Ashburton/Hakatere River flow and allocation regimes: Update of modelling results

Prepared for Environment Canterbury

November 2012

Authors/Contributors:
Graeme Horrell
Roddy Henderson
Jani Diettrich

For any information regarding this report please contact:
Graeme Horrell
Scientist
Applied Hydrology
+64-3-343 8036
Graeme.Horrell@niwa.co.nz

National Institute of Water & Atmospheric Research Ltd
10 Kyle Street
Riccarton
Christchurch 8011
PO Box 8602, Riccarton
Christchurch 8440
New Zealand

Phone +64-3-348 8987
Fax +64-3-348 5548

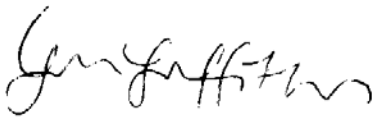
NIWA Client Report No: CHC2012-140
Report date: November 2012
NIWA Project: ENC12504

Contents

Tables

Figures

Reviewed by



George Griffiths

Approved for release by

Charles Pearson

1 Executive Summary

The Ashburton catchment hydrology model of Horrell (2009) has been upgraded and extended to enable modelling of three catchment management scenarios, the third being that of the proposed sub-regional plan.

The modelling results are described in terms of water users' reliability of supply and residual flows at eight key water management locations in the Ashburton catchment.

2 Introduction

The objective of this study is to update and apply the Ashburton flow model developed by Horrell (2009) to demonstrate the impact and effectiveness of the Proposed Sub-Regional Plan for the Ashburton Catchment. In this report we:

- Describe the model, say why it was developed, what it does and what information it provides.
- Resolve a point of difference on the model noted in a peer review in 2002 by Richard de Joux and John Young[+], on the handling of channel leakage from the North Branch. (A meeting with the first reviewer resulted in an agreed methodology for handling leakage.)
- Check Environment Canterbury's consent data base, to find and remove inconsistencies in an earlier dataset provided to NIWA for modelling. Reload revised values into the model together with the specific tributary groundwater stream depletion estimates updated by Environment Canterbury Groundwater Scientist, Matt Smith.
- Include recorded flow data from December 2004 to April 2010 for Bowyers and Taylors tributaries.
- Update the model dataset from the existing end date of July 2008 to include data up until April 2010.
- Apply the model to test three scenarios.
  - Describe the results of running three scenarios and the effect on residual flows and reliability of supply for water users; and compare irrigator reliability of supply with current restrictions measured at State Highway One.

+ now deceased

3 Model description development and upgrades

3.1 Model description

A surface and groundwater investigation was undertaken between 1995 and 2000 to establish what the Ashburton tributaries and mainstem natural flow regime would be without abstraction. The Ashburton catchment has had water abstracted since the 1870's and is now highly allocated.

Ideally a long period of daily timeseries (modelling period here is 28 years) of river flow information at all the multiple river locations plus all abstraction and all bywash locations is required to determine the naturalised flow record at a daily time step. This is impossible as abstractions, bywash and flow at key stream locations across the plains are not continuously measured

The investigation involved concurrent flow measurements at 56 locations, including proposed minimum flow locations, abstraction and bywash locations, and included four permanent flow recorders and 7 monitoring wells.

The detailed concurrent flow measurement investigation does however provide adequate information to determine relationships (regressions Table 3-2) to extend and produce flow records at non-permanent flow locations from the permanently measured (primary sites) locations. These are the key components of the model. While a daily timeseries is impossible to attain, this model provides an adequate statistical method with monthly distributions as outputs.

The modelling of the scenarios are based upon the full record of the South Branch at Mt Somers (1967 to 2010), North Ashburton at Old Weir (1982 -2010) and Taylors from (2004 to 2010).

The individual monthly distributions resulting from the scenarios provide residual flow at the key minimum flow locations as well as the essential reliability of supply figures for water users.

The monthly distributions were combined to provide outputs for the irrigation season (October to April inclusive) and winter season (May to September) show in section 5 Results.

3.2 Why a model was developed and what it does

A model was developed to simulate and display how the Ashburton River and its tributaries would respond under the provisions of the Natural Resources Regional Plan (NRRP) (ECan 2004). The model integrates six tributaries, their residual flows, their stockwater and irrigation abstractions and their individual minimum flows in order to provide information on reliability of supply for all users. Furthermore, it provides valuable information about when and where abstractions could be reduced. But, most importantly, it predicts the behaviour of the residual flow regime at key tributary and main stem locations.

3.3 Model upgrade

The model was updated with additional flow information from 30 July 2008 to 8 April 2010. This extends many tributary records from 8 May 1982 to 8 April 2010, nearly 28 years of data (Section 3.6).

The consented abstraction information for the tributaries and mainstem were corrected and entered into the model (Section 3.5).

The North Branch at Confluence leakage model (section 3.4 below) was added to assess the naturalised flows at this location

Taylors at Confluence flow distributions were upgraded from flow recorders on Bowyers and Taylors, replacing regression values (Section 3.6 (b))

3.4 North Ashburton River at Confluence – leakage model

To allow modelling of the consequences of returning irrigation and stock water takes to the North Ashburton River, a model of leakage to the river bed was needed for the North Ashburton at the Confluence (with the South Ashburton River). This is because not all water returned to the river at a given take point will add to the flow at the Confluence. Until now, two extreme positions had been adopted: one, that all returned water would reach the Confluence; the other, that no returned water would reach the Confluence. The truth lies in between, and the model provides the best answer to this question.

A number of flow measurement gauging runs were available between 1998 and 2000. The dataset comprised flows from the recorder on the North Ashburton, gaugings of flow at the confluence with the South Ashburton, and measurements of major takes and bywash with estimates of the minor takes along the reach between these two locations. The data are shown in Table 2-1.

A relationship was required to populate column 5 of Table 3-1, viz the Pudding Hill contribution to North branch flows. Pudding Hill Stream enhances the North Branch mostly as subsurface flow; this is a steep channel which frequently has no observable surface flow (Figure 3-1). The subsurface delay times are the likely reason for the poor relationship with the North Branch at Old Weir measured flows (Figure 3-2). If more concurrent gaugings were available then the scatter and degree of correlation may still not improve. In 2004 when this issue arose the author considered this relationship to be too poor to use.

However, it is now agreed that by using this relationship (Figure 3-2) the North Branch leakage analysis can be advanced. In Figure 3-2 the North Branch flow measured at the Old Weir appears on the horizontal axis while the additional flow derived from a water balance at below the Methven Auxiliary stockwater take provides the Pudding Hill stream contribution on the vertical axis.

The total surface flow coming into the North Branch is the Old Weir + Pudding Hill ((column 5 - note that five of the 12 values are measured increases, while seven are from the regression shown in Figure 3-2) + 10 % of the gauged inflows of O'Sheas and Mt Harding (90% of the flow is assumed to be upstream losses from the North Branch and 10 % assumed to be rainfall contribution – as recharge into these spring fed streams) (Table 3-1).

Table 3-1: North Branch leakage model inputs and outputs (l/s).

1	2	3	4	5	6	7	8	9	10	11	12	13	14
Date	Old Weir (6 am)	Residual no flows O'Shea	Mt Harding	Pudding Hill (tribs u/s of Methven auxillary	Total surface inflows (sum of cols 2 to 5)	Abstraction	Bywash Coniston removed	Net flow at confl. w/o leakage (col 6 + col 8 – col 7)	Actual measured minus Coniston	Leakage Estimate (col 9 – col 10)	Leakage model linear residual vs net	Net flows with leakage	Net flow with leakage minus actual (residua)
24/06/1998	4080	44	131	581		1440	4		284				
05/10/1998	6041	39	954	1141	7281	2325	4	4960	2546	2414	2898	2062	-484
20/01/1999	2678	12	184	117	2815	2458	4	361	242	119	231	130	-112
29/01/1990	2631	588	416	86	2817	1973	4	848	170	678	513	335	165
05/02 /1990	2693	31	261	122	2845	2469	4	380	184	196	242	138	-46
11/02/1990	2570	33	371	70	2681	2685	4	1	136	-135	22	0	-136
25/02/1990	2084	506	123	0	2147	1979	4	172	110	62	121	51	-59
09/03/1990	2288	34	398	21	2352	2313	4	43	115	-72	46	0	-115
23/03/1990	2738	58	436	515	3302	2457	4	849	207	642	514	335	128
26/03/1990	4790	255	693	1658		2438	4		1428				
21/12/1990	6659	24	775	1258	7997	2810	385	5572	2196	3376	3253	2319	123
29/02/2000	4646	19	733	140	4861	2646	540	2755	573	2182	1619	1136	563
												Bias	3
												RMS error	257

The leakage model will be used to assess losses along the reach, and is driven by modelled flows at the downstream end of the reach (Table 3-1). Thus the system to be modelled is the reach, its leakage and its inflows and abstractions. Total inflows along this reach of the river are the sum of the upstream river flow (North Branch at Old Weir, column 2), Pudding Hill Stream (column 5) and the rainfall component of O'Sheas and Mt Harding (columns 3 and 4 respectively). It is assumed that all other flow in these two tributaries has leaked from the North Branch and is thus recycled within the reach. The rain recharge value has been set at 10% of the flow in these two tributaries. Column 6 is the net inflow to the reach. Column 7 is the sum of measured and estimated abstractions. Column 8 is the Coniston bywash. Column 9 is the expected North Ashburton flow at the Confluence with the South Ashburton if there was no leakage to groundwater outside the reach. Column 10 is the measured flow at the Confluence. Column 11 is the difference between columns 9 and 10, and represents the estimated leakage. We examined these residual values with respect to other measured quantities, and found a reasonable relationship with the expected flow at the Confluence (Figure 3- 3).

Figure 3-1: Pudding Hill river channel downstream of State Highway 72.

We excluded the values from the single winter measurement set (24 June 1998) because they plotted as a significant outlier, and were not representative of the usual conditions during the irrigation season. We also excluded the values from 26 March 1999 as the reach was gradually recharging after a significant dry spell.

The linear regression of Figure 3-3 is applied to the estimated flows without leakage from column 11 to give the estimated leakage (column 12). This is subtracted from the estimated flow of column 9 to give the estimated net flow at the confluence, set to be always greater than or equal to zero (column 13). Differences between the modelled flow at the confluence and the measurements are in column 14. At the bottom the bias (3 l/s) and the RMS error (257 l/s) is shown.

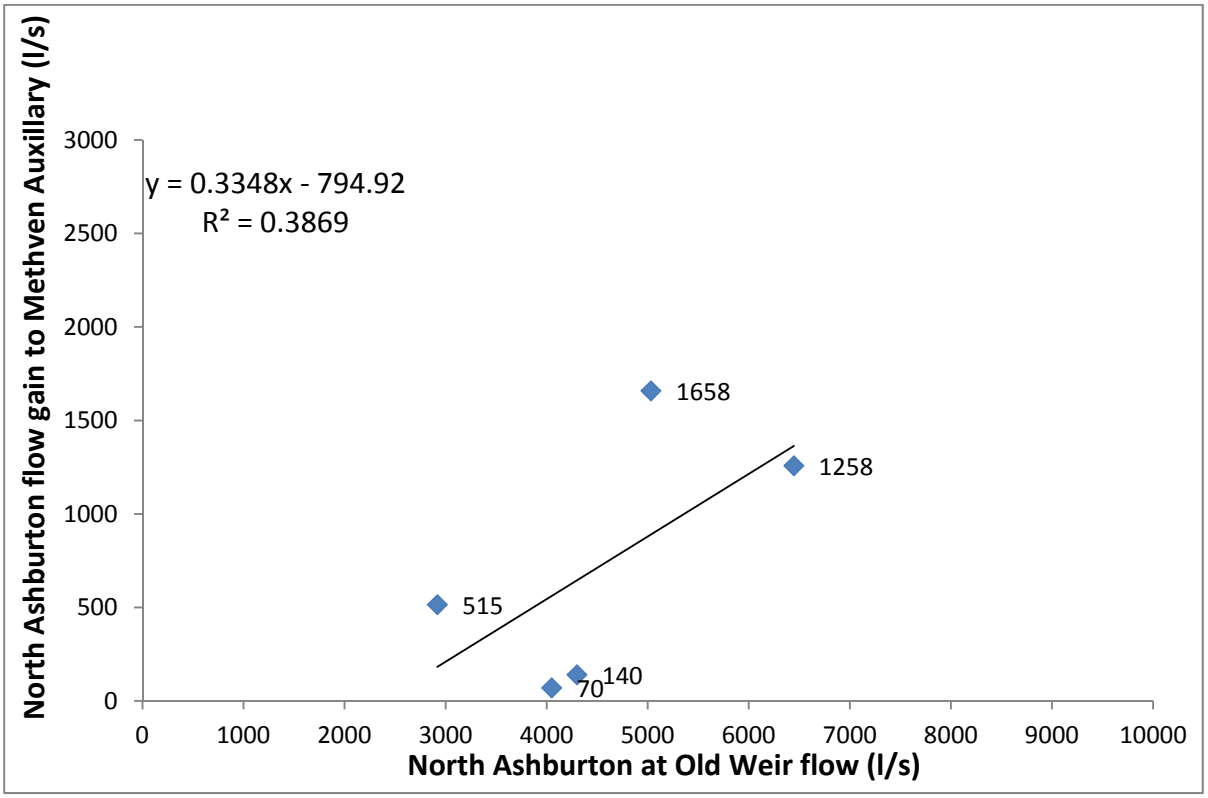


Figure 3-2: Relationship between North Branch flows measured at the Old Weir and gains in flow (Pudding Hill) contribution to the Methven Auxiliary on the North Branch.

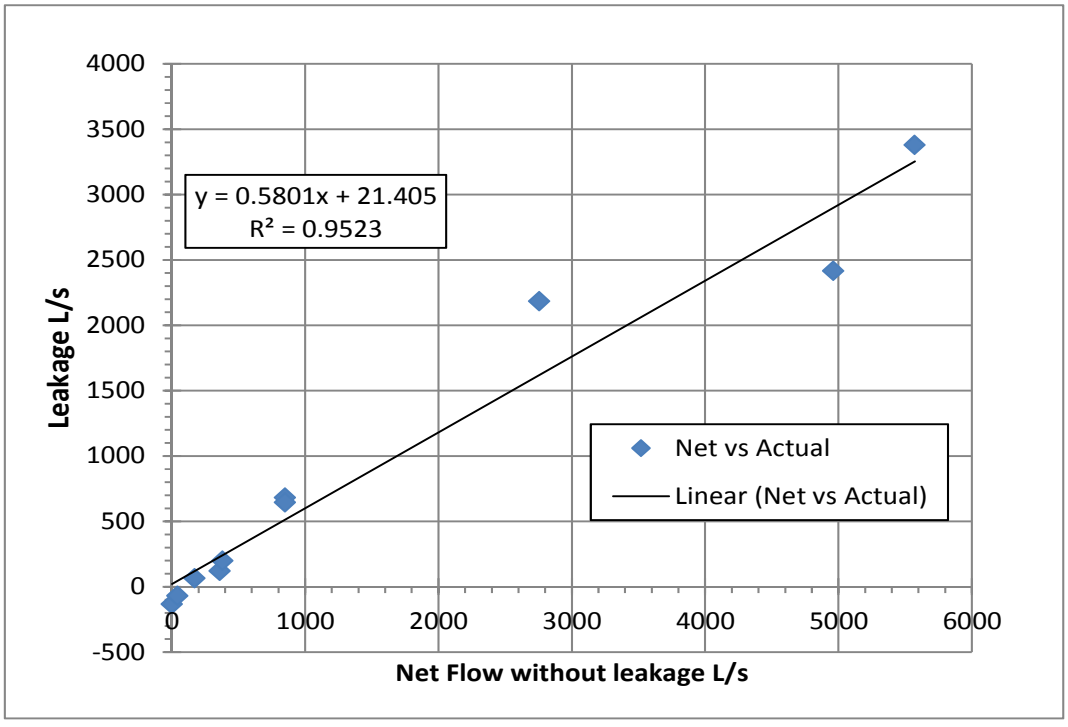


Figure 3-3: Net North Ashburton flow at the Confluence with the South Ashburton, allowing for leakage versus without leakage.

The general result of the application of this model is that approximately 60% of flows in the river are lost to groundwater. It is not reasonable to assume that this proportion persists at high flows in the river, and so application of this relationship is capped at 5,000 l/s (a maximum loss rate of 5,000 l/s). This model is applied to a daily flow series of the natural flows in the North Ashburton and its major surface flow tributaries, to derive a natural flow series at the Confluence

This groundwater-surface water interaction relationship could be described with a curve rather than a straight line. We looked at using a curve, but it would show losses peak at about 3,000 l/s whereas it is believed to be more. The straight line was employed to give a peak at 5,000 l/s. Also the straight line goes through zero as required, which the curve did not.

Richard de Joux commented on the above analysis:

"I have looked at your data and assumptions and agree with your methodology. Even though the "crude bit" might seem to be crude, in reality I would not expect a very good relationship because there is considerable storage within the gravel fan of Pudding Hill and there will be variable time delays when this water is released from storage back into the North Ashburton River. Your method does allay my concern regarding how abstractions should be treated within losing reaches of the river."

3.5 Consent corrections

Time was spent at Environment Canterbury (ECan) offices and with, the assistance of Sarah Hunt (ECan), many inconsistencies, and consents located in the incorrect tributaries, were identified. As a result, A block irrigators were reduced on the North Branch by 33 % and on Mt Harding Stream by 91%. These were the two tributaries of concern to the author.

The derived consented abstractions for the tributaries applied to the updated model are listed in Appendix A.

3.6 Other model enhancements

(a) The flow records were split into two seasons; irrigation (1 October to 30 April) and non-irrigation or winter season (1 May to 30 September). Each season was modelled to provide information on the likely residual flows at the minimum flow locations. In addition, the records were split into monthly periods for each year of analysis. Distributions were completed for individual months as well as for the combined months of the irrigation and non-irrigation seasons.

(b) In December 2004 ECan installed water level recorders on Bowyers Stream and Taylors Stream; records (2004 to 2010) from these sites were preferred to the previously predicted ones using flows from the North Branch and nearby Hillview groundwater levels.

3.7 Model updating

The model was extended with data from 30 July 2008 to 8 April 2010. The method used was the same as that described in the Horrell (2001, 2004) reports for six of the eight regressions. The equations from Horrell (2004) are shown in Table 3-2 along with the updated Taylors regression using the two new recorders Bowyers at State Highway 72 and Taylors at State

Highway 72 from Horrell (2009). The revised North Branch at South Branch regression equation (Table 3-2) is also included.

A flow record was produced for all key locations. The primary site records have many gaps (approximately 1 year in 26 years). Gaps were omitted from the analysis.

Table 3-2: Regression equations relating flow (l/s) at water level recorder sites to tributary flows (l/s).

Regression equations (flow, l/s)	Adjusted r^2	Standard Error l s^{-1}	Number of values
South Ashburton at Valetta = (Mt Somers x 0.892) – 141	.94	413	12
Taylors at South Branch confluence = (Bowyers + Taylors) x 1.577 – 1,018	.92	412	19
South Branch at Nth Confl = (Valetta + Taylors) x 1.242 + 2,306	.98	509	10
Leakage = (Old Weir + Pudding Hill + 10% O'Shea +10% Mt Harding) x 0.5801 +21.4 (Note: Leakage is maximised at 5,000 l/s)	.95	234	10
North Branch at Sth Conf = (Old Weir + Pudding Hill + 10% O'Shea +10% Mt Harding) - Leakage			
SH1 = (Sth Branch at Confl + Nth Branch at Confl) x 1.049 + 75	.99	460	13
Digby's Bridge = Nth Branch at Confluence x 0.982 - 443	.99	152	9
Mt Harding = ($\log_{10}$ Old Weir) x 1,530 – 4,352	.78	134	11
O'Shea + Snowden = ($\log_{10}$ Old Weir) x 513 + (Ashburton Forks x 0.638) + 4	.83	79	10

3.8 Model reliability

The model was constructed using the regressions displayed in Table 3-2. Their standard errors should be taken into account when evaluating model outputs.

3.9 Model outputs

The model was used to establish a natural flow time series which is able to be used to test various scenarios.

4 Modelled scenario

Ideally modelling the flow regime status quo along with management scenarios in a daily time step model is preferable. However such modelling is impossible because catchment wide abstractions were not measured. Without any knowledge of where or when abstractions occurred, it is impossible to model what was taken and to calculate its reliability. To attempt to overcome this, a dataset of naturalised flows was used from which prescribed allocations can be modelled. Model outputs such as residual flows at minimum flow locations or abstraction reliability were estimated.

The residual flow data recorded at SH1 (the current minimum flow site) from 1996 to the present is useful only to provide fully restricted information (all abstractions cease) for comparison with the scenario outputs.

The management options to be examined and their modelling requirements are described in the following sections.

4.1 Scenario 1

This represents the worst case abstraction scenario representing the status quo with full instantaneous consented takes for the Rangitata Diversion Race Limited (RDRL) from the South Ashburton, Ashburton District Council (ADC) stockwater abstractions as they stood at the beginning of this LWRP process, and all A and B permit maximum rates of abstraction within the catchment. Modelling of minimum flows on all tributaries are as proposed in the 2004 NRRP displayed in Table 4-1.

Table 4-1: 2004 NRRP A and B Permit minimum fows and locations.

Tributary	A and B permit minimum flow location	A Permit minimum flow (l/s)	B Permit minimum flow (l/s)
South Branch	Below RDR intake	3,200	4,000
Taylors	At South Branch confluence	500	3,700
North Branch	At South Branch confluence	1000	4,000
O'Sheas	Above North Branch confluence	450	1,000
Mt Harding	Aitken Road	500	1,100
Pudding Hill	Above ADC intake	80	1,600
Main stem	State Highway 1	6,000 Oct – April 5,000 May - Sept	14,000

One change is to the mainstem at State Highway One (SH1) minimum flow with the introduction of the Land and Water Regional Plan 6,000 l/s all year, a modification of the 2004 NRRP, 6,000 l/s from October to April (inclusive) and 5,000 l/s from May to September.

Those groundwater abstractions not subject to a minimum flow (such as ADC) will not be restricted when a minimum flow in the tributary or mainstem occurs.

4.2 Scenario 2

This is the same as Scenario 1 with one change - the A permit surface water abstractions are modelled at their average rate of abstraction instead of their maximum instantaneous rate.

This scenario represents A permit (maximum) abstraction rates closer to what would really occur.

4.3 Scenario 3

This represents the notified LWRP and has the following modifications:

RDR, A permit is reduced to 5,100 l/s from 7,100 l/s and is subject to a residual flow of 3,200 l/s in summer and 2,300 l/s in winter, and B Permit provides RDR with a take of 2,000 l/s.

ADC consented takes from the Ashburton Catchment are reduced by a total of 2,000 l/s. As the most difficult river reach to achieve the LWRP minimum flows is the North Branch, the largest reduction to ADC takes is on the mainstem and tributaries of the North Branch. The method employed to achieve this was to reduce the ADC surface takes on the North Branch mainstem and tributary takes by 57 %. The South Branch and Taylors takes are reduced by 30% (Table 4-2).

Table 4-2: Ashburton District Council stockwater abstractions and proposed reductions.

Tributary	Name of abstraction	Total abstraction l/s	Reduction l/s	Reduction %	Remaining take l/s
Taylors	Bushside Goughs Carneys	376	113	30%	263
Pudding Hill	Pudding hill	509	290	57%	219
Mt Harding	Winchmore	566	323	57%	243
North Branch Main Stem	Methven Auxillary	1,133	646	57%	487
North Branch Main Stem	GW Melrose and unnamed	Stream depletion 25	0	0%	25
Nth Branch Main Stem	McFarlanes Tce	84	48	57%	36
South Branch above RDR	Brothers	1,699	510	30%	1189
South Branch above RDR	Woolshed	113	34	30%	79
South Branch below RDR	Langdons120 and 42 (42 part of 120)	120	36	30%	84

All other A permits were modelled at their average rate of take. Groundwater stream depletion takes of 5 l/s or more were subjected to a minimum flow while those under 5 l/s were able to continue exercising their abstraction after a minimum flow was reached.

B permits abstract at their full rate of take.

Greenstreet Irrigation Scheme abstracts only from South Branch (not also from O'Sheas as is the case currently) and with LWRP notified minimum flow.

5 Results

The results of modelling Scenario's 1, 2 and 3 are described below. Further definitions are available in Table 5-1.

Table 5-1: Further explanation of figures and tables.

Example	Explanation
Residual River flows	
% of time below minimum flow	Minimum flow is the level at which irrigators are on full restriction. This is the % of time irrigators are on full restriction.
% of time at minimum	Flat lining at minimum flow indicates the duration of time the residual flow is low due to stockwater and irrigation abstractions. Irrigators may reduce abstractions to maintain flows just above the minimum flow.
Irrigation and stockwater reliability	
Full abstraction	All abstractions start at full abstraction on the left of the graph, the reliability of supply of the full abstraction is derived from the horizontal axis as a percentage of time.
Full restriction (no abstraction)	River is below the minimum flow (or for stockwater, natural river flows have depleted) there is no irrigating and the abstraction line drops to zero. The period of time at full restriction can be derived from the horizontal axis as a percentage of time.
Partial restriction	The period an irrigator cannot take their full abstraction to avoid reducing the flow below the minimum

The current reliability relates to actual use of water and is obtained from the residual flow measured at the SH1 recorder in terms of irrigation occurring or not occurring, whereas, the rest of the scenario analyses provide values for irrigation abstractions for the potential irrigable water available.

The full abstraction of the 7,100 l/s RDR take from the South branch is a large abstraction which equates to approximately 70% of the natural South Ashburton River mean flow at the RDR intake. It is not exercised very often as water from the Rangitata River frequently satisfies RDR's needs. The flows and management decisions of the RDR related to the Rangitata River abstraction are not modelled here, so a full take by the RDR is assumed. However an observation of RDR's abstraction record from the South Branch for the period 21 September to 2009 to 5 September 2011 while only for two years, shows the full 7100 l/s was never abstracted, the maximum take was 6690 l/s for a short period and more than 5000 l/s was abstracted for only 2% of .this time.

The values in the results which follow simply display the water available from the South Branch, and the low reliability of supply for the full abstraction displayed in the graphs is a reflection of the very large consented take.

The modelling of the scenarios are based upon the full record of the South Branch at Mt Somers (1967 to 2010), North Ashburton at Old Weir (1982 -2010) and Taylors from (2004 to 2010). The primary sites were applied to the respective locations and tributaries using the regression equations in Table 3-2, with the resulting flow distributions being the information the model uses.

5.1 Scenario 1

5.1.1 A Block reliability of supply

As described above it is difficult to describe the impacts upon the large RDR take knowing the full use of this abstraction occurs only rarely.

For A Block irrigators reliability of supply refer to Figure 5-1.

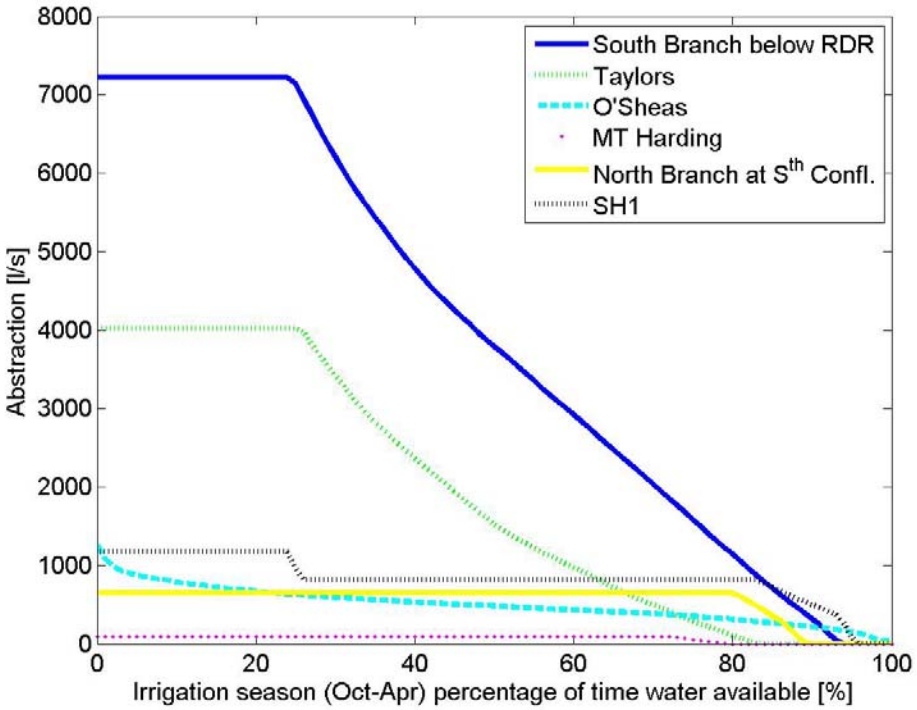


Figure 5-1: Scenario 1 A block irrigators reliability of supply.

Taylors irrigators would be able to take the full abstraction for 25 % of the time and abstract less than their maximum rate for 75 % of the time. This is similar to the RDR South Branch situation which is, a very large take compared to the flow regime.

O'Sheas abstraction graph shows that the one large Greenstreet take along with other O'Sheas irrigators would not be fulfilled for 99% of time. However the supplementary take from the South Branch would partially improve the reliability of supply in this scenario for Greenstreet who would be the best off for reliability of all irrigators in Scenario 1, although they would be below what could be actually achieved today.

Mt Harding and North Branch irrigators would receive their full allocation for approximately 72 % and 80 % of the time respectively but their abstractions would be reduced for the remaining 28 % and 20 % of the time.

5.1.2 Residual flows at minimum flow locations

The South Branch below the RDR will be flat lined (Figure 5-2) for approximately 68 % of the time, while Taylors stream will be flat lined at the minimum flow for at least 57 % of the time. O'Sheas will be flat lined for 95 % at the minimum flow.

The Pudding Hill ADC stockwater take is very large for the size of the stream and the river will be below the minimum flow for 16 % of the time.

The North Branch and Ashburton mainstems will not experience long periods of flat lining (both 9%), but they will both be below the minimum flow for 11 % of time.

For winter residual flows – the South Branch below RDR would be flat lined for 67 % of the time and on full restriction for 8 % of the time. SH1 would be below the minimum for 4 % of the time (Figure 5-3).

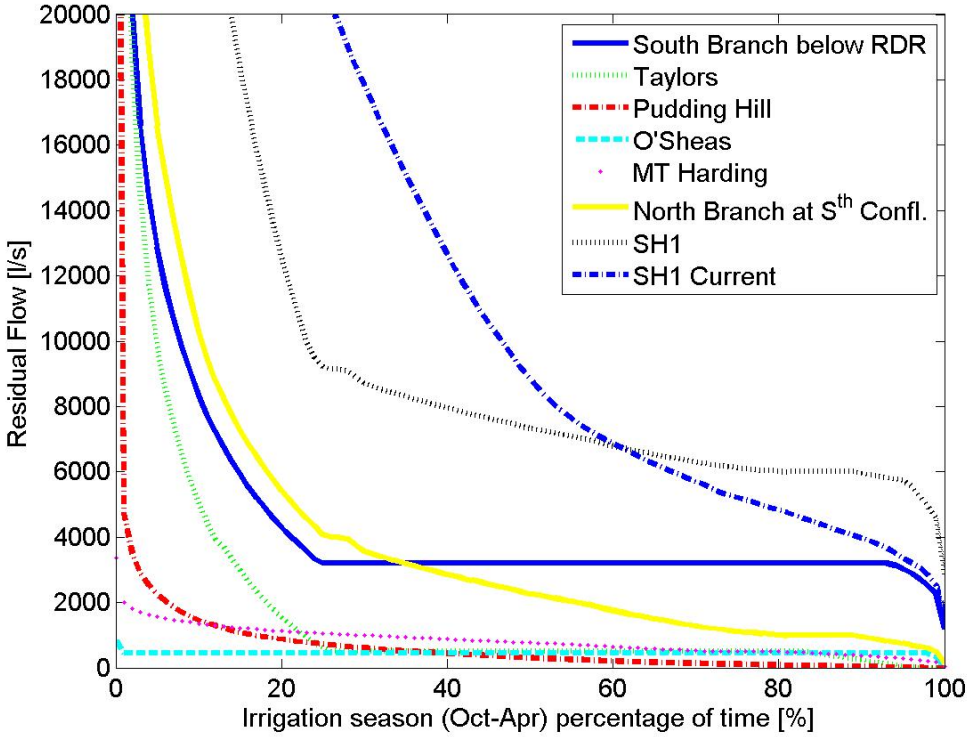


Figure 5-2: Scenario 1 residual flows at minimum flow locations (irrigation season).

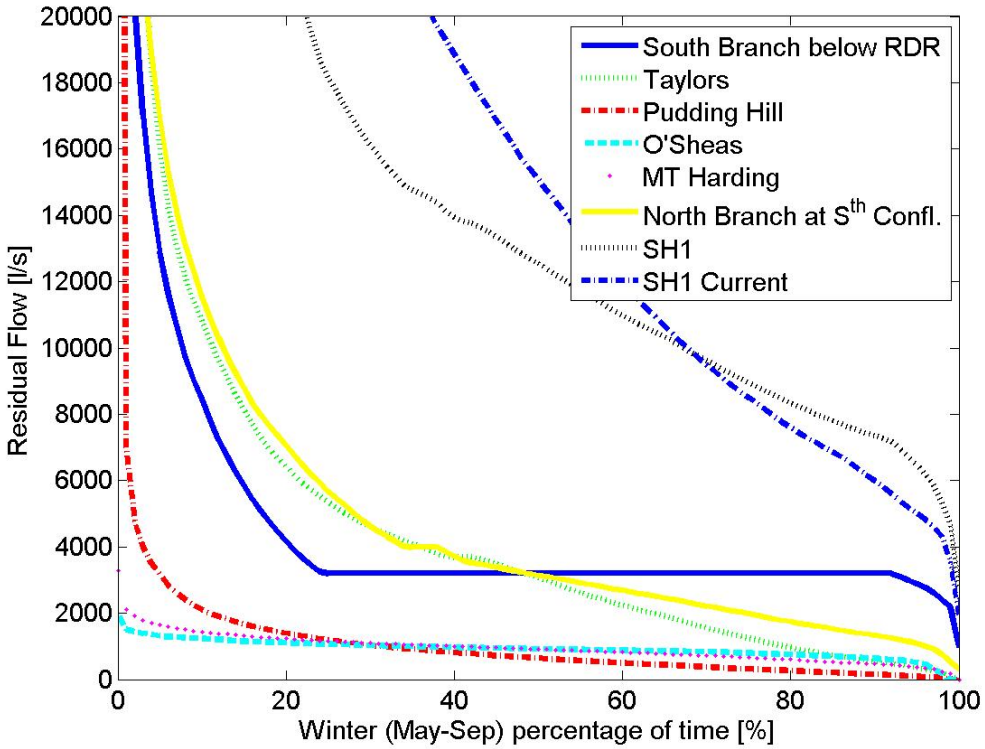


Figure 5-3: Scenario 1 residual flows at minimum flow locations (non-irrigation season).

5.1.3 ADC stockwater reliability of supply

The only reduction to stockwater abstractions (Figure 5-4) is the take from Pudding Hill where during the summer the take will be reduced for 28 % of the time while in winter for 9 % of time (Figure 5-5).

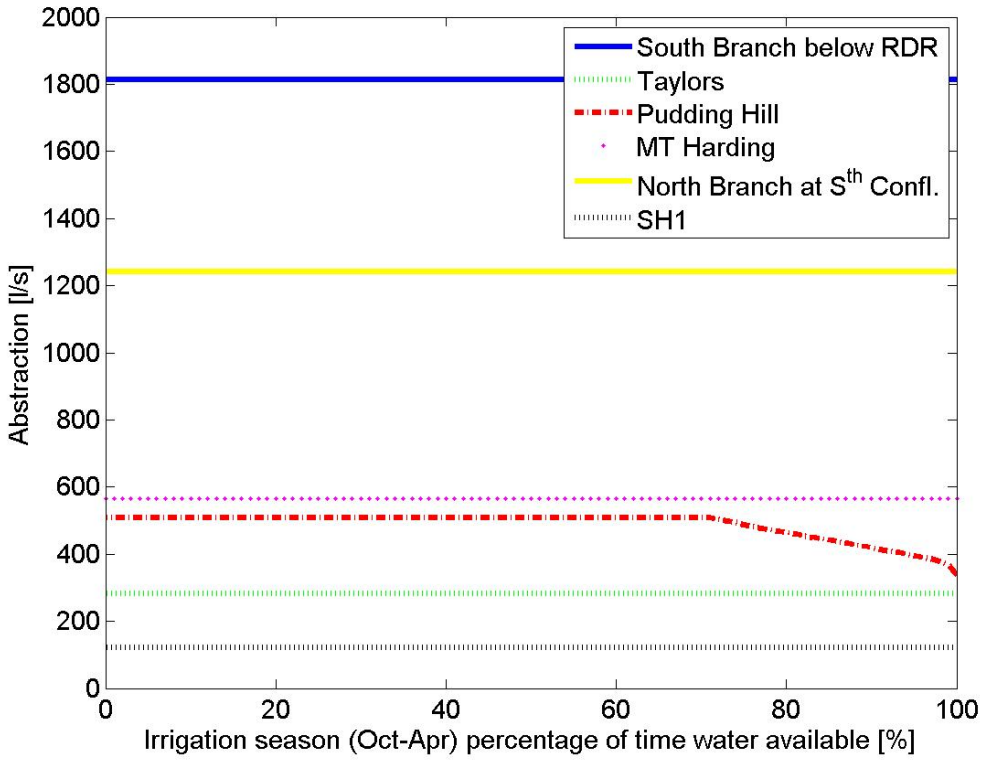


Figure 5-4: Scenario 1 ADC stockwater reliability of supply (irrigation season).

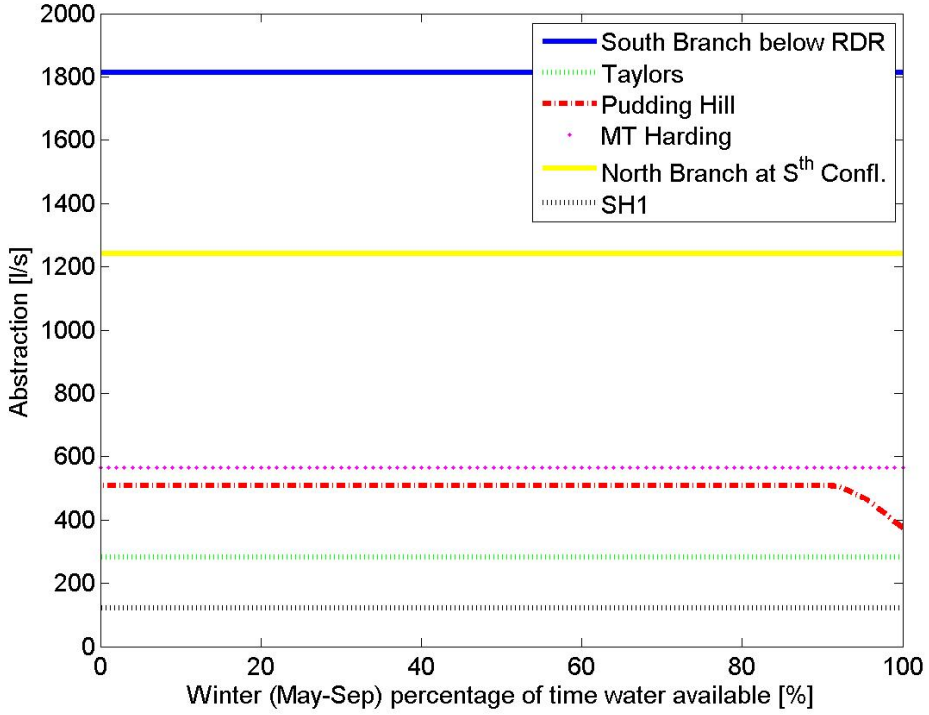


Figure 5-5: Scenario 1 ADC stockwater reliability of supply (non-irrigation season).

5.1.4 B Block reliability of supply

Taylors and North Branch B block abstractors would have the opportunity of full abstractions during the irrigation season (Figure 5-6) for 12 % and 25 % of the time.

During the winter (non-irrigation season) the full abstraction from Taylors is available 39 % and for North Branch 34 % of the time (Figure 5-7)

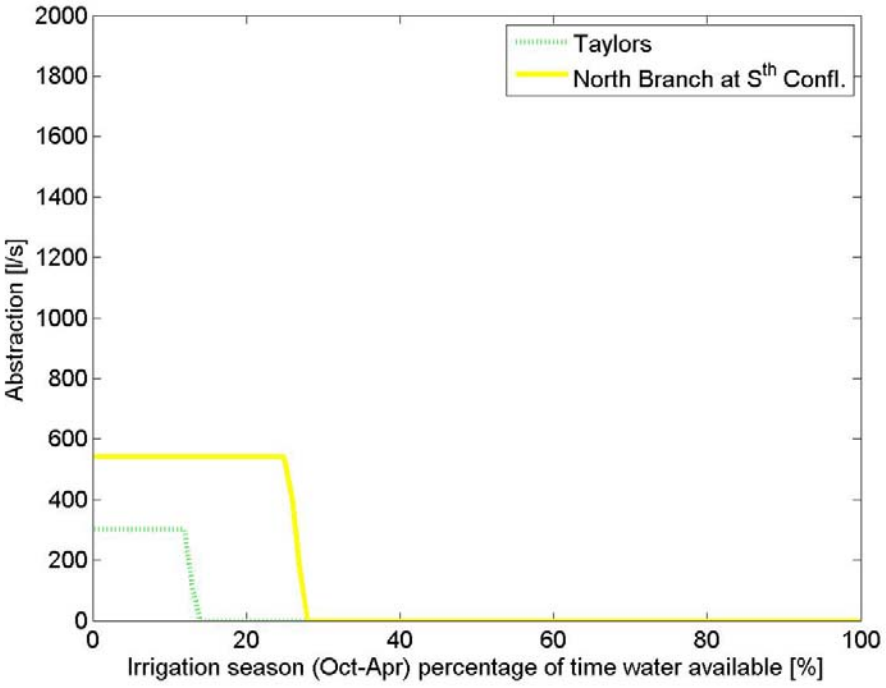


Figure 5-6: Scenario 1 B block irrigators reliability of supply (irrigation season).

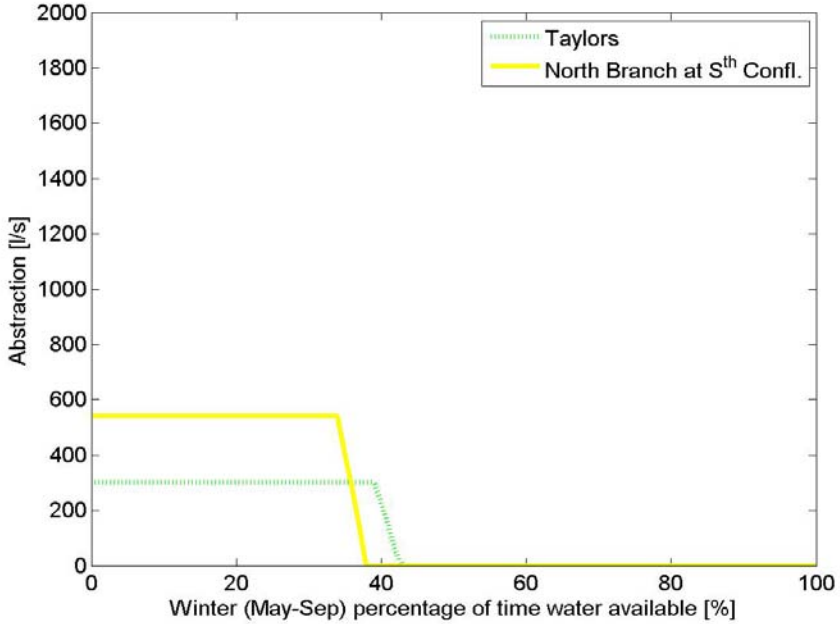


Figure 5-7: Scenario 1 B block irrigators reliability of supply (non-irrigation season).

5.2 Scenario 2

5.2.1 A Block reliability of supply

Here too as described above it is difficult to describe the impacts upon the large RDR take knowing the full use of this abstraction occurs only rarely.

For A Block irrigators reliability of supply refer to Figure 5-8.

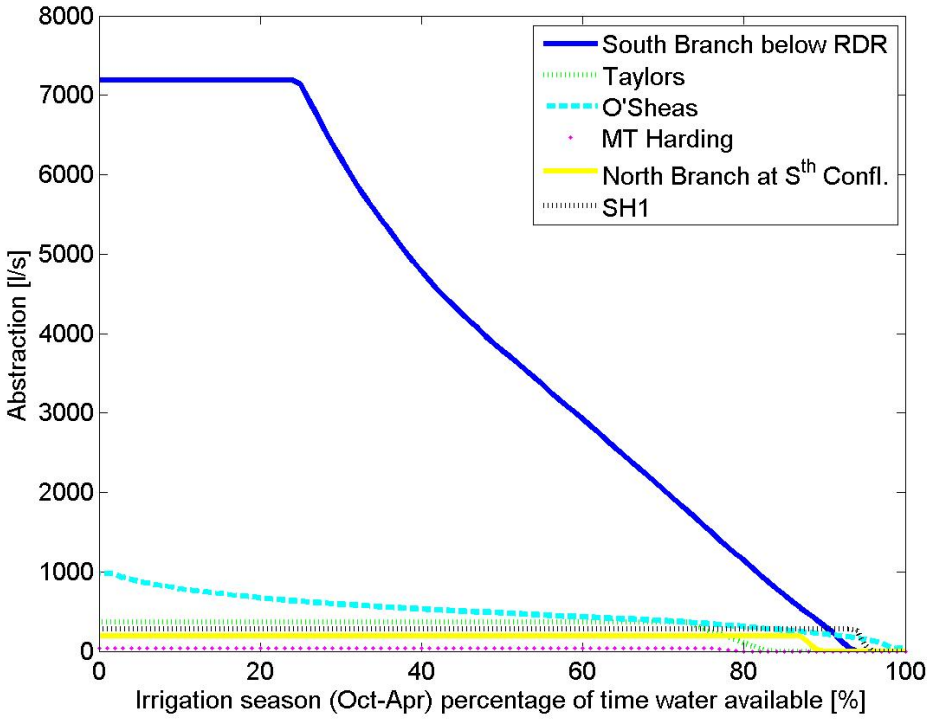


Figure 5-8: Scenario 2 A block irrigators reliability of supply.

Taylors irrigators would be able to take the full abstraction for 73 % of the time and abstract less than their maximum rate for 27 % of the time. This Scenario considerably reduces the consented takes from 4,020 l/s down to 365 l/s owing to the averaging of consented abstractions.

O'Sheas abstraction graph shows the one large Greenstreet take along with other O'Sheas irrigators would not be fulfilled for 97 % of time, but the supplementary take from the South Branch would partially improve the reliability of supply in this scenario for Greenstreet.

Mt Harding and North Branch irrigators would receive their full allocation for approximately 76 % and 87 % of the time respectively but their abstractions would be reduced for the remaining 24 % and 13 % of the time.

5.2.2 Residual flows at minimum flow locations

The South Branch below the RDR will be flat lined (Figure 5-9) for approximately 68 % of the time while Taylors stream will be flat lined at the minimum flow for at least 10 % of the time. O'Sheas will be flat lined for 95% of the time.

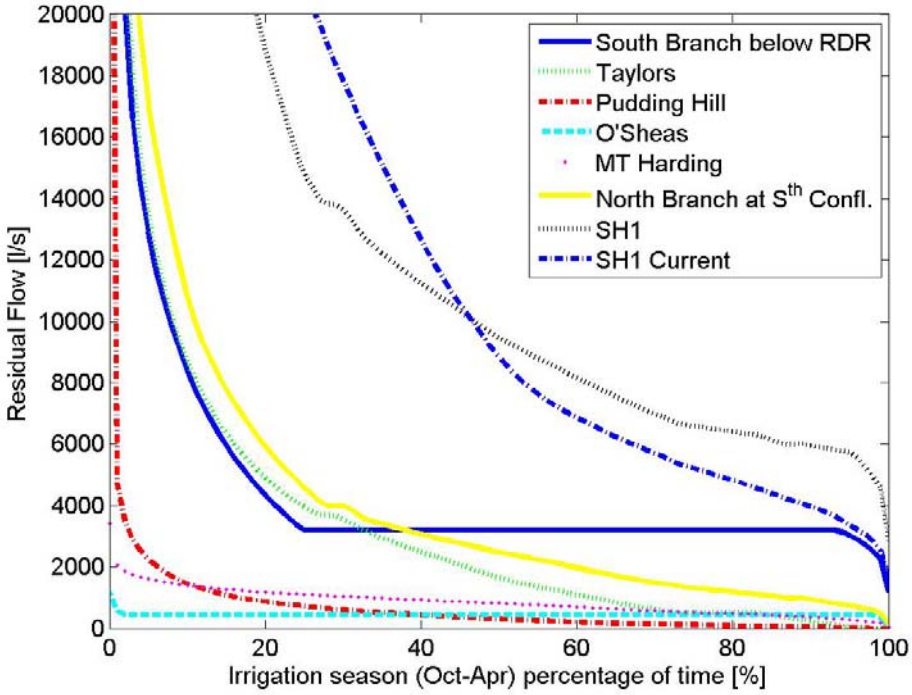


Figure 5-9: Scenario 2 residual flows at minimum flow locations (irrigation season).

The Pudding Hill ADC stockwater take is very large for the size of the stream and the river will be below the minimum flow for 16 % of the time.

The North Branch and Ashburton mainstems will not experience long periods of flat lining, but they will be below the minimum flow for 11 % of time.

For winter residual flows the South Branch below RDR would be flat lined for 67 % of the time and on full restriction for 8 % of the time. SH1 would be below the minimum for 4 % of the time (Figure 5-10).

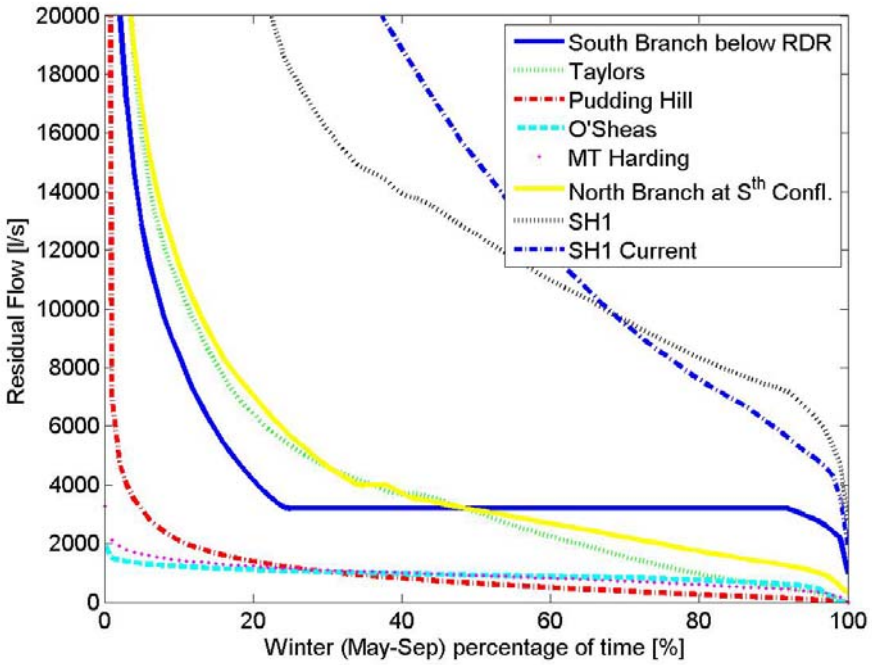


Figure 5-10: Scenario 2 residual flows at minimum flow locations (non-irrigation season).

5.2.3 ADC stockwater reliability of supply

The only reduction to stockwater abstractions (Figure 5-11) is the take from Pudding Hill where during the summer the take will be reduced for 28 % of the time while in winter for 9% of time (Figure 5-12). These are the same results as Scenario 1.

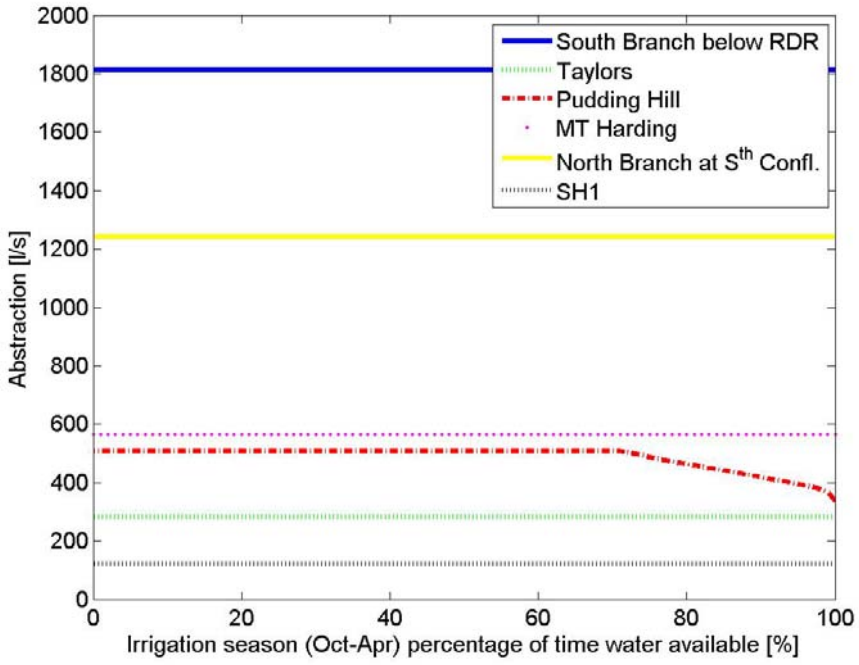


Figure 5-11: Scenario 2 ADC stockwater reliability of supply (irrigation season).

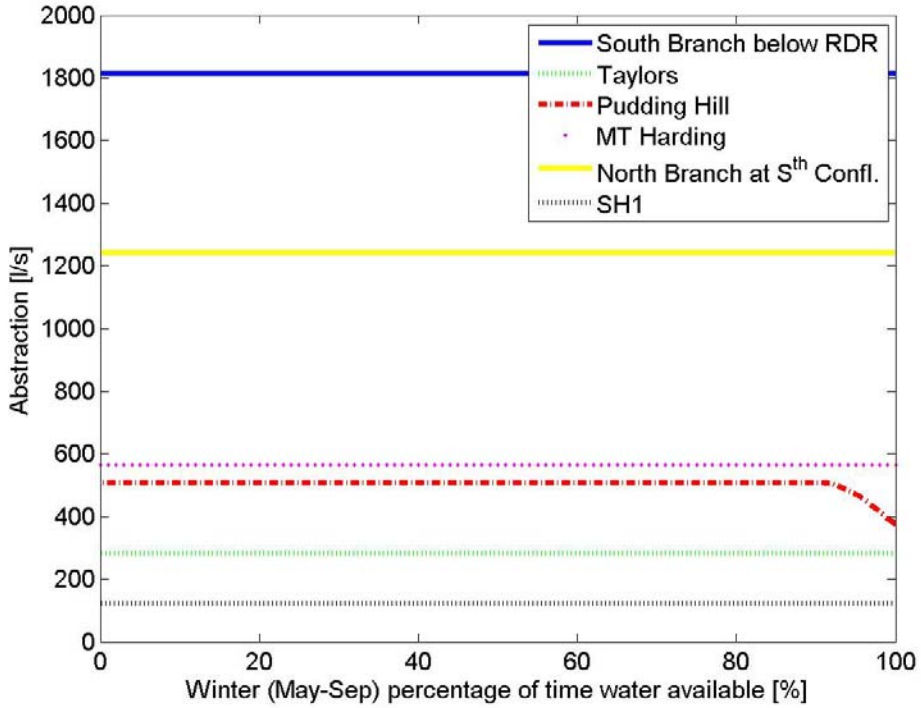


Figure 5-12: Scenario 2 ADC stockwater reliability of supply (non-irrigation season).

5.2.4 B Block reliability of supply

Taylors and North Branch B block abstractors would have the opportunity of full abstractions during the irrigation season (Figure 5-13) for 26 and 27 % of the time respectively.

During the winter (non-irrigation season) the full abstraction from Taylors is available 39 % of the time for North Branch 34% of the time (Figure 5-14).

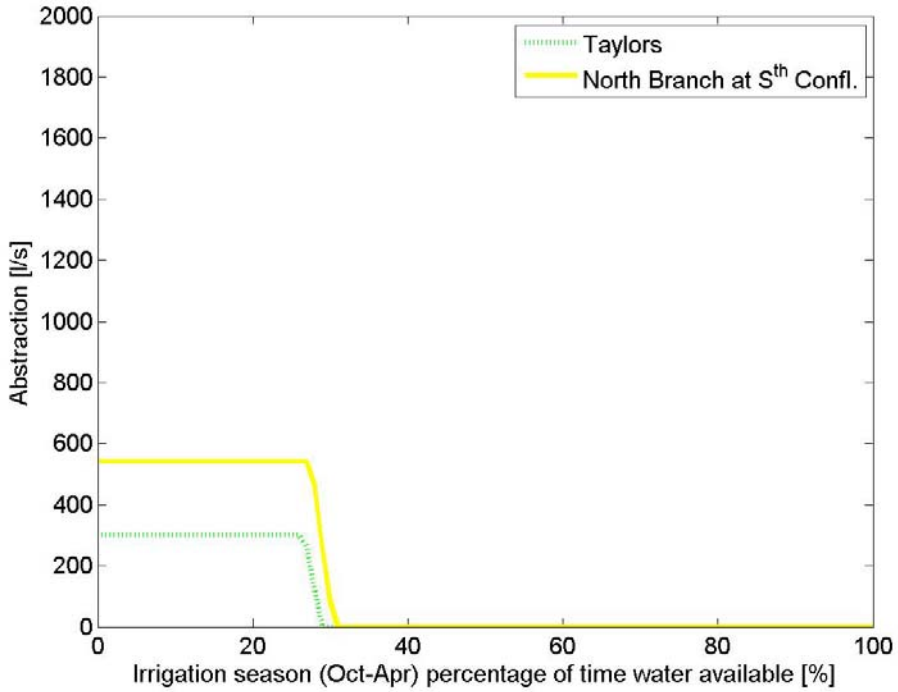


Figure 5-13:Scenario 2 B block irrigators reliability of supply (irrigation season).

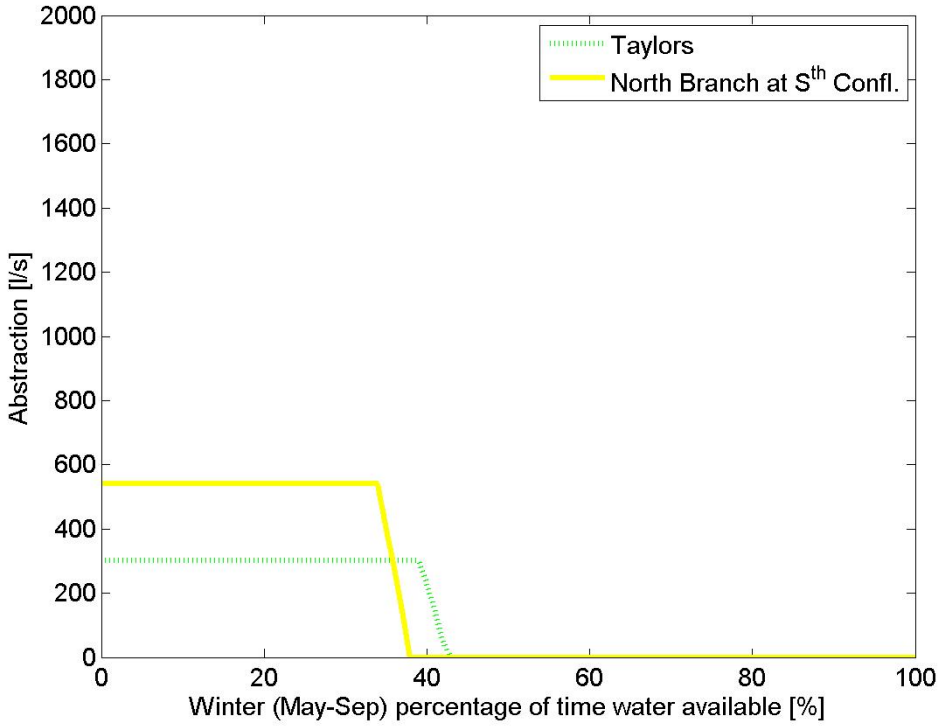


Figure 5-14:Scenario 2 B block irrigators reliability of supply (non-irrigation season).

5.3 Scenario 3

5.3.1 A Block reliability of supply

Again as described above it is difficult to describe the impacts upon the large RDR take knowing the full use of this abstraction occurs only rarely.

For A Block irrigators reliability of supply refer to Figure 5-15.

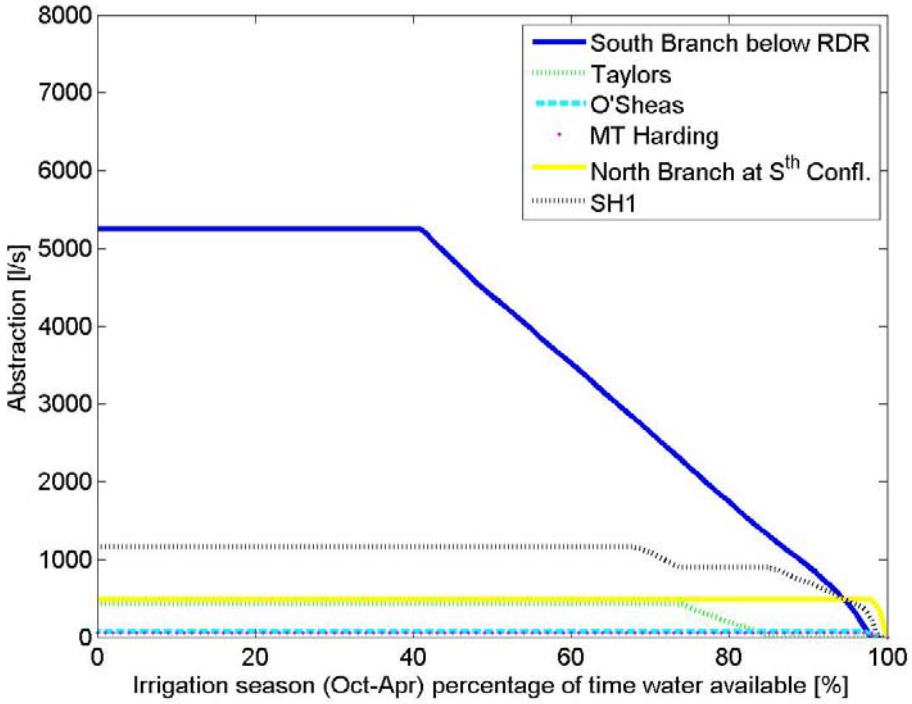


Figure 5-15:Scenario 3 A block irrigators reliability of supply.

Taylors irrigators would be able to take the full abstraction for 73 % of the time and abstract less than their maximum rate for 27 % of the time.

O'Sheas abstractions show a very high reliability of supply 97 % of the time as a result of the Greenstreet full take being transferred to the South Branch.

Mt Harding and North Branch irrigators would receive their full allocation for approximately 97 % and 98 % of the time respectively which is an improved reliability of supply compared to previous scenarios

5.3.2 Residual flows at minimum flow locations

The South Branch below the RDR will be flat lined (Figure 5-16) for approximately 55 % of the time at the A permit minimum flow while a further 12 % is due to the B permit abstractions, while Taylors stream will be flat lined at the A permit minimum flow for at least 12 % of the time and for a short duration owing to the B permit takes. O'Sheas will only be flat lined for 1 % of the time.

The Pudding Hill ADC stockwater take is very large for the size of the stream and the river will be below the minimum flow for 16 % of the time.

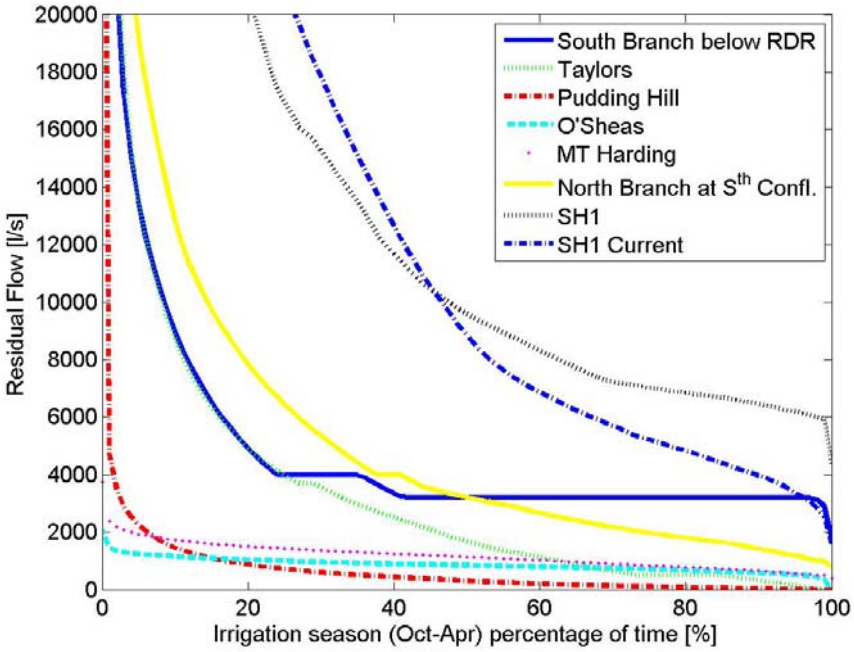


Figure 5-16: Scenario 3 residual flows at minimum flow locations (irrigation season).

The North Branch and Ashburton mainstem will not experience long periods of flat lining but they will be below the minimum flow for 1 % and 2 % of time respectively.

For winter residual flows the South Branch below RDR would be flat lined for 28 % of the time and on full restriction for 1 % of the time. SH1 would be below the minimum for 3% of the time (Figure 5-17).

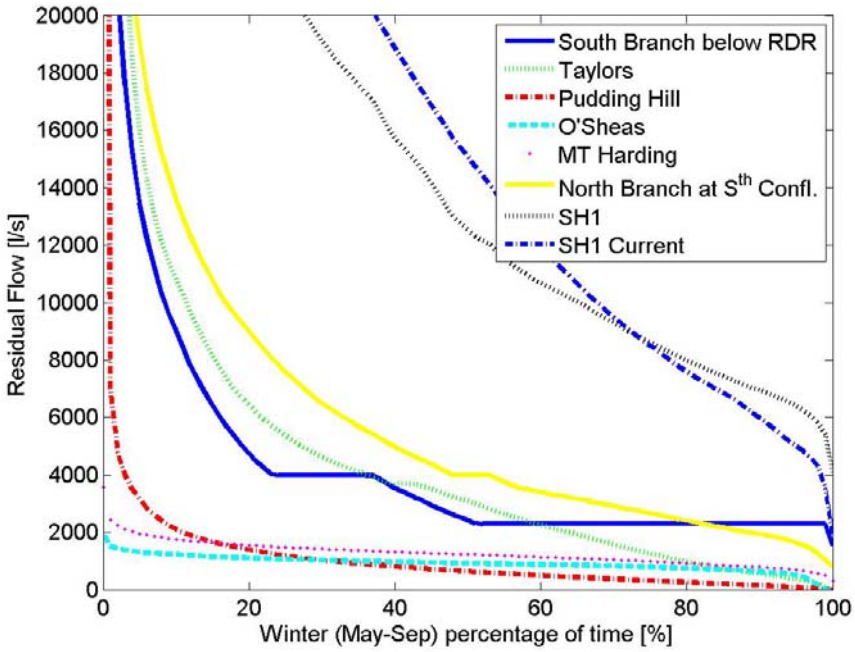


Figure 5-17: Scenario 3 residual flows at minimum flow locations (non-irrigation season).

5.3.3 ADC stockwater reliability of supply

ADC would have 100% reliability of supply from all of their abstraction locations. (Figure 5-18 and Figure 5-19).

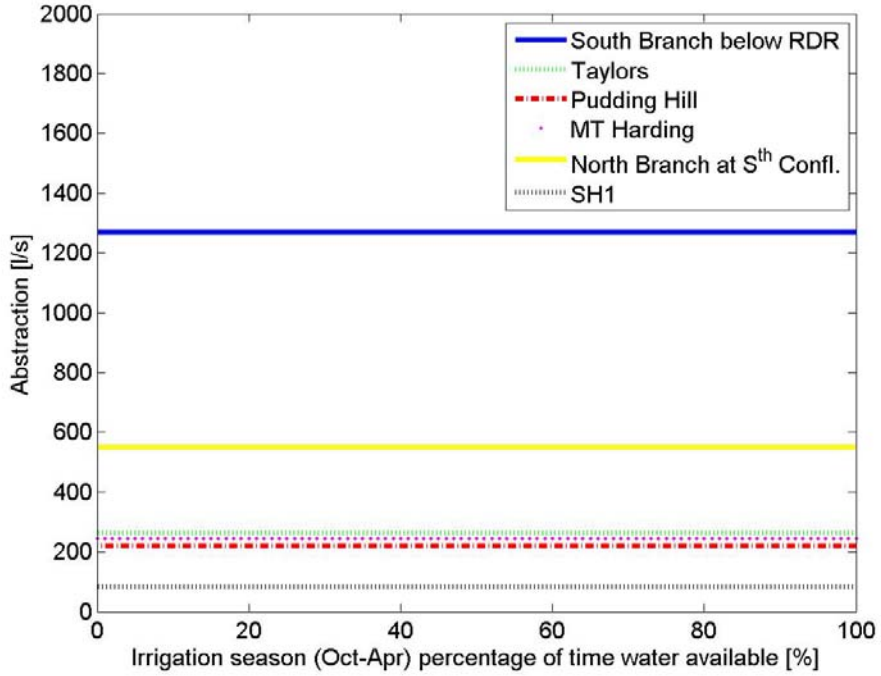


Figure 5-18: Scenario 3 ADC stockwater reliability of supply (irrigation season).

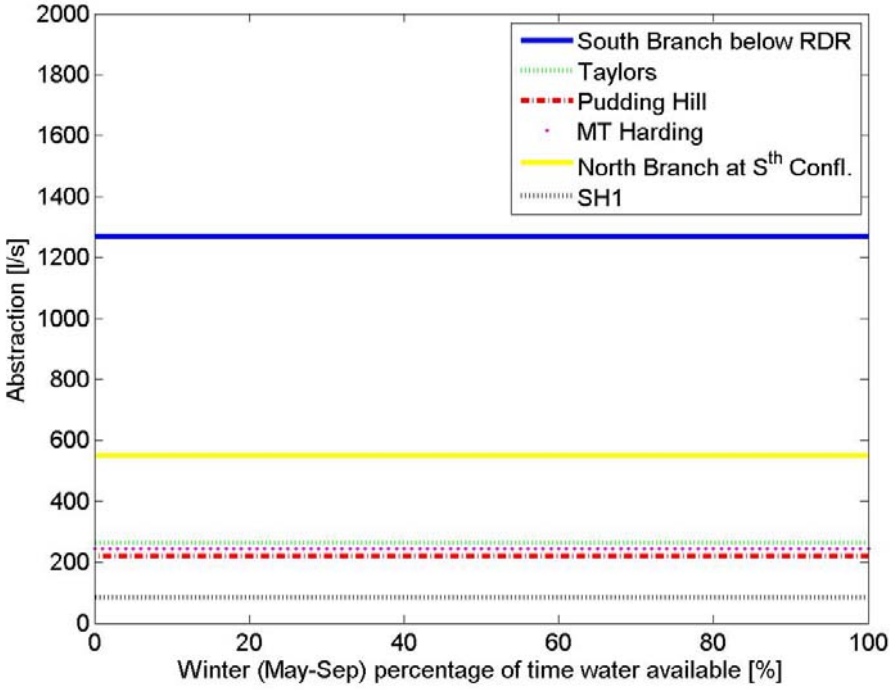


Figure 5-19:Scenario 3 ADC stockwater reliability of supply (non-irrigation season).

5.3.4 Block reliability of supply

South Branch, Taylors and North Branch B block abstractors would have the opportunity of full abstractions during the irrigation season (Figure 5-20) for 23, 26 and 37% of the time respectively.

During the winter (non-irrigation season) the full abstraction from South Branch is available for 23 % of the time, Taylors is available 39 % of the time and North Branch for 47% of the time (Figure 5-21).

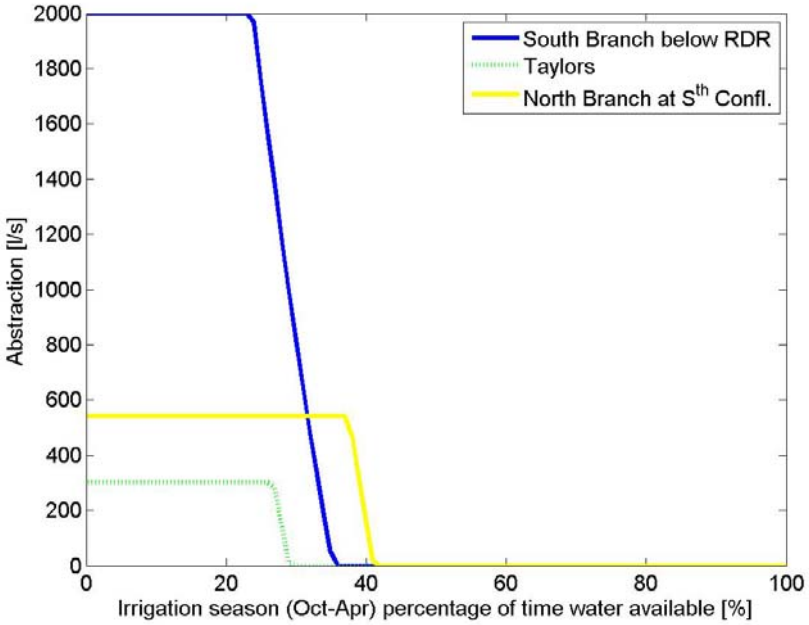


Figure 5-20: Scenario 3 B block irrigators reliability of supply (irrigation season).

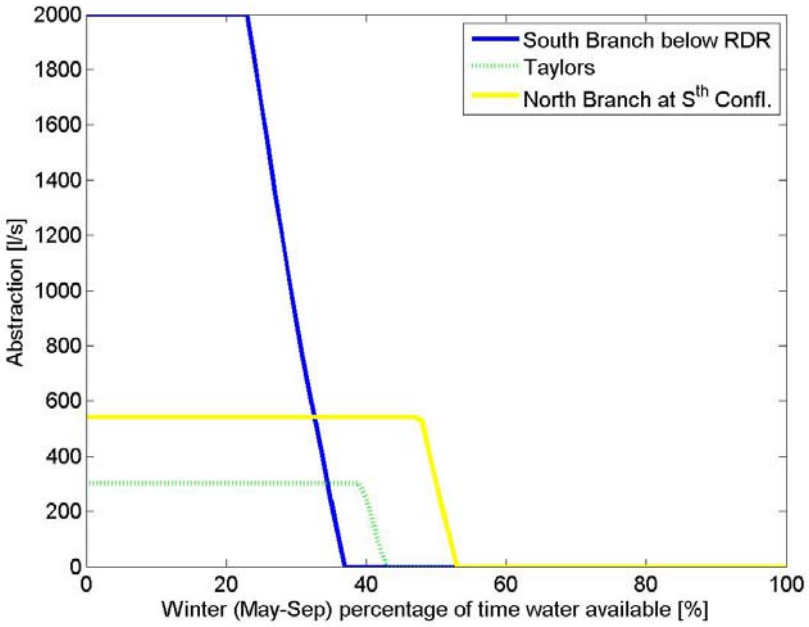


Figure 5-21: Scenario 3 B block irrigators reliability of supply (none-irrigation season).

6 Discussion

In summary, B permits have adequate reliability of supply during summer and winter to fill storages in all Scenarios.

ADC stockwater has 100 % reliability of supply in Scenario 3 and is not subjected to restrictions at minimum flow.

Considerable flat lining has the potential to occur in all scenarios on the South Branch downstream of the RDR intake as well as Taylors at the South Branch confluence. However these residual flows will be higher than those that occur under the current management regime.

The scenarios are summarised from an irrigator's perspective in Table 6-1. Overall the scenario with the greatest time with full abstractions and least time in partial abstraction and full restriction is Scenario 3. In Scenario 3 there is extremely high reliability of supply results for irrigators on O'Sheas, Mt Harding and the North Branch. As discussed earlier the RDR take on the South Branch is a very large abstraction for the size of the river and one cannot expect high reliability of supply. Taylors is in a similar situation to the South Branch and in some occasions goes dry (mainly due to the stockwater abstractions upstream). Thus Taylors has the largest result for the percentage of time in full restriction of all the tributaries. This has been clear to the local irrigators for many years and they have actively secured B permit water for storage to enhance their reliability of supply during the irrigation season.

Table 6-1: A permit irrigation season reliability (% of time) of supply for Scenario 1, 2 and 3.

% of time	South Branch below RDR	Taylors	O'Sheas	Mt Harding	North Branch at South confluence	SH1	Actual SH1
Scenario 1: A permits irrigation season							
Full abstraction	24	25	1	72	80	24	?
Partial abstraction	69	58	97	7	9	71	?
Full restriction	7	17	2	21	11	5	12
Scenario 2: A permits irrigation season							
Full abstraction	24	73	2	76	87	93	?
Partial abstraction	69	10	96	3	2	2	?
Full restriction	7	17	2	21	11	5	12
Scenario 3: A permits irrigation season							
Full abstraction	41	73	97	97	98	68	?
Partial abstraction	56	11	1	2	1	30	?
Full restriction	3	19	2	1	1	2	12

Irrigators on the South Branch below the RDR down to SH1 (SH1 column) look worse off in Scenario 3 compared with Scenario 2. This occurs because under Scenario 2 the large Greenstreet abstraction is supplied first from O'Sheas and secondly from the South Branch. As a result most of the water for most of the time comes from O'Sheas, and the South Branch supplies the vital top up, but overall has less water abstracted.

In Scenario 3 the full Greenstreet abstraction is only taken from the South Branch. The 2 % of time in restriction is an improvement on the actual situation now which is on average 12 % of the time fully restricted. Another statistic to show is that 75 % of the abstraction from the South Branch would be available 85 % of the time, as displayed in Figure 5-15. The South Branch reliability is also affected by the large RDR take upstream and when modelling RDR's abstraction every litre that could be abstracted was taken.

7 Acknowledgements

The author would like to thank Environment Canterbury staff for assistance in formulating the consent water use list of abstractions for the Ashburton catchment; Sarah Hunt for assistance in formulating the surface water consents and Matt Smith for formulating the stream depletion values for the groundwater consents.

8 References

Environment Canterbury. (2004). Variation 1 of the Proposed Natural Resources Regional Plan, Chapter 5: Water quantity. Canterbury Regional Council Report No. R04/15/5, 285p.

Horrell, G.A. (2001). Ashburton River Low Flow Regime. Canterbury Regional Council Report No. U01/26, Canterbury Regional Council, Christchurch, New Zealand. 71 p.

Horrell, G.A. (2004). Ashburton River Low Flow Regime – review and update Canterbury Regional Council Report No. U04/20, Canterbury Regional Council, Christchurch, New Zealand. 83 p.

Horrell, G.A. (2009). Ashburton River/Hakatere flow and allocation regimes: review and update of options. NIWA Client report CHC 2009-009. 24 p.

Appendix A Consented abstractions from the Ashburton Catchment

Surface water takes in South Branch (Upper)						
				Rate/day or		
RecordNo	ClientName	MaxRate	Hours/day	Stream depletion	Concurrent	Minimum Flow Condition
CRC000205.1	Mr & Ms H A & M E Smith & Roysmith	38.0		7.7		no min flow (irrigate 100ha)
CRC020501.1	Valetta Farms Limited	18.0		5.7		no min flow (irrigate crops and pasture)
CRC021736.5	Jetol Farm Limited	38.0		4.7		no min flow (irrigate pasture - dairy)
CRC021736.5	Jetol Farm Limited	38.0		9.7		no min flow (irrigate pasture - dairy)
CRC030336.1	Valetta Holdings Limited	24.0		9.2		no min flow (irrigate crops and pasture)
CRC051164	Mr & Mrs G W B & T M Gallagher	105.0		0.3		no min flow (irrigate crops and pasture)
CRC951101	Mr K A Omelvena	6.3		0.1		no min flow (irrigate 1.6ha crops and pasture)
CRC990240.1	Valetta Farms Limited	82.7		1.6		no min flow (irrigate 200ha)
CRC990240.1	Valetta Farms Limited	82.7		2.3		no min flow (irrigate 200ha)
CRC030336.1	Valetta Holdings LTD	24.0		9.2		no min flow
CRC020501.1	Valetta Farms Limited	18.0		5.7		no min flow
CRC000205.1	Mr H A Mrs M E Smith and Roy Smith	38.0		7.7		no min flow
CRC022026	Ashburton District Council	4.9		3.7		no min flow
CRC011245	Rangitata Diversion Race Management Limited	7100	24	7100.00		4 min flows @SH1 80%, 50%, 25% and 0% takes (irrigation, stockwater, generate electricity at highbank power station)
CRC030367	Webbs Transport Limited	30	3.44	4.30		2min flows @SH1, 1 to stop take and 1 to halve the take. (gravel and sand washing) Not a consumptive use
	RDR (for Scenario 3 2000 l/s removed from A Block and added to B Block)	0		0.00		2000 for Scenario 3
CRC951604.1	MrN K & Mrs K L Hammond	80	22	73.33		2min flows @SH1, 1 to stop take and 1 to halve the take. (Irrigate 80ha)
CRC952164.2	Mr & Mrs Ryan	45.5	9.8	18.58		2min flows @SH1, 1 to stop take and 1 to halve the take.(take from sth branch to irrigate 180ha)
SCY710033	Ashburton District Council (Brothers)	1699	24	1699.00		No min is required (divert & take from sth branch community stock and domestic water supply)
SCY710044	Ashburton District Council (Stoney Creek)	113	24	113.00		min flow may be required (to divert and take from stoney creek for community stock and water supply)
	Total groundwater abstractions	517.6		67.58		
	Stockwater	1812.00		1812.00		
	A Block direct surface takes (excluding stockwater)	7225.50		7191.91		
	Total	9555.10		9071.49		
	A Block	9555.10		9071.49		
	B block	0.00		0.00		
	A Block surface and groundwater takes with NO minimum flow (excluding stockwater)	517.60		67.58		
	A Block surface and groundwater takes with minimum flow	7225.50		7191.91		

Surface water takes in Taylor's Stream						
				Rate/day or		
RecordNo	ClientName	MaxRate	Hours/day	Stream depletion	Concurrent	Minimum Flow Condition
CRC052609	Alford Park Limited	80.0		16.3		no min flow (irrigate crops and pasture)
CRC991516.1	Mr C J & Mrs A M Allen	65.0		25.0		no min flow (irrigate 300ha)
CRC021619	Meadow Lee Limited	135.0		5.0		no min flow (irrigation crops and pasture)
CRC054032	Mr & Mrs D & J G Symons	29.0		0.4		no min flow (dairy shed washdown, milk cooling plant)
CRC030598.2	Mr R D L & Mrs D J Withers and AW Trustee Services LTD	53.0		16.6		no min flow
CRC980990	Mr & Mrs I L & K A Totty	12.0		6.9		no min flow (irrigation pasture - dairy)
CRC073341.1	Tayler Smith Holdings Limited	200.00	24.00	200.00		2 min flow sites. 1 @SH1 14000L, 1 @ Taylors stream confluence 3000L. To take, dam and use for irrigation of pasture and crops)
CRC074198.1	Mr & Mrs C W M & D Shannon	100	24	100.00		2 min flows @SH1 14000L, & @Taylors Stream confluence 3000L. (Take water from bowyers stream and dam and irrigate)
CRC030560.1	The Picnic Creek Stock Water Scheme Promotion Committee	7.70	5.40	1.73		no min flow (stock water and dairy shed)
CRC951862.4	Jetol Farm Limited	12	23.1	11.55		2min flows @SH1, 1 to stop take and 1 to halve the take (take from spring fed pond in bowyers stream to supplement water supply for irrigation).
CRC950885	Mr C J & Mrs A M Allen	1000.00	1.60	66.67		2min flows @SH1, 1 to stop take and 1 to halve the take (take from taylors stream for irrigation).
CRC950885	Mr C J & Mrs A M Allen	500.00	2.10	43.75		2min flows @SH1, 1 to stop take and 1 to halve the take (take from taylors stream for irrigation).
CRC950930.2	Alford Park Limited	1000.00	5.20	216.67		2min flows @ SH1, 1 to stop take and 1 to halve the take.(take from taylors stream for irrigation)
CRC950931.1	Mr C J & Mrs A M Allen	500.00	0.30	6.25		2min flows @SH1, 1 to stop take and 1 to halve the take (Take from Taylors stream for Irrigation).
CRC972504.1	Mr C J & Mrs A M Allen	1000.00	0.40	16.67		2min flows @SH1, 1 to stop take and 1 to halve the take. (To take for Taylors stream for irrigation)
SCY710045	Ashburton District Council (Taylors at Bushside) do above	141	24	141.00		no min flow (to divert and take from taylors stream for community stock and domestic water supply)
CRC012031	Ashburton District Council (Durrans)	42.00		42.00		no min flow (take from taylors stream for community stock and domestic water supply)
CRC012031	Ashburton District Council (Carneys)	10.00		10.00		no min flow
CRC012031	Ashburton District Council (Alford Forest)	42.00		42.00		no min flow (take from taylors stream for community stock and domestic water supply)
CRC012031	Ashburton District Council (Gough's Crossing)	141.00		141.00		no min flow may be required (take from taylors stream for community stock and domestic water supply)
	Total groundwater abstractions	374.00		70.2		
	Stockwater	376.00		376.00		
	A Block direct surface takes (excluding stockwater)	4019.70		363.28		
	Total	5069.70		1109.50		
	A Block	4769.70		809.50		
	B block	300.00		300.00		
	A Block surface and groundwater takes with NO minimum flow (excluding stockwater)	374.00		71.93		
	A Block surface and groundwater takes with minimum flow	4019.6		361.56		

Surface water takes in O'Shea Creek						
				Rate/day or		
RecordNo	ClientName	MaxRate	Hours/day	Stream depletion	Concurrent	Minimum Flow Condition
CRC082117.1	Tauhei Farms Limited	40.0		8.6		min flow at O'sheas creek 50L (irrigation)
CRC082117.1	Tauhei Farms Limited	30.0		3.9		min flow at O'sheas creek 50L (irrigation)
CRC082117.1	Tauhei Farms Limited	40.0		8.6		min flow at O'sheas creek 50L (irrigation)
CRC082117.1	Tauhei Farms Limited	96.0		0.7		min flow at O'sheas creek 50L (irrigation)
CRC950584	Mr & Mrs R J T & M A Snowden	38.0		16.3	C - Expired	min flow @SH1 (irrigate 89ha) Concurrent CRC921480
CRC951553	Mr D G Aschen	53.0		6.8		No min flow (irrigate 109ha)
CRC951553	Mr D G Aschen	53.0		5.3		No min flow (irrigate 109ha)
CRC951596.1	Wallaura Farm Limited	32.0		9.8		No min flow (irrigate 37ha)
CRC021199	Mr C J & Mrs A M Allen	26.0		5.9		no min flow
CRC980368.1	Mr M F M & Mrs A B B Talbot and Whitehouse Ten Trustees Limited	42.0		9.0		No min flow (supplement flow of water races for irrigation)
CRC921547F.2	Greenstreet Irrigation Society Limited (from Osheas and Snowden)	1200.00	18	896.4		2 min flows, SH1 and Osheas Creek. This is supplemented by CRC921547C from the South Branch
	Total groundwater abstractions	450.00		74.8		
	Stockwater	0.00		0.00		
	A Block direct surface takes (excluding stockwater)	1200.00		896.40		
	Total	1650.00		971.20		
	A Block	1650.00		971.20		
	B block	0.00		0.00		
	A Block surface and groundwater takes with NO minimum flow (excluding stockwater)	206.00		36.80		
	A Block surface and groundwater takes with minimum flow	1444		934.4		

Surface water takes in Mt Harding						
				Rate/day or		
RecordNo	ClientName	MaxRate	Hours/day	Stream depletion	Concurrent	Minimum Flow Condition
CRC970931.1	Taralea Farms Limited	45.5		20.3		no min flow (dairy shed water and irrigation 110ha)
CRC960067.2	Mr B G & Mrs A S Leslie	21.0		11.2		no min flow (salmon farming) NOT CONSUMPTIVE
CRC021998.1	Mr D A & Mrs A K Shearer	30.00	7.28	9.1		2 min flows @SH1, 1 to stop take and 1 to halve the take.(irrigation)
CRC951232	Willowdale Farm Limited	28.00	14.50	16.9		2min flows @ SH1, 1 to stop take and 1 to halve the take.
CRC951530	Mr D A & Mrs A K Shearer	30.00	7.28	9.1		2min flows @ SH1, 1 to stop take and 1 to halve the take. (Spray irrigation)
CRC960065.2	Mr B G & Mrs A S Leslie	360.00	24.00	360.0		no min flow (salmon farming) NOT CONSUMPTIVE
CRC990718.1	Ashburton Lyndhurst Irrigation Society Limited	114.00	24.00	114.0		Take when discharging from Ashburton-lyndhurst irrigation. (Irrigation 267ha) NOT CONSUMPTIVE OF MT HARDING
SCY710054	Ashburton District Council	566.00	24.00	566.0		no min flow (community stock and domestic water supply)
	Total groundwater abstractions	45.50		20.30		
	Stockwater	566.00		566.00		
	A Block direct surface takes (excluding stockwater)	88.00		35.10		
	Total	699.50		621.40		
	A Block	699.50		621.40		
	B block	0.00		0.00		
	A Block surface and groundwater takes with NO minimum flow (excluding stockwater)	45.5		20.3		
	A Block surface and groundwater takes with minimum flow	88		35.1		

Surface water takes in North Branch						
RecordNo	Client Name	MaxRate	Hours/day	Rate/day or Stream depletion	Concurrent	Minimum Flow Condition
CRC010365	Willowdale Farm Limited	38.0		21.8		No min flow (irrigation)
CRC012324.1	Mr S J & Mrs T M Weily & Leech & Partners Trustees Limited	11.5		3.3		No min flow (irrigation)
CRC020211	J and J Van Polanen Family Trust	45.0		32.5		No min flow (irrigation crops and pasture)
CRC020811	Mr P A Lowe	40.0		21.7		No min flow (irrigation crops and pasture)
CRC021057.1	Pekanga O Te Awa Farms Limited	40.0		44.6		No min flow (irrigation pasture - dairy) 35 x 2 chk later
CRC021199	Mr C J & Mrs A M Allen	26.0		5.9	C	No min flow (irrigation pasture and crops)
CRC021613	Mr M J Gaylor	20.0		4.3	C	No min flow (irrigation pasture)
CRC021680	Pencarrow Farm Ltd	48.0		7.5		No min flow (irrigation pasture) Moderate
CRC030337	Red Cow Farms Limited	72.0		39.6	C	No min flow (irrigation)
CRC030557	Mr & Mrs D D & M E Stewart	39.0		5.8	C	No min flow (irrigation crops and pasture)
CRC030721	Mr B K & Mrs P R McIlroy			Too deep		Too deep
CRC050465.1	Monty Fields Limited	80.0		15.1		No min flow (irrigation crops and pasture, dairy shed used, stock water supply)
CRC051210.1	Pekanga O Te Awa Farms Limited	105.0		20.0	C	No min flow (irrigation pasture)
CRC090967	Mr J B & Mrs L K Tavendale	41.4		1.0		No min flow (irrigation crops and pasture)
CRC921550B	Greenstreet Irrigation Society Limited	30.0		7.9		No min flow (irrigation 44ha)
CRC921550C	Greenstreet Irrigation Society Limited	95.0		7.2		No min flow (irrigation 89ha)
CRC921550D	Greenstreet Irrigation Society Limited	27.0		8.1		No min flow (irrigation 63ha)
CRC921550E	Greenstreet Irrigation Society Limited	28.0		9.6		No min flow (irrigation 28ha)
CRC921550G	Greenstreet Irrigation Society Limited	36.0		6.4		No min flow (irrigation 39.7ha)
CRC991516.1	Mr C J & Mrs A M Allen	65.0		25.0	C	No min flow (irrigation 300ha)
CRC012671	Mr B K & Mrs P R McIlroy	13.0		7.1		no min flow
CRC940155.1	Mr K L Mrs L Hydes	4.5		0.4		no min flow
CRC921550F	Greenstreet Irrigation Society Limited	5.0		1.1		min flow at SH1 bridge
CRC001975.1	Lumphanam Farms LTD	11.4		2.8		no min flow
CRC021499.3	Briggs Holding LTD	11.0		5.1		no min flow
CRC992268	Mr G V R Read	7.0		1.8		No min flow (irrigation 12ha)

CRC000072.1	Mr & Mrs D & J G Symons	60.00	24.00	60.00		3 min flows, 2 @ old weir nrth Branch (pro rata), flow of 10L/s in unnamed drain (irrigation of crops and pasture 140ha) (Band 1)
CRC031720	Methven Golf Club Inc	6.10	5.00	1.27		2min flows @SH1, 1 to stop take and 1 to halve the take. (irrigation of golf course)
CRC073581.4	Lochan Mor Limited Partnership	200.00	24.00	200.00		@ nth branch confluence 3400L. (Storage water in Dam crc082376.3)
CRC103031	Cairndhu Dairy Limited	340.00	24.00	340.00		3min flows, 1 @ SH1 14000L, 1 @ old weir 9200L, 1 @ nth branch confluence 3400L. (Storage water in Dam crc103030)
CRC951934.2	Cairndhu Dairy Limited	341.00	5.00	71.04		2min flows @SH1, 1 to stop take and 1 to halve the take. (irrigation of pasture and stock water)
CRC952441	Mr & Mrs C D & L A Galloway	240.00	6.20	62.00		2min flows @SH1, 1 to stop take and 1 to halve the take. (irrigation of 150ha)
SCY710049	Ashburton District Council	84.00	24.00	84.00		No minimum flow is required (stock and domestic water supply)
SCY710053	Ashburton District Council	1133.00	24.00	1133.00		No minimum flow is required (stock and domestic water supply)
CRC002108	Ashburton District Council	20.0		10.2		No min flow (domestic supply, stockwater, dairy washdown)
CRC011923	Ashburton District Council	36.0		15.3		public water supply- no minimum flow is required
	Total groundwater abstractions (excluding stock water)	938.80		305.60		
	Stockwater (including stockwater groundwater takes)	1273.00		1242.44		
	A Block direct surface takes (excluding stockwater)	647.10		194.31		
	Total	3398.90		2282.32		
	A Block	2858.90		1742.32		
	B block	540.00		540.00		
	A Block surface and groundwater takes with NO minimum flow (excluding stockwater)	933.80		304.44		
	A Block surface and groundwater takes with minimum flow	652.10		195.41		

Surface water takes in Pudding Hill						
RecordNo	**ClientName**	**MaxRate**	**Hours/day**	**Rate/day**	**Concurrent**	**Minimum Flow Condition**
CRC001953.1	NZSki Limited	28	24	28		No min flow
SCY710059	Ashburton District Council (Washpen Stream)	340	24	340		(community stock and domestic water supply). A divert into Washpen Stream of Pudding Hill take, therefore effectively not a take.
SCY710052	Ashburton District Council (Pudding Hill)	509	24	509		No minimum flow is required (stock and domestic water supply)
	Total groundwater abstractions	0		0		
	Stockwater	509		509		
	A Block direct surface takes (excluding stockwater)	28		28		
	Total	537		537		
	A Block	537		537		
	B block	0		0		
	A Block surface and groundwater takes with NO minimum flow (excluding stockwater)	28		28		
	A Block surface and groundwater takes with minimum flow	0		0		

Surface water takes in South Branch (Lower)						
				Rate/day or		
RecordNo	ClientName	MaxRate	Hours/day	Stream depletion	Concurrent	Minimum Flow Condition
CRC000248.1	James & Clare Freeth Limited	23.0		4.4		no min flow (irrigate 50ha)
CRC000305	C G & H K Rapsey	45.0		0.0		no min flow (irrigate 160ha)
CRC020255.1	Messrs A J & M J Sim	22.0		1.7		no min flow (irrigate crops and pasture)
CRC020255.1	Messrs A J & M J Sim	22.0		0.0		no min flow (irrigate crops and pasture)
CRC020257.1	Mr & Mrs G M & S M Fechney	66.0		6.1		no min flow (irrigate crops and pasture)
CRC021572.1	Mr & Mrs G M & J M Waddell	65.0		0.6		no min flow (irrigate crops and pasture)
CRC032236.1	Delos Farm Ltd	232.0		2.5		no min flow (irrigate pasture - dairy)
CRC032236.1	Delos Farm Ltd	232.0		1.4		no min flow (irrigate pasture - dairy)
CRC040613.5	Westerfield Water Limited	199.0		3.1		no min flow (irrigate crops and pasture)
CRC042190.2	Gregory Partnership	73.4		3.2		no min flow (irrigate crops and pasture)
CRC051210.1	Pekanga O Te Awa Farms Limited	105.0		20.0		no min flow (irrigate pasture)
CRC054425	Tullymett Farm Limited	120.0		15.7		min flow@ SH1 14000L (irrigate crops and pasture)
CRC960050.2	Mr J F Snowden	38.0		16.7		min flow at SH1 (irrigate pasture)
CRC960050.2	Mr J F Snowden	38.0		16.7		min flow at SH1 (irrigate pasture)Spk to Matt
CRC982179	Delos Farm Ltd	75.0		32.0		2 min flows @ SH1 1 to stop take, 1 to halve take (irrigate 318ha)
CRC960050.2	Mr J F Snowdon	38.0		16.7		no min flow
CRC921547J	Greenstreet Irrigation Society Limited	230	2.7	25.88		2min flows @SH1, 1 to stop take and 1 to halve the take (To take water from Spring Creek and irrigate
CRC921547C	Greenstreet Irrigation Society Limited	990	14	577.50		min flow SH1
CRC921547H	Greenstreet Irrigation Society Limited	230	5.00	47.9		2 min flows @ SH1, 1 to stop take and 1 to halve the take. (irrigate 114ha)
CRC951119	Gregory Partnership	23	24	23.00		3 min flows @SH1. 1 to stop take, 1 to halve take and 1 is an error. (spray irrigation)
CRC951552	Mr D G Aschen	240	1	10.00		2min flows @SH1, 1 to stop take and 1 to halve the take. (take from Sth Branch to augment flow in unnamed stream)
CRC951747	Mr D G Aschen	240	1	10.00		2min flows @SH1, 1 to stop take and 1 to halve the take. (take from unnamed stream and irrigate 25ha pasture)
CRC951956	Mr & Mrs R J & B J Tait	38	15.7	24.86		2min flows @SH1, 1 to stop take and 1 to halve the take.(take water from hole adjacent to Ashburton river for irrigation purposes)
CRC952061.1	Mertyn Trust	85	15.2	53.83		2min flows @ SH1, 1 to stop take and 1 to halve the take. (take water from sth branch to irrigate 131ha)
SCY710035	Ashburton District Council (Langdons)	42	24	42.00		No min is required (divert & take from sth branch community stock and domestic water supply)
CRC980746	Ashburton District Council (Langdons)	120	24	120.00		
	Total groundwater abstractions	1393.4		140.72		
	Stockwater	162.00		162.00		
	A Block direct surface takes (excluding stockwater)	2076.00		772.97		
	Total	3631.40		1075.70		
	A Block	3631.40		1075.70		
	B block	0.00		0.00		
	A Block surface and groundwater takes with NO minimum flow (excluding stockwater)	1122.40		59.62		
	A Block surface and groundwater takes with minimum flow	2347		854.07		

Surface water takes in Asburton Mainstem (Upper above SH1)						
				Rate/day or		
RecordNo	ClientName	MaxRate	Hours/day	Stream depletion	Concurrent	Minimum Flow Condition
CRC022038	Mr & Mrs R G & N T Read	4.9		2.7		no min flow (irrigation crops and pasture)
CRC040705.3	Mr C A & Mrs E M Hill and Myers & Co Trustees Limited	4.4		0.0		no min flow (irrigate vineyard)
CRC050225.1	Ashburton District Council	630.0		0.6		(community water supply)
CRC050225.1	Ashburton District Council	630.0		0.7		(community water supply)
CRC050225.1	Ashburton District Council	630.0		0.2		(community water supply
CRC050225.1	Ashburton District Council	630.0		4.0		(community water supply)
CRC110621	Mr W J & Mrs J L Donald	38.0		15.8		2 min flows @ SH1
CRC021793	Ashburton contracting LTD	23.0		3.7		no min flow
CRC022052.15	Mr P J & Mrs G S Watson	31.0		2.5		min flow at SH1
CRC991408	Fulton Hogan	12.6		9.1		no min flow
	Total groundwater abstractions (excluding community water supply)	88.40		33.80		
	Community water supply	2520.00		5.50		
	A Block direct surface takes (excluding stockwater)	0.00		0.00		
	Total	2633.90		39.30		
	A Block	2633.90		39.30		
	B block	0.00		0.00		
	A Block surface and groundwater takes with NO minimum flow (excluding stockwater)	44.90		15.50		
	A Block surface and groundwater takes with minimum flow	43.50		18.3		