustained at higher than natural flows from 1945 –1973/74 as a result of this high level of waste, and also leakage at North Ashburton Siphon because of a very low sill.

With the introduction of 24 hour clocks, on-farm distribution became automated and irrigation could be undertaken over night. Automation resulted in these schemes being fully developed by the 1985/86 season. A consequence of this was as development progressed so did the frequency and magnitude of water being wasted back to the Ashburton River system reduce.

Water could and was also spilt from the RDR via the North and South Ashburton spill weirs. The structure at the South Ashburton is a siphonic spill weir which operates when the height of water levels in the RDR activate its operation. No records exist prior to 1997 of the frequency and magnitude of what was spilt via this structure. The structure at the North Ashburton is a broad crested weir with two radial gates centrally located within the weir. The South Canterbury Catchment Board required MWD the historic operators of the RDR to advise them when flows in excess of 6 cumecs over a 12 hour period were to be spilt. Again no records exist prior to 1997 of the frequency and magnitude of these spills. Prior to telemetry operation, that is 1997, spill via this structure particularly during the irrigation season was reasonably frequent but the magnitude of these spills rarely exceeded 1 cumec.

An example of irrigation spill from the Ashburton Lyndurst Scheme to the North Branch was provided for a period in January 1953. The irrigation season of 1952/53 being a wet summer used little water, only 12% of the 1944-66 average seasonal usage was required. Furthermore the scheme was 1.3 % developed in 1944/45 and 34.5% in 1965/66 while 19.2% in 1952/53. This provides the background to the low demand for water. The spill that resulted was up to  $5.5 \text{ m}^3 \text{ s}^{-1}$  for 12 hour periods over the North Branch spill weir and via schemes waste races to the North Branch.

Infrequent spills (mainly winter) of a larger magnitude historically did and still do occur with outages from Highbank Power Station. These were historically reported to South Canterbury Catchment Board staff at the time of occurrence.

The fish habitat was depleted when the North and South Branches were straightened. The meanders were lessened and the pools made shallow. Therefore the percentage of riffles was increased.

**Trevor Chinn** (24 September 1999, Snow line expert NIWA, telephone conversation)

Studies of snowline elevation of the Southern Alps at the end of each summer show that from 1977 to 1998 the Southern Alps have had above average snowfalls. This is well illustrated by the Franz Joseph Glacier advance which started in 1987. Typically snow/ice takes 5 years to travel through the Franz Joseph Glacier system. 1993-1995 are the biggest snow years in the Old Man range in living history, from local anecdotal evidence.

Roughly there is no variation where you observe the snowline, e.g. if low in Fiordland it will be low in Kaikoura.

Trevor's conclusions state "The results show a trend to positive mass balances which follows a long period of glacial recession that commenced in the 1890s. From the records of the Franz Josef and Tasman Glaciers, the period of greatest recession was in the 1950s and 1960s. From the results it is possible to predict that the present advancing state of the glaciers should continue over the next few years."

His summaries appear in *Arctic and Alpine Research*, 1995, Vol. 27 (2)

**Noel Green** (14 December 1999, Rangitata Diversion Race, Raceman, telephone conversation).

Questioned about use of waste races

RDR Waste race lateral 8 – K37:046095 seldom used

RDR Waste race lateral 7 – K36:035116 closed off is unusable

RDR Waste race lateral 5 – K36:022130 not used last year – rarely used

RDR Waste race lateral 3 – K36:005141 discharges the most frequently – although not often. Has to keep race topped up for spray irrigators- could be  $15 \text{ l s}^{-1}$  spilt – this is very small.

RDR Waste race lateral 2 – K36:992162 seldom used, but small spill approx.  $15 \text{ l s}^{-1}$

RDR Waste race lateral 1B - K36:978172 spill each morning when irrigator shifted - approx.  $60 \text{ l s}^{-1}$

RDR Waste race lateral 1A – K36:966194 seldom used – but small spill approx.  $15 \text{ l s}^{-1}$

**Ross Spicer** (14 December 1999, Rangitata Diversion Race, Raceman, telephone conversation).

Waste race RDR lateral 9 - K37:077066 seldom used – not used in last 5 years.

**Ron Cocks** (9 March 2000 and 11 April 2001, farmer at Ashburton Forks since 1970)

His property has been irrigated for the past 30 years. He can spill excess irrigation water into a stockwater race that enters the South Branch at K36:932176.

During the irrigation seasons 1997-2000 he has not spilt water back into the South Ashburton.

Taylor's Stream at South Ashburton confluence never went dry between 1970 – 1997, but one elderly farmer in the district recalled this happening sometime in the previous 50 years. In 1998 Taylor's Stream and North Ashburton both went dry for a very short time. In 2001 they were both dry for several weeks.

## *Ashburton River low flow regime*

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years. In 1998 Taylors Stream and North Ashburton both went dry for a very short time. In 2001 they were both dry for several weeks.

A considerable area of his farm has been drained with 9 inch pipes.

Ron has never seen a fisherman on Taylors Stream in 30 years, although he has seen trout in it. There are more trout in his pond and irrigation races. As far as he is aware the Acclimatisation Society have never regarded Taylors Stream as a fishery. He does believe Bowyers Stream can support a spawning area.

The 1913 drought was the worst in the area. The 1992 drought was a bad one as it went into early winter (no autumn growth).

**Jim Martin** (9 March 2000 and 11 April 2001, farmer at Willowdale since 1965).

Arrived in August 1965 after the flood through Bland's property in 1964. In 1968 there were freshes across paddocks upstream of Thompsons Track. They came across the road and re-entered the river near his house.

Jim states the North Branch originally started on his farm and water that flows under Thompsons Track bridge today would have historically flowed into the South Branch. The farm upstream of Jim, owned by the Clarks, has a large number of springs that flow towards the North Branch. A 1978 aerial photo held by Jim displays old surface channels from the Mt Hutt, Methven direction heading for Jim's farm.

Water diviners had indicated that the groundwater under Jim's farm came from the Mt Somers direction.

When Jim first arrived, there was a sizeable swamp on his property that displayed high water levels in summer and low levels in winter (similar to the local groundwater trend), which is in direct contrast to the flow patterns of the North Branch. The swamp was unusual in that grass and soil seemed to float on water under pressure.

The swamp was drained in 1974, when Briggs Brothers deepened existing drains through his property towards Mt Harding Creek. Since then the springs have maintained a constant flow with no noticeable changes even with the Blands Reach gravel build up. Furthermore they do not run discoloured when the North Branch is in flood.

Jim is aware of the reduced flows in summer on the North Ashburton but is not sure what has caused this.

Jim recalled that when shingle was removed from a deep hole near Shearers Crossing some years ago, water appeared in the Shearer's paddocks because he thought a sealing layer in the river bed had been cut through.

Murray Bland the farmer down stream from him sold out because he felt it was inevitable that he would be seriously flooded out one day.

**William Thompson** (12 June 2000, retired farmer, telephone conversation)

Lived for nearly 70 years at 5 km to the east of the North Branch on Thompsons Track Road.

He had been told that before the turn of the century farmers had gone to the Rangitata River with a horse and dray for water because the North Branch had gone dry.

**Murray Walkham** (15 June 2000, farmer, Greenstreet).

Lived in Greenstreet next to the North Branch for 65 years. He can remember seeing salmon in the North Branch in the 1940s. He believes there has been a climate change, less Norwesters for shorter durations, and less rainfall from the Norwest. He can remember regularly getting 3/4 of an inch per Norwest event. It happens only rarely now. Also the winters are warmer now with less frosts.

His family used to swim in the hole at Shearers Crossing from the 1950s to late 1960s when it first went dry. From then on they swam in the South Branch. From the late 1960s the river was dry for long periods where it was not before. Even in this wetter summer of 1999/2000 the river was dry on occasions at Digbys Bridge.

In the early years the river didn't have a large flow in summer in general, and the positioning of the early Winchmore Main Drain intake opposite the O'Shea and Snowden Creek inflows suggests there were sometimes limited flows in the North Branch. He never saw any reach of the North Branch dry until the late 1960's.

**Lewis Buchan** (3 July 2000, grew up at Digbys Bridge during 1950s and 60s. Telephone conversation).

Lewis grew up near Digbys Bridge, at the location on the North Branch which he believes has the lowest flows. During his childhood he spent a lot of time in the North Branch River bed upstream as far as Thompsons Track. The river was often dry (approx. late 60s) for short periods up to Wakelin Road (where there was always water). The whole river environment was changed when the river was straightened. Before then there were more trees within the river and the meanders created good swimming holes close to the banks. The reach from Wakelin Road to Thompsons Track had salmon. They could also hear the salmon running when working in their sheep yards at Digbys Bridge. The South Branch was almost dry (just a trickle) at the confluence with the North Branch in about 1966/67. One of the contributing factors to the North Branch going dry at Digbys Bridge was the straightening of the river (April 1966, according to T Goodwin), as clays which sealed the bottom of the bed were dug through, allowing water to escape.

**Stuart Wilson** (15 September 2000, President of Mid Canterbury Federated Farmers, Telephone conversation).

Farmed and lived in the Hinds area for 55 years. Started using RDR water for irrigation in 1965 and only used water during the week, therefore he stopped at 5 p m on Fridays and restarted at 8 am on Mondays. He believes RDR irrigators near the North Branch would have operated the same way and therefore spilled wastewater directly into the river.

**Edna Guthrie** (27 October 2000, grew up on Racecourse Road, telephone conversation)

Rode ponies up from Race Course Road to Rawles Crossing (Second Crossing) during the 1930s and 40s. There were always deep holes for swimming she can remember once a hole of at least 10 feet deep. She often rode up the river as far as Shearers Crossing, the river was much wider above Digbys Bridge and had many deep holes. There were also lots of willows within the riverbed. In the early 1950s she shifted to Tinwald. She used to regularly swim in the mainstem during the 1950s where there was always good pools,

a hole of at least 10 feet deep. She often rode up the river as far as Shearers Crossing, the river was much wider above Digbys Bridge and had many deep holes. There were also lots of willows within the riverbed. In the early 1950s she shifted to Tinwald. She used to regularly swim in the mainstem during the 1950s where there was always good pools, however during the 1960s these flows declined and they built a swimming pool at home. She says the RDR wastewater had nothing to do with the good flows during the 1930s, 40s. She never saw the North Branch dry during those years from the Second Crossing to Shearers Crossing. She believes the decline in the 60s was due to river straightening.

**Edna Guthrie** (19 January 2001)

Edna disagrees with statements by Flint Hill and Ray Walkam regarding the dry reaches of the North Branch in the 1930s and 40s.

**Don Riley** (27 October 2000, retired farmer, Thompsons Track, telephone conversation)

Farmed for 10 years on the west side of the North Branch just above Thompsons Track. His irrigation water was from the North Branch and a large spring located on his property. This large spring flows into the North Branch 50 metres above Thompsons Track Bridge. In the early 1980s the North Branch was dry above the spring inflow.

**Stuart Walkham** (19 December 2000, farmer and manager of Greenstreet Irrigation Scheme).

Grew up and now farms at Greenstreet, near the intake of the Greenstreet Irrigation Scheme. The North Branch above the confluence with O'Shea Creek is becoming dry more often in the summer months.

Farms upstream of his have turned to swamp as the gravel in the North Branch has risen. The paddock near the stopbank where his father grew potatoes is no longer used. This is due to the water lying in that area today. Also Jack Evans had to abandon growing crops in his neighbouring paddock (down river) which boarded the stopbank. Furthermore the Shearers over the east side of the North Branch have stopped cropping and graze stock now due to the raised water levels. O'Shea Creek has increased flows in it today compared to when he was a child, due to the raised gravels in the North Branch River.

**Linden Webb** (17-1-2000, farmer Greenstreet, telephone conversation)

Farms in Greenstreet near the North Branch just below Walkham Road

Arrived in Greenstreet in approximately 1954/56. His father caught a 12.5 pound trout in the North Branch, shortly after they arrived, when the river was very low.

They developed a border dyke irrigation scheme in the 1960s. Their intake ( $226 \text{ l s}^{-1}$ ) was 1.5 km downstream of Shearers Crossing where there was always water until the late 1960s.

Some years prior to the drying up at Shearers Crossing a short reach 2 km downstream, and just above the Mt Harding confluence, could go dry on occasions.

Linden believes the drains dug from Mr Martin's property down to Mt Harding Creek, intercepted large amounts of water destined for the North Branch along Blands Reach. Thus diverting it into Mt Harding Stream, leaving less water in Blands Reach and affected their reliability to abstract from the North Branch.

**Roger Snowdon.** (17 January 2001, farmer, near O'Shea and Snowdon Creeks, telephone conversation)

The farm is upstream of the Greenstreet Scheme, between the Ashburton Staveley Road and the North Branch. When he bought the farm in 1967 many of the paddocks were swamp. He has drained these swamps with field tiles, which he maintains today. The drained water goes into O'Shea and Snowdon Creeks.

Was informed by a farmer, who has since died, that around 1900 the drainage from his farm was actually towards the North Branch - whereas today the drainage is away from the river. Furthermore 70 to 80 years ago his farm was not in a swamp.

**Thelma Bland** (18 January 2001, farmers wife then later managed the farm until her son Murray took over in 1975. East of North Branch above Shearers Crossing)

Farmed near Bland's reach from 1946-1975. In the early years there were good swimming holes at the back of the farm in the North Branch. By the early 1970s for most summers there were periods of no surface flows. She believes the flows disappeared into the gravel in Blands Reach.

**Peter Reveley** (18 January 2001, farmer near Mt Somers)

The locations of recently drained swamps shown on Figure A1.2 were provided by Peter. Peter noted that the Staveley drain is almost dry now. Woolshed Creek is dry at present and never has been dry before this is due in part to swamp drainage. The large swamp at Mt Somers Station which Bob Burnett said could not be drained, was drained in the 1980s.

This was due to improvements in draining swamps (using lightweight hydraulic diggers that could dig drains down to 5 feet deep) large areas of swamp were drained recently in the 1980s and 1990s. Frequently these techniques broke through the water table making drainage more effective.

Most of the swamps shown into Figure 3.1 drained into Bowyers Stream. Peter has observed the quicker runoff in Bowyers Stream resulting from the drainage of swamps. This has encouraged more shingle to enter the river. Many smaller areas have been drained during the 1980s and 90s but are not shown on Figure A1.2.

Since the flood of August 2000 the South Branch behind Peter's farm has shifted into an old channel to the north. The old water holes on this north side now have water in them again, and as a result there are more losses from the channel. Recently people riding tubes down the river towards Valetta have been forced to pull out at Peter's farm due to insufficient water.

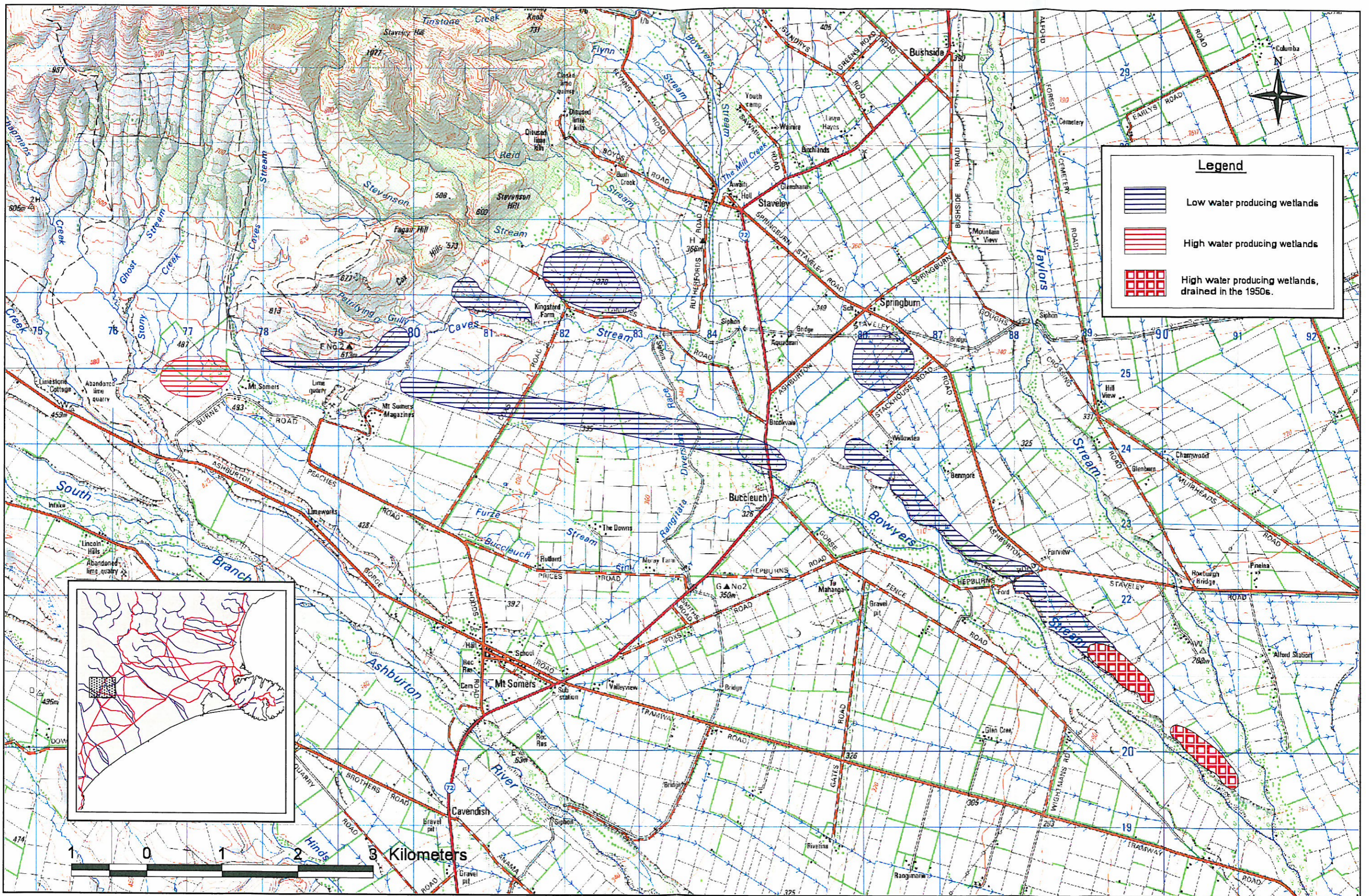


Figure A1.2: Wetlands drained in the Bowyers and South Ashburton Catchments between 1980 and 2000. (Information provided by Mr P. Reveley).

**Ray Walkham** (18 January 2001, retired in Ashburton)

Shifted to Greenstreet when 6 years old in 1934. He did a lot of rabbit shooting in the North Branch riverbed up until 1945 big snow (21 inches). He grew up half way between the Greenstreet and Forks Schools (on the west side of the North Branch). He could not get into the North Branch to shoot between the O'Shea confluence and Hyde's Engineering due to the swamp. The North Branch was dry on occasions between Gayler's and Well's properties. This reach starts half way between Ollivers Road and Wakelin Road and extends down to Wakelin Road (approx. 2km).

Ray often went shooting during the war up as far as SH 72 on the North Branch (never saw it dry above O'Shea confluence) and also up to Bowyers and Taylors stream.

The river was dry at Digbys Bridge in 1945 for a small reach for a short period of time.

Commenting on the gravel build up in the North Branch, he can remember the difficulty the blacksmith had in shifting his shop in 1940 from the east side of the North Branch across Shearers Crossing, due to the steep drop down to the river bed.

**Mr R Moriarty** (19 January 2001, Chertsey, telephone conversation)

Grew up in Greenstreet just upstream of Digbys Bridge from 1960 to 1970. As a schoolboy he helped with the wild flood irrigation scheme. They had a consent to take  $79 \text{ l s}^{-1}$  which they almost always got. If they couldn't get the full  $79 \text{ l s}^{-1}$  they would divert the river over to their intake. When flows were low and close to drying up they waited until the weekend and RDR spillage would give them sufficient water to irrigate. He estimates from 1960 to 1970 during the summer there was water in the river at their intake 95% of the time.

**Jack Evans** (29 January 2001, retired farmer, formally at Greenstreet from 1958 to 1984, telephone conversation)

Farmed at Greenstreet just down river from Stewart Walkam. Grew lucerne and cropped next to the North Branch. The gravel build up in the river caused minor seepage out into his paddock, but did not curtail his crop growing adjacent to the stop bank. He was surprised to hear his former paddocks next to Walkams cannot be cropped now, owing to seepage through the stopbank.

**Murray Bland** (29 January 2001, farmed at Bands Reach 1975 to 1995, telephone conversation)

Son of Thelma Bland. Grew up on the farm which he ran from 1975 to 1995.

His observation of the spring fed, drain (natural hollow developed by man over many years) from Martins property is that it has a continuous flow and has varied only with the wet or dry seasons. He can recall in 1962, when the North Branch didn't have a great flow in it, that O'Shea Creek was choked with salmon as they couldn't get up the North Branch.

In about 1980-81 he had excavation machinery on his property for five and a half weeks. Two drains were dug parallel to the stopbank, one linked into the drain from Martins property while the other joined up with a tributary of Mt Harding Creek. When they were being dug one could observe the water entering the drain from the North Branch side. At that stage if one stood on the stopbank there was a 5-foot drop to river water level and a 22 foot drop to the swamp on their farm side. When the drains were completed paddocks

## ***Ashburton River low flow regime***

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next to the stopbank could be ploughed for the first time in 15 years. These drains enhanced the flows of Mt Harding Creek with the North Branch water.

Water diviners were used in 1981 to locate under ground streams when Murray wished to sink an irrigation well further north of the stopbanks. Underground streams flowing directly from the north (Rakaia Gorge direction) towards the North Branch were detected.

**Ivan Ayers** (29 January 2001, retired farmer, telephone conversation)

Retired farmer aged 76 who grew up and later farmed 2 km east of Thompsons Track Bridge on Thompsons Track. He remembers at age 6 or 7 needing assistance to cross the swift middle channel of the North Branch in summer, to access their favourite swimming hole on the west bank of the river. Today it is only ankle deep often in the summer. He believes the majority of river flows are going through the gravels under the surface.

**Bob Bell** (31 January 2001, retired Greenstreet farmer, telephone conversation)

Farmed at Greenstreet below Walkam Road from 1947 to 1979. He started border dyke irrigation in the late 1950s, and used an intake in which the Webbs and Buttericks also shared, approximately 1.5km downstream from Shearers Crossing. The North Branch flows were reliable up until the late 1960s. During the 1970s the river often ceased to flow after Christmas, and could be dry as far down as Mt Harding Stream confluence. Bob cannot recall the North Branch being dry. From 1947 to the late 1960s either at his intake near Shearers Crossing (where they had a swimming hole) or at Digbys Bridge, where they crossed on their way to Ashburton township.

Bob cannot understand the drop off in norwest rain over his property. They used to get heavy norwest rain, even though 2 miles down the road they got none. Latter years on the farm they failed to get this norwest rain to the same extent.

**Donald Shearer** (7 Febraury 2001, farmer Orton Green)

Donald farms the land to the east of the North Branch above and below Shearers Road (Shearers Crossing). This was part of Athol Shearer's farm. Donald grew up at Orton Green and took over the farm in 1977. Donald stopped cropping for economic reasons in 1985 and now fattens bulls.

In 1976 they drained their duck pond (now a 30 acre paddock) above the Orton Green house and exposed a spring (K36/0337 Aitchison Earl, (2000)). This spring is the source of Spring Creek (unnamed) which flows past his house, and has never stopped flowing. The flow fluctuates seasonally with more in the winter and less in late summer.

Donald has noticed that the North Branch has developed meanders again opposite and upstream of the Orton Green house ( similar to 1960s) with deeper pools on the outside bends. Previously the river ran straight and remained shallow. Unfortunately when the hottest days of summer occur the pools are often dry.

**Laurie Armstrong** (7 Febraury 2001, Water Ranger, Ashburton District Council)

Joined the Ministry of Works and Development in the late 1960s. First tasks were contour levelling of paddocks to receive RDR water for irrigation. By the time the MWD Ashburton

The Ashburton/ Lyndhurst RDR waste races were regularly used in the 1970s to discharge water not required by farmers back into the North Ashburton River. During the late 1970s and early 80s spillover weirs were built that would allow water to pass to downstream irrigators avoiding the need to waste water back to the river. Many waste races have never been used since these improvements.

Mill Creek, prior to advent of stockwater races, was fed by a spring on Coniston. The first Mill Creek intake was positioned below Rawles Crossing. However today it is fed from the Winchmore submain.

**Bandy Lynn (S.J)** (28 March 2001, local recreational river user)

Has been fishing in the North Branch and tributaries for over 40 years and can remember catching sea run trout in O'Shea Creek.

There are a few factors that have caused the North Branch to go dry above the O'Shea Creek confluence. One affect of raised gravel levels in Blands Reach is the increased seepage out of the river into springs and drains dug beside the stopbank on the eastern side. The greatest losses were after the stopbanking and straightening of the North Branch throughout Blands reach and as far upstream as the RDR syphon from 1966 to 1968. It is not a coincidence that the North Branch became dry in parts of Blands Reach from 1968 onwards. He believes important sealing clays were removed from the bed of the river allowing surface water to disappear.

One thing he finds puzzling is that a drain on Jim Martin's property, some distance away from the North Branch, runs discoloured when the North Branch is discoloured, however at the same time spring fed streams closer to the river don't run discoloured.



## Appendix 2

### Data sets

#### Consented abstractions

##### 1 South Branch downstream to Valetta Bridge

Purpose	Consent Number	Type	Rate l s <sup>-1</sup>	Depletion rate l s <sup>-1</sup>
<b>Stock Water</b>				
ADC Lincoln Race(Brothers	SCY 710033	Surface Water	gauged	NA
ADC Woolshed Creek	SCY 730026	Groundwater	5	5
RDR at Syphon	SCY690788	Surface Water	340	within RDR
ADC Stoney Creek	SCY 710044	Surface Water	113	NA
<b>Irrigation</b>				
RDR at Syphon	SCY690786	Surface Water	gauged	NA
Hammond N	CRC951604	Surface Water	180	NA
Ryan J	CRC952164	Surface Water	46	NA
Webbs Transport	CRC921562	Surface Water	30	15 discharged

#### Seasonal assumptions applied to abstractions

Irrigation season total = Gauged RDR + (180 + 46) x 55%

Stock Water = Gauged Lincoln +5 +113 + (Webbs)15

**Irrigation season total = 257 l s<sup>-1</sup> + gauged Lincoln (default 1243) + RDR**

**Non-irrigation season = 133 l s<sup>-1</sup> + gauged Lincoln (default 1243) + RDR**

**South Branch to Valetta Dataset**      Flows in Litres per second (l s<sup>-1</sup>)

Date	Recorder Mt Somers (6 am)	Abstractions				2 hours later	
		RDR at Syphon	Lincoln Race	ungauged irrigation	ungauged stockwater	(RDR) residual at Valetta	Valetta + abstractions
4/02/98	6085	1852	1348	124	133	1912	5369
26/02/98	6652	3330	1345	124	133	1192	6124
5/03/98	5299	574	1290	124	133	1903	4024
17/03/98	7615	4499	1243	124	133	1750	7749
26/03/98	6212	3290	1236	124	133	753	5536
7/04/98	7098	4102	1220	124	133	1237	6816
29/04/98	8333	2784	1211	124	133	3492	7744
15/05/98	4533	1082	1243	124	133	1766	4348
24/06/98	4763	2315	1110	0	133	1332	4890
5/10/98	9796	5698	1176	124	133	2191	9322
9/12/98	10090	5968	1243	124	133	1617	9085
1/02/99	8273	3884	1243	124	133	2160	7544

**Consented abstractions |**

**2 Taylors and Bowyers Streams down to South Ashburton confluence**

<b>Purpose</b>	<b>Consent Number</b>	<b>Type</b>	<b>Rate l s<sup>-1</sup></b>	<b>Depletion rate l s<sup>-1</sup></b>
<b>Stock Water</b>				
ADC Bushside	SCY 710045	Surface Water	gauged	NA
ADC Durrans Carneys RD	SCY 730026	Surface Water	gauged	NA
ADC Goughs	SCY710048	Surface Water	gauged	NA
<b>Irrigation</b>				
Allen C J	CRC950885	Surface Water	gauged	NA
Allen C J	CRC972504	Surface Water	gauged	NA
Highgate Farm Limited	CRC930133c	Surface Water	gauged	NA
Ron Cocks	CRC950930	Surface Water	gauged	NA
Hydes S K	CRC921499	Groundwater	33	25
Allen C J	CRC950931	Surface Water	gauged	NA
Hydes S K	CRC951862	Surface Water	12	NA

**Seasonal assumptions applied to abstractions**

Irrigation season total = 37 x 55% + gauged takes

Stock Water All gauged

**Irrigation season = 20 l s<sup>-1</sup> + gauged stockwater and irrigation takes**

**Non-irrigation season = gauged stockwater takes**

Flows in Litres per second (l s<sup>-1</sup>)

**Tailors at South Branch Confluence Dataset**

Date	Recorder Old Weir (6 am)	Hillview (negative)	Abstractions				Allen/Highgate/Cocks ungauged irrigation	Gauged	
			ADC Durrans	ADC Bushside	ADC Goughs	Confluence at with South Br		Residual + abstractions	
50495	3428		75	79	27	51	20	2310	2562
190495	7817		40	81	35	128	20	2523	2827
60296	4844		83	68	14	923	20	1002	2110
200396	8313	3640	98	46	44	113	20	3579	3900
220396	5462	3640	73	75	45	96	20	3133	3442
270396	4756	3650	55	52	53	103	20	2620	2903
290396	4589	3650	52	45	42	99	20	2430	2688
91297	4676	5271	49	52	25	53	20	672	871
210198	3286	5740	63	51	14	277	20	153	578
40298	2576	5900	64	55	15	39	20	7	200
260298	3287	6111	56	49	16	617	20	22	780
50398	2358	6188	53	49	6	104	20	7	239
260398	3889	6253	62	52	14	12	20	359	519
70498	5385	6394	59	48	15	115	20	698	955
290498	5902	6639	58	65	18	637	20	1026	1824
240698	4080	5577	71	63	18	8	0	1970	2130
160798	7037	3976			average of three	145	0	3540	3685
220798	5464	4030			145	0	0	2274	2419
40898	10100	4203			145	0	0	3117	3262
51098	6008	5260	56	55	12	17	20	1291	1451

**Consented abstractions**

**3 South Branch from Taylors confluence down to North Branch confluence**

Purpose	Consent Number	Type	Rate $l\ s^{-1}$	Depletion rate $l\ s^{-1}$
<b>Stock Water</b>				
ADC	SCY690644	Groundwater	269	128
<b>Irrigation</b>				
Delos Farm Limited	CRC921798	Groundwater	27	21
Greenstreet irrigation	CRC921550A	Groundwater	7	6
Greenstreet irrigation	CRC921550G	Groundwater	10	2
Stewart D	CRC920653	Groundwater	12	2
Aschen D	CRC951747	Surface Water	240	NA
Ashburton Contracting	CRC960507	Surface Water	6	NA
ADC (only dry periods)	SCY710035	Surface Water	42	NA
Greenstreet irrigation	CRC921547C	Surface Water	gauged	NA
Greenstreet irrigation	CRC921547H	Surface Water	230	NA
Greenstreet irrigation	CRC921547J	Surface Water	230	NA
Scott D	CRC952061	Surface Water	85	NA
Tait R	CRC951956	Surface Water	38	NA

**Seasonal assumptions applied to abstractions**

Irrigation season total = 902 x 55% + gauged Greenstreet take  
 Stock Water = 128  
**Irrigation season = 624  $l\ s^{-1}$  + gauged Greenstreet Take**

**Non-irrigation season = 128  $l\ s^{-1}$**

Flows in Litres per second (l s<sup>-1</sup>)

**South Branch at North Branch Confluence Dataset**

Date	Recorder Valetta (6 am)	Taylors at Confluence	Abstractions			Gauged	
			Greenstreet	ungauged irrigation	ungauged stockwater	Confluence at with North Br	Residual + abstractions
4/02/98	1651	7	430	496	128	2968	4022
26/02/98	891	22	497	496	128	2960	4081
5/03/98	1447	7	100	496	128	3382	4106
26/03/98	486	359	247	496	128	2912	3783
7/04/98	936	698	282	496	128	4333	5239
29/04/98	3658	1026	394	496	128	7473	8491
24/06/98	1285	1970	0	0	128	6329	6457
5/10/98	1795	1291	300	496	128	5935	6859
23/03/99	455	1603	77	496	128	3588	4289
26/03/99	4421	5664	83	496	128	14326	15033

**Ashburton River low flow regime**

**Consented abstractions**

**4 North Branch from gorge down to South Branch confluence**

Purpose	Consent Number	Type	Rate l s <sup>-1</sup>	Depletion rate l s <sup>-1</sup>
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**Stock Water**

ADC Pudding Hill	SCY710052	Surface water	Gauged	NA
ADC	SCY710058	Groundwater	18	15
ADC Carneys/Alford Fores	SCY710047	Surface water	42	NA
ADC McFarlanes Tce	SCY710049	Surface water	84	NA
ADC Rawles Crossing	SCY710051	Surface water	226	Never used
ADC Methven Auxillary	SCY710053	Surface water	Gauged	NA
ADC Winchmore Main	SCY710054	Surface water	Gauged	NA

**Irrigation**

**North Branch Main stem**

Aschen B R	CRC951596	Groundwater	12	7
Aschen D G	CRC951553	Groundwater	13	10
Brown J	CRC922073	Groundwater	25	14
Champion Farms LTD	CRC921498	Groundwater	19	7
Champion Farms LTD	CRC921676	Groundwater	15	3
Champion Farms LTD	CRC921677	Groundwater	19	10
Clark W G	CRC970931	Groundwater	4	3
Greenstreet irrigation	CRC921550D	Groundwater	26	11
Greenstreet irrigation	CRC921550E	Groundwater	28	8
Greenstreet irrigation	CRC921550F	Groundwater	5	1
Greenstreet irrigation	CRC921550G	Groundwater	26	5
McIlroy B K	CRC922038	Groundwater	12	5
Shearer D	CRC921565A	Groundwater	13	6
Shearer D	CRC921565B	Groundwater	2	1
Southmark Horticulture	CRC921494	Groundwater	30	8
Stewart D	CRC920653	Groundwater	6	1
Willowdale Farm Limited	CRC921678	Groundwater	28	13
Galloway C	CRC952441	Surface water	240	NA
Leslie B G	CRC960065	Surface water	360	NA
Lowe G A	CRC942232	Surface water	341	NA
Shearer D	CRC951530	Surface water	30	NA
Willowdale Farm Limited	CRC951232	Surface water	28	NA

**Mt Harding Stream**

Clark W G	CRC970931	Groundwater	42	29
Shearer D	CRC921565A	Groundwater	17	9
Shearer D	CRC921565B	Groundwater	28	14
Ashburton Lyndurst	CRC990718	Surface water	114	NA
Methven Golf Club	SCY880013	Surface water	24	NA
Rooney M	CRC951486	Surface water	50	NA

**Ashburton River low flow regime**

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**Osheas Creek**

Aschen B R	CRC951596	Groundwater	20	12
Aschen D G	CRC951553	Groundwater	40	31
Champion Farms LTD	CRC921498	Groundwater	19	7
Champion Farms LTD	CRC921676	Groundwater	23	4
Champion Farms LTD	CRC921677	Groundwater	15	8
Greenstreet irrigation	CRC921550A	Groundwater	21	18
Lowe N	SCY690424	Groundwater	44	11
Snowden R	CRC950584	Groundwater	38	32
Greenstreet irrigation	CRC921547F	Surface water	gauged	NA

**Seasonal assumptions applied to abstractions**

Irrigation season total = 1475 x 55% + gauged Greenstreet take  
 Stock Water = 141 + gauged Pudding Hill, Methven Auxillary, Winchmore Main

**Irrigation season = 952 l s<sup>-1</sup> + gauged takes, Pudding Hill, Methven Auxillary, Winchmore Main, Greenstreet Irrigation**

**Non-irrigation season = 141 l s<sup>-1</sup> + gauged takes, Pudding Hill, Methven Auxillary, Winchmore Main**

Flows in litres per second (l s<sup>-1</sup>)

North Branch Dataset

Date	Recorder		Abstractions					Bywash		residual at Sthbr conflu	correct flow at South Confl	Nth branch at sth con + takes	GW51 Hillview level mm
	Old Weir	Daily mean	Pudding Hill	Methven Aux	Greenstreet	Winchmore Mill	ungauged irrigation	ungauged stockwater	lateral spill				
40298	2551		258	1195	599	289	811	141	28	320	292	3585	-5890
260298	3111		342	937	452	208	811	141	22	516	494	3385	-6110
50398	2352		255	1168	478	178	811	141	40	270	230	3261	-6190
260398	3849		399	1248	916	203	811	141	25	270	245	3963	-6251
70498	5275		353	1166	858	206	811	141	79	430	351	3886	-6392
290498	5521		540	1145	671	232	811	141	1218	2360	1142	4682	-6640
240698	4014		458	1164	0	276	0	141	0	284	284	2323	-5577
51098	5838		495	1068	700	100	811	141	1332	3878	2546	5861	-5260
200199	2620		217	1285	651	298	811	141	28	270	242	3645	-6563
290199	2596		405	1448	109	260	811	141	0	170	170	3126	-6352
50299	2684		370	1272	593	339	811	141	0	184	184	3710	-6178
110299	2544		359	1507	485	428	811	141	7	143	136	3867	-6367
250299	2120		243	1514	84	200	811	141	0	110	110	2935	-6664
90399	2318		452	1329	399	361	811	141	0	115	115	3608	-6556
230399	3595		433	1108	709	375	811	141	0	207	207	3784	-6173
260399	4749		375	1192	662	319	811	141	0	1428	1428	4928	-6040
211299	6446		447	1155	857	533	811	141	121	2317	1815	5759	-3892
290200	4299		407	1223	824	334	811	141	51	624	37	3777	-4240

**Consented abstractions**

**5 Between the North and South Confluences and State Highway One**

Purpose	Consent Number	Type	Rate l s <sup>-1</sup>	Depletion rate l s <sup>-1</sup>
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**Water supply**

ADC	SCY 690643	Groundwater	41	25
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**Irrigation**

Ashburton Contracting	CRC92485	Groundwater	23	6
Brook G T	SCY820104	Groundwater	38	8
Donaldson F L	SCY690106	Groundwater	5	5

**Seasonal assumptions applied to abstractions**

Irrigation season total =  $19 \text{ l s}^{-1} \times 0.55 = 10$

Water supply =  $25 \text{ l s}^{-1}$

**Irrigation season =  $35 \text{ l s}^{-1}$**

**Non-irrigation season =  $25 \text{ l s}^{-1}$**

**Ashburton at SH1 Dataset** Flows in Litres per second (l s<sup>-1</sup>)

Date	Abstractions			gauged			
	South Branch at confluence	North branch at confluence	Combined South and North Branch flows	ungauged irrigation	ungauged water supply	Ashburton at SH1	Ashburton at SH1 + takes
3/04/96	6703	752	7455	10	25	8200	8235
4/02/98	2968	320	3288	10	25	3751	3786
26/02/98	2960	516	3476	10	25	3656	3691
5/03/98	3382	270	3652	10	25	3616	3651
26/03/98	2912	270	3182	10	25	3541	3576
7/04/98	4333	430	4763	10	25	4846	4881
29/04/98	7473	2360	9833	10	25	9318	9353
24/06/98	6329	284	6613	0	25	6767	6792
5/10/98	5935	3878	9813	10	25	10496	10521
23/03/99	3588	207	3795	10	25	4222	4257
26/03/99	14326	1428	15754	10	25	16674	16709
21/12/99	6738	2196	8934	10	25	10274	10309
29/02/00	4513	573	5086	10	25	5126	5161

**Consented abstractions**

**6 Between Digbys Bridge and the North Branch Confluence with the South**

Purpose	Consent Number	Type	Rate $\text{l s}^{-1}$	Depletion rate $\text{l s}^{-1}$
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**Irrigation**

Greenstreet Irrigation	CRC921550D	Groundwater	26	11
Greenstreet Irrigation	CRC921550E	Groundwater	28	8
Mcllroy B.K	CRC922038	Groundwater	12	5

**Seasonal assumptions applied to abstractions**

Irrigation season total =  $24 \text{ l s}^{-1} \times 0.55 = 13$

**Irrigation season** =  $13 \text{ l s}^{-1}$

**Non-irrigation season** =  $0 \text{ l s}^{-1}$

**Ashburton River low flow regime**

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**North Ashburton at Digbys Bridge Dataset**

Flows in Litres per second (l s<sup>-1</sup>)

Date	gauged		Takes		gauged		
	North Branch at Digbys Bridge		ungauged irrigation		North Ashburton at South Confluence Residual	Coniston Waste race	Natural North Branch
18/07/74	5060		0		5540	0	5540
20/01/99	0		13		242	28	227
26/03/99	899		13		1428	0	1441
21/05/99	0		0		405	0	405
23/06/99	2044		0		2413	0	2413
25/06/99	1352		0		1778	0	1778
30/06/99	178		0		678	0	678
21/12/99	1331		13		2196	121	2088
29/02/00	0		13		573	51	535

7 Pudding Hill Dataset

Flows in Litres per second (l s-1)

Date	Gauged	Recorder
	Above ADC intake	Selwyn at Whitecliffs
		Daily mean flow
230372	323	587
190273	211	707
120275	1206	2119
210176	596	971
20476	843	2258
260876	897	2298
20279	468	979
140279	362	921
200279	617	1003
280379	1797	4168
80780	621	2435
10980	1274	4123
270181	652	934
210182	607	753
50282	333	619
250285	311	668
130887	610	1900
130887	610	1978
200887	598	1579
180987	684	1724
180987	684	1833
70188	781	1184
70188	781	1184
170388	611	915
140488	454	833
140488	454	833
270592	429	1144
30692	399	1060
21297	504	852
91297	458	802
181297	293	741
80198	335	699
150198	277	617
210198	288	717
300198	219	718
40298	258	757
110298	188	812
260298	342	772
50398	255	694
190398	785	622
260398	520	529
70498	422	572
51098	514	954
200199	217	620
290199	434	629
50299	510	649
110299	384	647
250299	263	544
90399	543	657
230399	817	1301
260399	1740	4399
211299	1146	1639
200229	672	1010