Memo

Date	9 October 2017
To	OTOP Zone Committee
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From	Dan Clark

Flow and allocation for the Opihi and Temuka catchments

PURPOSE:

The purpose of this paper is to:

- Provide further background and analysis of the implications of flow and allocation decisions in the Opihi and Temuka Catchments.

INTRODUCTION

This paper builds on previous Opihi water quantity discussions with the OTOP Zone Committee and a number of existing reports and papers (Dodson and Steel 2016, Hayward 2017 and Davison et al 2017). In previous workshops the Zone Committee has discussed flow and allocation, and made a number of recommendations which may form part of the ZIP addendum. These can be summarised into the following major themes.

Recap of previous key decisions

- **Set minimum flows and allocations on tributaries**
- **Allocation based on actual usage in Orari FMU**
- **Cap A and B blocks to prevent further allocation**
- **Intent to improve flows in steps over time**
- **Prevent re-allocation until below allocation limit**
- **Incentivise/ provide for water user groups**
- **Adopt 150 day stream depletion test**

These previous decisions lay the foundation for the remaining areas of discussion on the Opihi River flows and allocations. The existing flow plans for the Orari catchment and Pareora catchment are also likely to play are part in informing the Opihi decisions, as these flow plans already adopt a number of the potential solutions for the Opihi Catchment.

Background hydrology reports and additional work recently completed

The Opihi current state hydrology report (Dodson and Steel 2016) was released in its draft form to allow interested parties access to the technical information as soon as possible and to allow feedback to be incorporated into the final published document.

This report has received criticism, regarding naturalisation of flows used to derive 7dMALF. These concerns have been described by de Joux (2017) and presented to the zone committee by the Te Ngawai water users group. The report by de Joux challenges the assumption that upstream abstractions can be added back to recorded flows to estimate a natural flow series. In response to these concerns ECan met with Opuha Water Limited (OWL) and their hydrology consultants (21 August 2017) in an attempt to resolve the issue. It was agreed that ECan hydrology team would investigate how flow statistics (specifically 7dMALF) varied if different naturalisation methodology was applied. Table 1 shows the 7dMALF statistics for key sites in the Opihi catchment if no abstraction is added back to flows, if water use data is used to naturalise flows and if the previously used methodology of assuming consent holders abstract 50% of their max rate is applied. This shows that using the previous methodology (of assuming consent holder take 50% of their max rates) results in 7dMALF estimates which are generally slightly higher but all within the margin of error of flow measurement. This additional work has not given ECan hydrologists any reason to change from the current methodology of applying water use data when estimating naturalised flows. The flows in Table 1 vary slightly from those used in Hayward (2017) due to slightly differing data periods being used for the test, this will not result in any significant changes to the ecological flow recommendations. It has recently been agreed with Mr de Joux (pers comm), while there may be some disagreement about the methodology, it is not worth pursuing the differences as the true flow numbers will probably be close to ECan's estimates.

Minimum flow site locations

The ORRP sets out minimum flow site locations for managing consent restrictions in the Opihi and Temuka Catchments. These sites have flow recorders and are considered to be suitable sites for reliable flow measurement. **The zone committee has previously recommended setting minimum flows and allocations at a tributary scale. This means each main tributary will have a minimum flow set at the permanent flow recorder location within the catchment**.

The main stem of the Opihi River (below Opuha) currently has two minimum flow locations (Saleyards Bridge and State Highway 1). OWL have presented to the zone committee, recommending that the minimum flow site for managing affiliated consents remains at Saleyards Bridge. We acknowledge that since the Opuha Dam has been operating and flows have currently been managed at this site a lot of learning has occurred. There are some benefits of managing all takes on the river from the site at the bottom of the catchment (Opihi River at SH1), as the residual flow below most takes is known. However recognising that OWL's management has been based on Saleyards Bridge and the many years of data collected from this site are likely to outweigh the benefits of shifting to SH1.

Key Decision Areas

- **Minimum flow location on the Opihi main stem (below Opuha).**

- **Option one – Control all consents in this SWAZ with a minimum flow located at the bottom of the Catchment**
- **Option two – Recognise the knowledge gained in managing Opuha Dam and shareholders at Saleyards Bridge and continue with the existing minimum flow locations on the Opihi River**

Table 1 Updated flow statistics for key recorder locations in the Opihi catchment

Site	Data record (water years)	Recorded 7dMALF (l/s)	Naturalised 7dMALF using water use (l/s)	Naturalised 7dMALF using 50% rule of thumb (l/s)
S Opuha at Stoneleigh	1/7/03-30/6/15	1024	1113	1107
S Opuha at Monument	1/7/97-30/6/15	529	667	696
N Opuha at Clayton Road bridge	1/7/1997-30/6/15	823	826	832
Opuha at Skipton	1/7/72-30/6/15 (not incl 1999-2011)	2343	2410	2459
Opihi at Rockwood	1/7/72-30/6/15	1192	1291	1361
Te Ana a Wai at Cave Picnic Grounds	1/7/82-30/6/15	535	614	659
Temuka at Manse Bridge	1/07/1983-30/3/15	1195	1751	

AMWG proposal and affiliated consents

While much of this paper focuses on the flow regime for un-affiliated consents, decisions made on the Opihi flow regime also affect affiliated consent holders. The zone committee has agreed to a number of principles related to the proposal from the Adaptive Management Water Group (AMWG), including setting a flow regime with variable flows and minimum flow requirements based upon the available water within the catchment. The AMWG has proposed a flow regime which includes monthly average minimum flows and instantaneous minimum flows based on the Potential Available Water (PAV) within the catchment. This PAV is an estimate of the volume of water stored within the Dam and as snowpack within the catchment. The PAV methodology is still being developed so the impacts of this proposal cannot yet be evaluated. This means that changes to reliability of supply for affiliated consents cannot be quantified until OWL's proposal included PAV triggers for minimum flows.

Annual volumes for affiliated consents

ECan currently allocates annual volumes for irrigation consents based on a reasonable use test, which grants consent holders sufficient volume to meet their irrigation demand in nine years out of ten. This recognises that in a very dry year a consent volume may not be sufficient to meet crop demand. Opuha Water Limited has its own method for granting volumes to its shareholders. This method treats all shareholders in the same way and grants them all the same allocation of water, regardless of their actual demand to meet crop needs. This means that all shares are worth the same amount of water, wherever in the scheme it is abstracted. OWL has requested that their shareholder volumes are recognised through the zone committee process. If OWL becomes a water user group or the company holds all consents on behalf of its shareholders, this issue becomes less critical and it is up to OWL how water is allocated amongst the shareholders. If OWL do not become a water user group, this can be achieved by enabling affiliated shareholders to replace their consents to amend their annual volume in line with their shareholdings. On renewal of these consents, this should become a requirement.

Key Decision Area

- **Consent annual volumes for affiliated consents**
    - **Option one set affiliated consent annual volumes in the same way as un-affiliated consents**
    - **Option two set affiliated consent annual volumes based upon shareholding volumes**

Water usage

A number of studies both recent (Dodson and Steel 2016) and less recent (Sanders 1998, Aqualinc 2010) indicate that in general consent holders do not use their full consented allocation. These studies generally agree that on average 40-60% of consented allocation gets used. In recent years wider uptake of metering has allowed us to investigate how water use compares to consented allocations. Overall water use in OTOP shows a similar pattern to those in wider Canterbury. Metering data has allowed us to investigate how water use varies over a year and season.

Water use is influenced by the total allocation, climate, on-farm practices and availability of water. In periods of restriction, water use will be reduced even at times when demand is high. In this paper I have included plots in Appendix 1 showing how metered usage compares to allocation for the major parts of the catchment where sufficient data were available to provide a meaningful picture. The plots show the consented allocation which is metered (this increases over time as more meters were installed), water usage and for surface water takes an indication of how much of the allocation was available (e.g. how much water could be taken while still complying with any minimum flows and restrictions). As would be expected, these plots show a usage profile with most water being taken in the peak of the irrigation season. And very little of the consented allocation being taken in the shoulder and winter months.

This indicates that reducing instantaneous rates by a percentage of seasonal volume used will mean that in peak summer periods consent holders may not have sufficient water to meet demand.

Unfortunately these periods of high demand often occur at the same time as dry climatic conditions and lower river flows, an example of this is in the 2014-2015 irrigation season.

Key decision area

- **Consent annual volumes for un-affiliated consents**
    - **Option one- set consented annual volumes based on water usage data, taking account of conditions at the time of metering**
    - **Option two- Continue to set consented allocations based on a reasonable use test as per the LWRP**

Takes to storage

The current ORRP sets A and B blocks, these are based on consents granted at the time of the plan process. In other places A block water is considered to be high reliability run of river takes and B block is water taken at times when the flow is high. The B block takes are generally taken to storage for later use in high demand times. Under the current framework AA, AN and BA takes are generally run-of river takes directly (with some also taken to storage) with high reliability and BN takes are low reliability high flow takes (usually takes to storage). BA takes have high reliability as these consents avoid the B minimum flow on the Opihi at SH1 by holding shares in OWL and receiving stored water from the Dam, providing high reliability.

Under the current plan, consent holders may take high reliability water to storage at times when they do not have an irrigation demand, this means that more abstractions are occurring at lower flows than would if high reliability water was only run of river direct use and only B water was stored. In the current situation of high allocation volumes, A allocation takes to storage can exacerbate periods of prolonged low flows. If reliability of supply decreases for run of river takes these consent holders may invest in storage, which may lead to increased volume of abstraction when above the minimum flow compared to current usage.

However, taking water to storage will help offset loss of reliability if minimum flows are raised. The challenge is to enable and even encourage water takes to storage, while ensuring that this does not compromise achieving improved ecological and cultural health by raising minimum flows. An example of how this may be achieved could be to allow smaller 'buffer' storage ponds (e.g. 10 days) to have the same A block reliability and large scale storage ponds have a higher minimum flow.

Large water takes to storage (especially diversions) have the potential to have dramatic impacts on river hydrology (rapid drops in flow) and hold a river at low flows for extended periods of time, and reduce flow variability and flushing flows. It is therefore, generally appropriate to set minimum flows for takes to storage at flows higher than run of river use. Setting appropriate minimum flow takes to storage can depend on the size of the take, time of year and nature of the river. In general, setting minimum flows for storage takes at around median flow (year round) provides general level of protection for ecological health and stream productivity by avoiding impacts on base flows, while providing for sufficient period for takes (median flows occur 50% of the time).

Key Decision Area

- **A block takes to storage**

An investigation into ecological flow recommendations is being carried out over this summer, which investigates the ecological values in tributaries of the Opihi and Temuka Rivers. This investigation will be completed after the ZIP addendum but prior to plan drafting. The findings of this work may be able to assist in determining appropriate minimum flows of A takes to storage.

  - **Option one- A block takes to storage continue to have the same minimum flow restrictions as A block run of river takes**

  - **Option two –A block takes to storage have higher minimum flow restrictions than A block run of river takes based on the findings of the ecological study being completed this summer**

  - **Option three- A block takes to storage continue to have the same minimum flow restrictions as A block run of river takes if they have less than 10 days stored volume, otherwise they have an increased minimum flow as per option two.**

- **B block takes to storage**
  - **Option one- Continue with existing B block minimum flows on tributaries**

  - **Option two - Set B block minimum flows on tributaries at a level which protect the local values in each tributary, e.g. B block minimum flow above median flow.**

Partial restrictions

To prevent residual flows from dropping below the minimum flow partial restrictions are included as part of a flow regime. Partial restrictions already apply in all of the FMU's in OTOP with Pro-rata restrictions in the Opihi catchment and stepped restrictions in the Temuka catchment. Flow sharing was introduced in the Orari catchment through the previous flow review. Partial restrictions on affiliated consents will be controlled by OWL as part of their dam and river management, partial restrictions on un-affiliated consents will be controlled by Environment Canterbury. Figure 1 shows an example graph of how different partial restrictions may apply and the amount of allocation available at different flow levels. Partial restrictions are particularly important for managing abstractions below minimum flow sites as these abstractions do not impact the recorded flows and may draw flows very low.

Partial restrictions can be applied in the following ways:

Stepped restrictions

As flow approaches the minimum flow threshold abstractors are required to reduce their take by a set percentage. These steps are usually based upon the size of the total allocation block e.g. 50% restriction may apply when recorded flow is less than the minimum flow plus the allocation block but above the minimum plus 50% of the allocation block. These steps should be set to ensure the residual flow does not breach the minimum. This method of applying partial restrictions provides a simple easy to understand and applied regime which should be more beneficial to the environment when applied correctly.

Pro-rata

The restrictions which apply are based on the amount of the allocation block available above the minimum flow on a given day e.g. If the flow equals the minimum flow plus 83% of the allocation block size, 83% of the consent holder's allocation is available to them on that day. This restriction regime allows consent holders the opportunity to abstract all of the available block of water above the minimum flow. However infrastructure logistics may limit an individual's ability to abstract at the given rate on the day (e.g. pump may not run at 83% of take). Pro-rata restrictions work well when operated within a water users group and has been used as an incentive in the Orari plan.

Flow sharing

The amount of water available above the minimum flow is shared between the abstractors and the environment. In 1:1 flow sharing, for every 2 l/s of flow above the minimum flow 1 l/s is available for abstraction and 1 l/s if left for environmental benefit. This regime retains some degree of natural flow variability at low flows prevents flat-lining, but provides the lowest reliability of supply for abstractors. In a 1:1 flow sharing regime the flow must be the minimum flow plus two times the allocation limit for consent holders to have access to their full allocation.

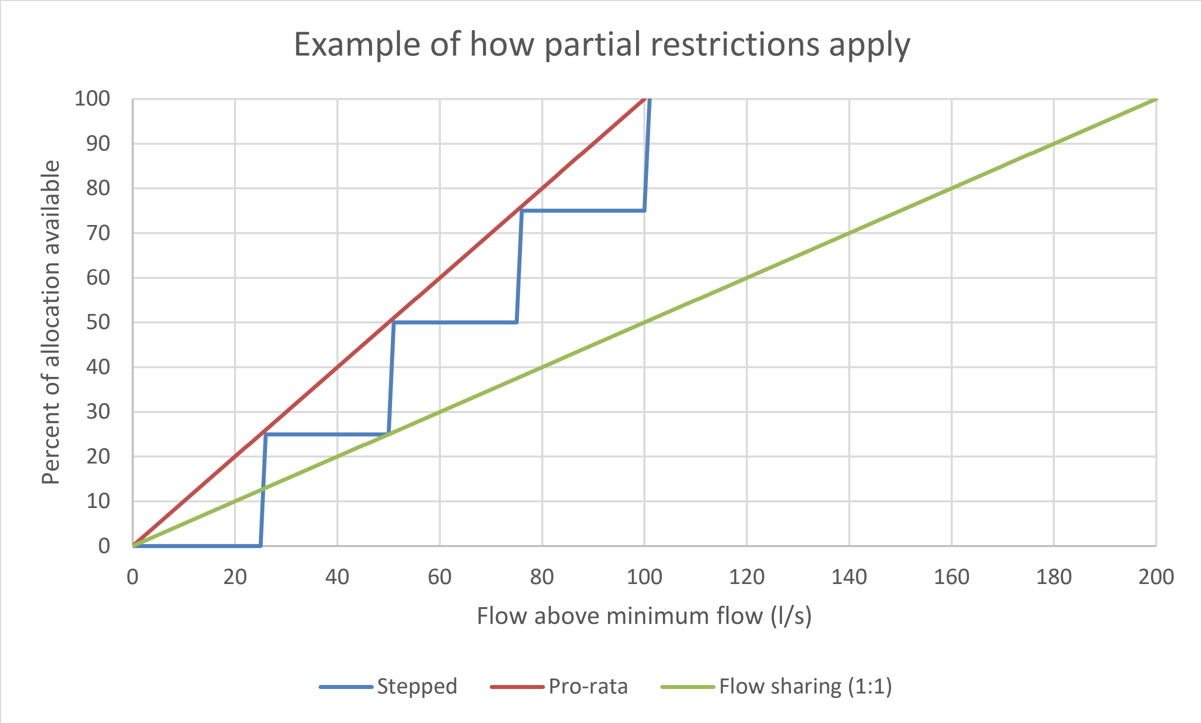

Figure 1 Diagram of how different partial restriction regimes may apply at varying flows

Key Decision Areas

- **What partial restriction regime should apply to non-shareholders in the Opihi and Temuka Catchment?**
  - **Option one-Stepped regime**
  - **Option two- Pro-rata**
  - **Option three - Flow sharing regime**

- **Should different partial restrictions apply if consent holders are part of a water user group?** Water user groups may be better able to utilise the available water in a pro-rata restriction regime as members can manage the available volume amongst themselves.

Reliability of supply - economic assessment

Reliability of supply is a term used to describe how often a consent holder is able to utilise their consent. However reliability of supply can be interpreted in a number of different ways. For example consents are granted sufficient water to meet their requirement in nine years out of ten, this can sometimes be interpreted as 90% reliability, whereas other measures of reliability describe how much of the irrigation season is affected by full or partial restrictions. Unfortunately no one measure of reliability of supply gives the full picture of the implications for consent holders. For this reason, in this paper we describe reliability of supply as the number of days within an irrigation season when the consent holder will be restricted, either fully or partially. The tables included in the paper and the attached appendix show how restrictions will apply both on an average season (table in the paper) and on each irrigation season with recent record (included in appendix). These reliability statistics will allow consent holders to see the implications on their water availability and make decisions based on how the economics of their individual situation are affected by these proposals. The full economic assessment of changing minimum flows will be completed on the package of recommendations form the zone committee.

In the previous workshop on Opihi minimum flows and allocation (17 July 2017) a simplified reliability statistic was presented, this showed the amount of time the flows were above each of the minimum flow options. This was done to specifically to assess minimum flow reliability independently of the allocation block sizes, which were yet to be discussed. As discussions have progressed we are able to do a more complete reliability of supply assessment and produce a range of statistics which show the amount of time on full restriction, the amount of time on partial restriction and the time where consent holders can take their full allocation.

In all of the following assessments of reliability we have modelled pro-rata restrictions applying. This allows comparison of the effects of the different minimum flow and allocation block options. This partial restriction regime would provide the highest reliability for abstractors and show the maximum possible impact on residual river flows. This does not preclude the zone committee recommending a different partial restriction regime.

Water use

Water use data for surface water and groundwater is shown in Figure 10 to Figure 16 . It can be seen in these figures that usage shows a seasonal pattern with the most abstraction occurring in 2014-2015. During these years it appears that the abstraction in some catchments was higher than the available volume as during these periods, water shortage directions were in place allowing lower flows than the plan specifies. If the plan rules had applied in these periods rather than the OEFRAG recommendations, very little water would have been available for abstraction.

South Opuha minimum flow and allocation

Consent holders on the South Opuha have a current minimum flow of 500 l/s on the South Opuha at Monument Bridge. Affiliated consents also have a minimum flow at Saleyards Bridge and un-affiliated consent holders have a SH1 minimum flow. Hayward (2017) classified the South Opuha as generally maintaining good health.

Changes to reliability

In the paper by Hayward (2017) there are proposed ecological flows, generally based upon the Draft National Environmental Standard (NES) on ecological flows and water level. These have also been described to the committee in Davison et al (2017). We have assessed what these minimum flows and allocations will do to reliability of supply for the South Opuha abstractors. Table 2 shows the number days in an average irrigation season consent holders will be restricted with the NES recommended flow regime. Both NES options modelled have the same minimum flow but one uses the NES default allocation (as percentage of MALF) and the other uses the current allocation, both of which are options in the NES. It can be seen that having a larger allocation block size (current) results in everyone having lower reliability than if the block size was smaller. Table 7 show the reliability of the current plan rules, it can be seen that restrictions on both the South Opuha and Opihi River influence the overall reliability experienced by consent holders. In the table below BA takes can be considered to be A block consents as they operate in the same way as A takes when OWL are releasing flows.

Table 2 Impacts on restrictions of differing minimum flow and allocation combinations for the South Opuha River

	Days on full restriction A block	**Days on partial restriction A block**	**Days on full restriction B block**	**Days on partial restriction B block**
Current plan rules	(BA 38)		BA 38 BN 194	0 BN 2
NES min flow, NES allocation	13	17		
NES min flow, current allocation	16	43		
COMAR min flow, current allocation	No recommendation			

The impact of these flow regime options has also been modelled to show the impacts on the residual flow (the flow left in the river). Figure 2 show the flow duration curve for these flow regimes, compared to naturalised flows. It can be seen that the NES with current allocations results in the largest deviation from the natural flows.

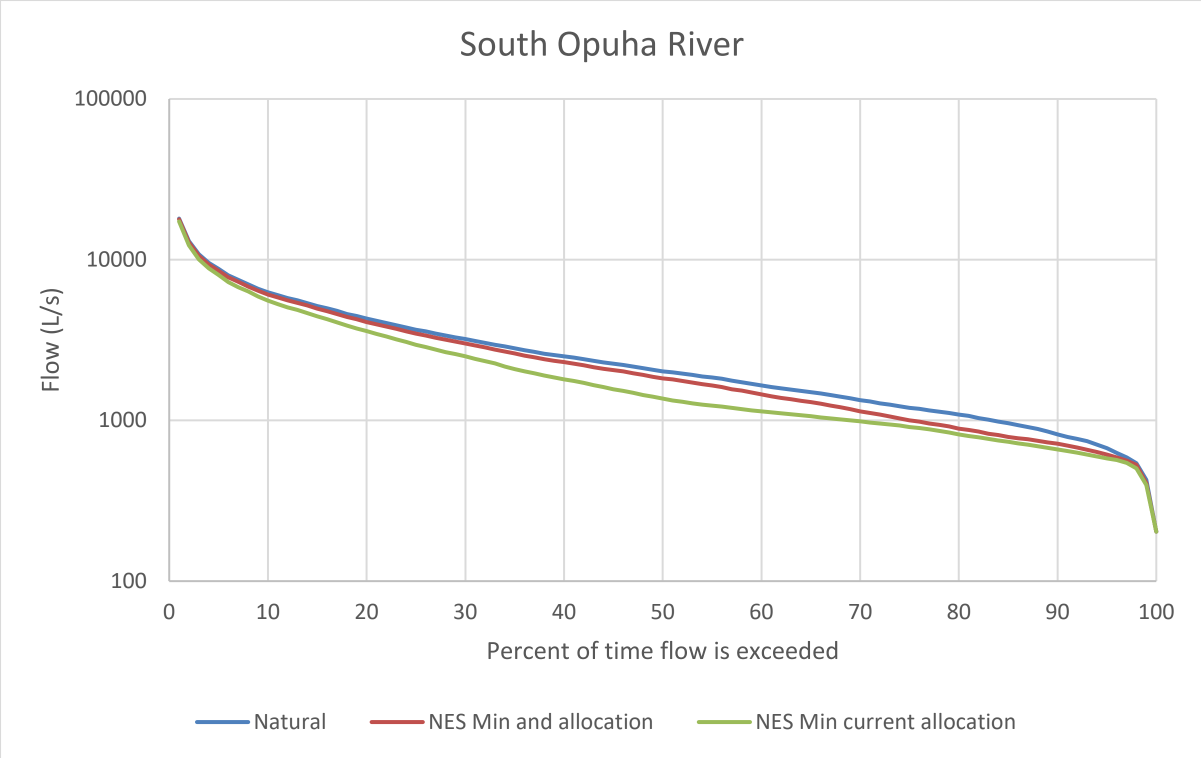

Figure 2 Flow duration curves for the differing minimum flow and allocation options compared to natural flow in the South Opuha.

Key decision areas

Minimum flows for the South Opuha

The zone committee has indicated its preference to move towards NES and ecological minimum flows over the next ten years. With an appropriate minimum flow in the South Opuha, without the need for dual minimum flows.

- **Option one – Confirm the recommendation in Table 8**
- **Option two - Following the further information in this paper, revise the minimum flow recommendations**

Allocation in the South Opuha

The size of the allocation limit has impacts on both the reliability of consent holders within the allocation block and on the residual flows left in the river.

- **Option one - Cap the current allocation as the limit**
- **Option two - Set the limit at the NES recommendation**
- **Option three - Cap the allocation at current with a sinking lid, reducing over time with unused water being surrendered and not reallocated until NES limit is reached.**

North Opuha min flow and allocation

Consent holders on the North Opuha have a minimum flow of 850 l/s on the North Opuha at Clayton Road. Affiliated consents also have a minimum flow at Saleyards Bridge and un-affiliated consent holders have a SH1 minimum flow. As there is significant abstraction below the minimum flow site we have modelled the residual flows at the recorder and also downstream of all abstraction (shown in Figure 20 and Figure 21), these show that flows at the recorder are not significantly altered and a partial restriction regime is important for maintain flows. Hayward (2017) classifies the North Opuha as generally having good health with current minimum flows and allocation close to ecological recommendations.

Changes to reliability

Table 10 shows the current restrictions faced by consent holders in the North Opuha. This show that affiliated consents are restricted by both the North Opuha Flows and the Opihi flow to a similar extent but that these restrictions can occur at different times. Un-affiliated consent are much more restricted by the Opihi flows and a large amount of time on partial restriction. Under the flow regimes modelled in Table 3 and Figure 3, keeping the current allocation block provides the largest number of restrictions**.**

Table 3 Impacts on restrictionsof differing minimum flow and allocation combinations for the North Opuha River

	Days on full restriction A block	**Days on partial restriction A block**	**Days on full restriction B block**	**Days on partial restriction B block**
Current plan rules	AA 21 AN 17	 AN 142	BA 21	
NES min flow, NES allocation	6	18		
NES min flow, current allocation	12	50		
COMAR min flow, current allocation	No recommendation			

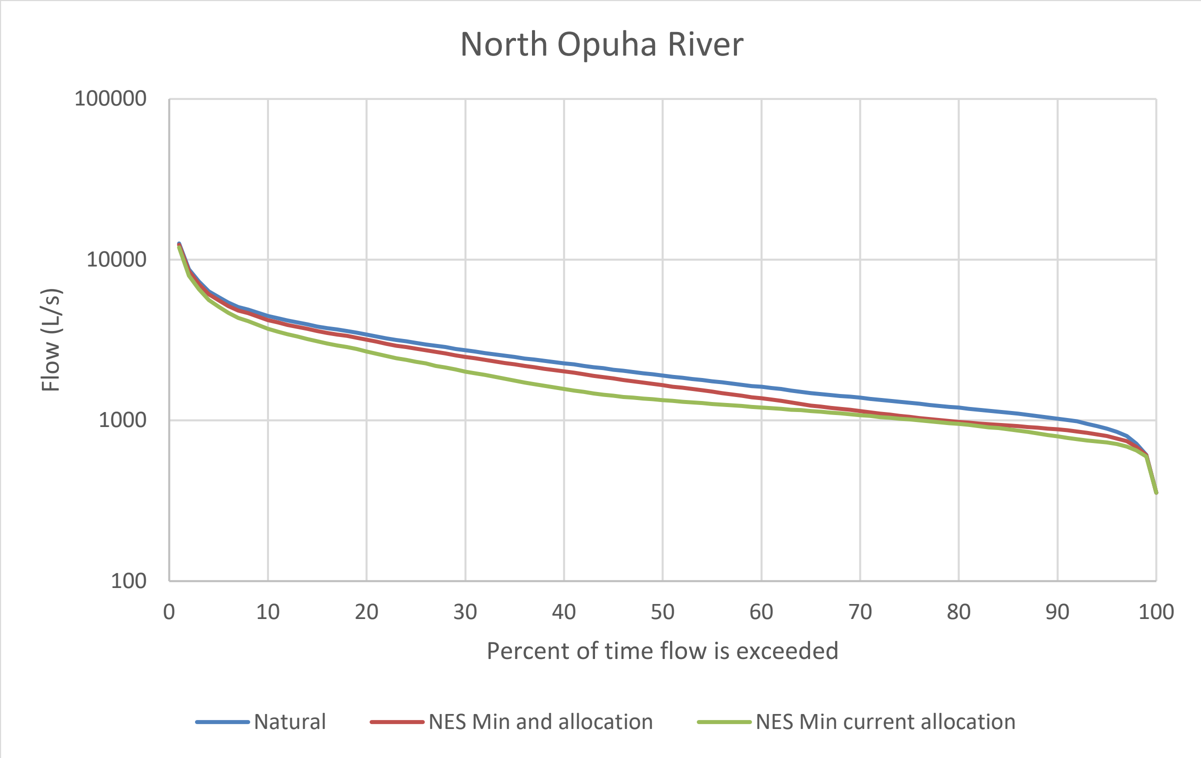

Figure 3 Flow duration curves for the differing minimum flow and allocation options compared to natural flow in the North Opuha.

Key decision areas

Minimum flows for the North Opuha

The zone committee has indicated its preference to continue with the existing minimum flow level in the North Opuha as this is currently similar to the ecological flows and NES minimum flow recommendation.

- **Option one – Confirm the recommendation in Table 8**
- **Option two – Following the further information in this paper, revise the minimum flow recommendations**

Allocation in the North Opuha

The size of the allocation limit has impacts on both the reliability of consent holders within the allocation block and on the residual flows left in the river.

- **Option one - Cap the current allocation as the limit**
- **Option two - Set the limit at the NES recommendation**
- **Option three - Cap the allocation at current with a sinking lid, reducing over time with unused water being surrendered and not reallocated until NES limit is reached.**

Temuka River

The ORRP sets an allocation limit for the Temuka Catchment for A and B Permits of 1.6 m^3/s and 0.4 m^3/s respectively. The Temuka catchment is currently over allocated for A permits within the catchment. These takes are distributed amongst the Temuka River and its tributaries. Hayward (2017) categorises the Temuka catchment as having flows and allocations which deviate significantly from ecological flow limit recommendations and exhibits poor health. Setting an appropriate minimum flow and allocation for the catchment will provide improvements to environmental health but will result in impacts on consent holders.

The zone committee has already recommended to adopt a 150 day stream depletion assessment methodology, which will provide some benefit to flow, they have also recommended setting allocations based on usage and surrendering unused paper allocation. While surrendering unused allocation will not improve the current flows, it does reduce the risk of increased abstractions reducing flows in the future. Surrendering unused water will not have a real cost on consent holders, but will come with an opportunity cost of not being able to increase usage in the future. The combination of these recommendations with the initial recommendation to move towards an ecological minimum flow (Table 6) in ten years should result in improved flows in the Temuka River.

Changes to reliability

Table 4 show the levels of restriction consent holders would experience with the current plan rules and with the NES and COMAR flow recommendations. Under the current plan rules consent holders spend more time on full restriction as this regime does not have pro-rata restrictions (a 50% restriction applies), which means abstraction within the catchment draws flows below the minimum, fully restricting consents. As the allocation is high compared to NES and COMAR recommendations, this results in partial restrictions occurring most frequently when current allocation is retained. This is due to much more flow needing to be in the river for the full allocation to be available for abstraction. Figure 4 shows the flow duration curves for the residual flows left in the river with each of the modelled flow and allocation combination. This shows that keeping the current large allocation block size has the potential to cause the greatest deviation from natural flows.

Table 4 Impacts on restrictions of differing minimum flow and allocation combinations for the Temuka River

	Days on full restriction A block	Days on partial restriction A block	Days on full restriction B block	Days on partial restriction B block
Current plan rules	44	6	88	29
NES min flow, NES allocation	13	60		
NES min flow, current allocation	17	154		
COMAR min flow, current allocation	16	50		

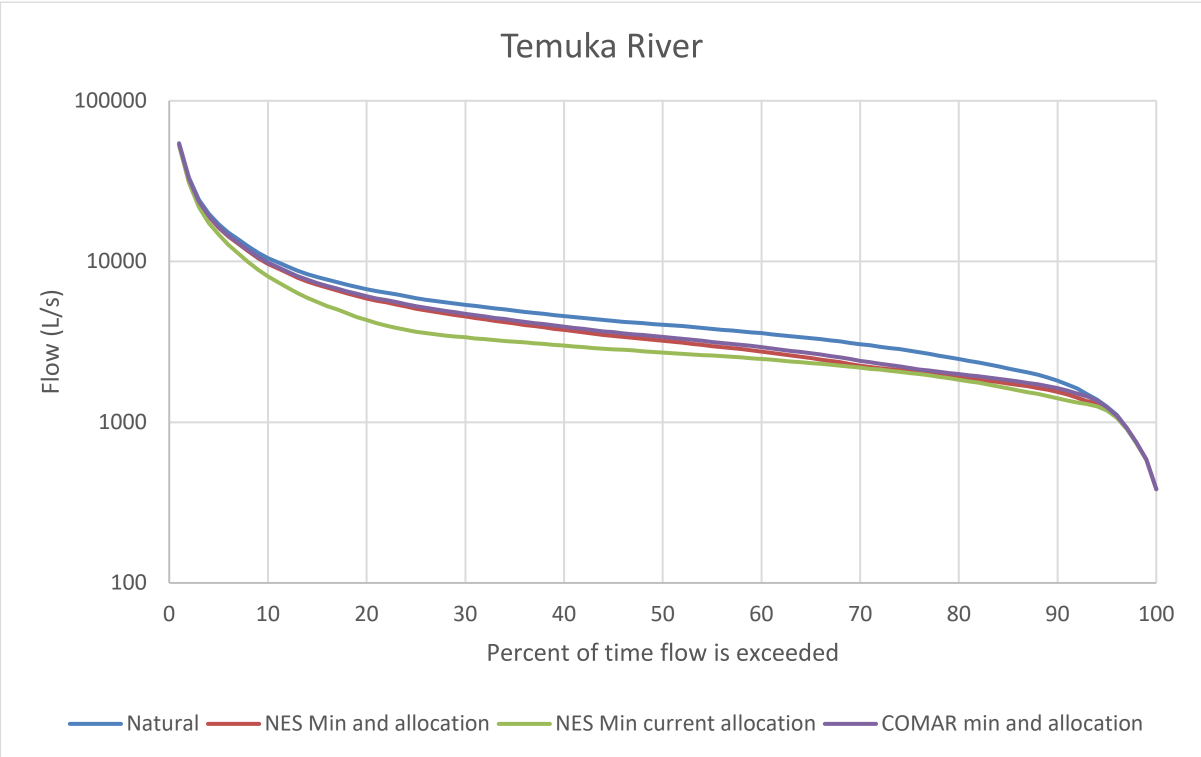

Figure 4 Flow duration curves for the differing minimum flow and allocation options compared to natural flow in the Temuka River

Key decision areas

Minimum flows for the Temuka River Catchment

The zone committee has indicated its preference to move to an ecological minimum flow in ten years, with a stepped increase in five years.

- **Option one – confirm the recommendation in Table 6**
- **Option two – following the further information in this paper, revise the minimum flow recommendations**

Minimum flows and allocation on tributaries of the Temuka

An investigation into ecological flow recommendations is being carried out over this summer, which investigates the ecological values of the Temuka tributaries. This investigation will be completed after the ZIP addendum but prior to plan drafting. The findings of this report may be able to set sub-catchment level minimum flows and allocations.

- **Option one- That the flows and allocations in the Temuka Catchment as a whole is addressed within the lifetime of this plan, with the intent to set minimum flows and allocations in the Kakahu, Hae Hae Te Moana and Waihi Rivers in the next review.**

- **Option two - Include allocations and minimum flows on the Kakahu, Hae Hae Te Moana and Waihi Rivers as part of this process if sufficient information becomes available through the summer investigation. These allocations should be based upon the principles decided for the Temuka Catchment as a whole.**

Allocation in the Temuka River

The size of the allocation limit has impacts on both the reliability of consent holders within the allocation block and on the residual flows left in the river.

- **Option one - cap the current allocation as the limit**
- **Option two- Set the limit at the NES recommendation**
- **Option three- cap the allocation at current with a sinking lid, reducing over time with unused water being surrender and not reallocated until NES limit is reached.**

Opihi River above Opuha confluence (Rockwood)

Consent holders in the upper Opihi River currently have a minimum flow on the Opihi at Rockwood and at either Saleyards Bridge or SH1, depending on if they are consents affiliated with OWL. Under these current rules affiliated consents are more constrained by the Rockwood flows and un-affiliated consents are more constrained by the SH1 flows (Table 11). The upper Opihi River is classified as generally exhibiting good ecological health but showing vulnerability to low flows and water quality pressures (Hayward 2017). The upper Opihi River has a minimum flow which is a lot lower than the ecological recommendations. The current allocation could have a greater impact on flow if consent holders used more of the currently allocated water as shown in Figure 19.

Changes to reliability

Table 5 shows how differing minimum flows and allocations impact on the time consent holders can take water. This shows that retaining the high current allocation in upper Opihi means that consent holders spend a large amount of time on partial restrictions. In this assessment we grouped BA consents with the A block consents as these are considered to be run of river takes. In these three options the residual flows deviate from the natural flow in periods of low flow, but retaining the large allocation results in effects occurring further up the flow duration curve, effecting mid-range flows too (Figure 5).

Table 5 Impacts on restrictionsof differing minimum flow and allocation combinations for the Opihi River at Rockwood

	Days on full restriction A block	**Days on partial restriction A block**	**Days on full restriction B block**	**Days on partial restriction B block**
Current plan rules	AN 26	AN 134	BA 30	
NES min flow, NES allocation	19	36		
NES min flow, current allocation (AN + AA+ BA)	22	97		
COMAR min flow, COMAR allocation	27	63		

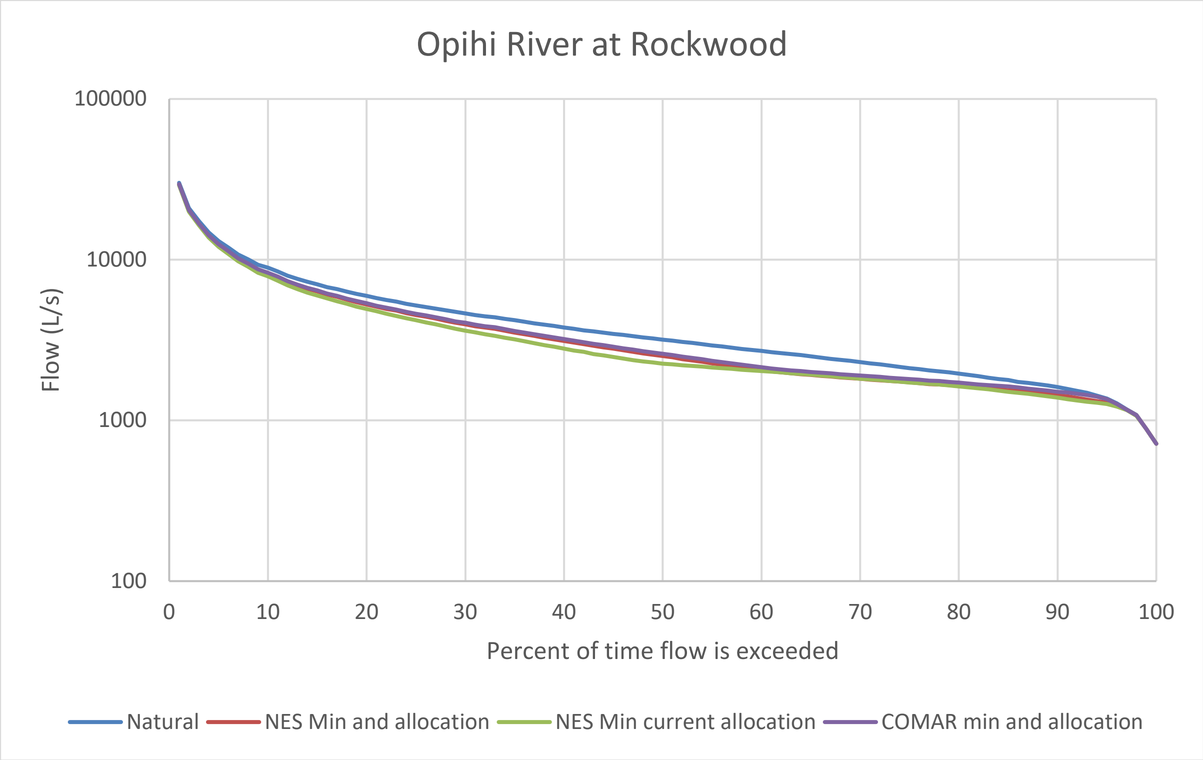

Figure 5. Flow duration curves for the differing minimum flow and allocation options compared to natural flow in the Opihi River

Key decision areas

Minimum flows for the Opihi River at Rockwood

The zone committee has indicated its preference to move to an ecological minimum flow in ten years, with a stepped increase in five years.

- **Option one – confirm the recommendation in Table** 8
- **Option two – following the further information in this paper, revise the minimum flow recommendations**

Allocation in the Opihi River at Rockwood

The size of the allocation limit has impacts on both the reliability of consent holders within the allocation block and on the residual flows left in the river.

- **Option one - cap the current allocation as the limit**
- **Option two- Set the limit at the NES recommendation**
- **Option three- cap the allocation at current with a sinking lid, reducing over time with unused water being surrender and not reallocated until NES limit is reached.**

Te Ana a Wai River

The Te Ana a Wai River currently has an allocation above that in the NES and a minimum flow below both the NES and cultural recommendation. Hayward (2017) classified it as a river which generally exhibits good ecological health but shows vulnerability to low flow and water quality pressures. Figure 17 and Figure 18 show that if all consented abstraction occurred, residual flow (below all takes) could cause flows to drop to very low levels. There are also gains in this reach which would result in a lesser flow reduction than modelled at the confluence with the Opihi River.

Changes to reliability

Table 6 show the effects of the current plan and the different NES and COMAR recommendation on the days consent holders are restricted. Table 12 indicates that affiliated consent holders are more restricted by the Te Ana a Wai minimum flows and the un-affiliated consents are more restricted by the Opihi minimum flows.

The effects of the different flow regimes (Table 6) show that the high COMAR minimum flow and small allocation block results in a large amount of time on full restriction and that keeping the current allocation block size would result in a large amount of time on partial restriction. The flow duration curve (Figure 6) show that the large allocation block size has an impact over much of the flow profile.

Table 6. Impacts on restrictions of differing minimum flow and allocation combinations for the Te Ana a Wai River

	Days on full restriction A block	**Days on partial restriction A block**	**Days on full restriction B block**	**Days on partial restriction B block**
Current plan rules	AA 21 AN 19	AA 14 AN 139	BA 21 BN 182	BA 14 BN 2
NES min flow, NES allocation	21	23		
NES min flow, current allocation (AN + AA+ BA)	24	45		
COMAR min flow, current allocation (AN + AA+ BA)	89	13		

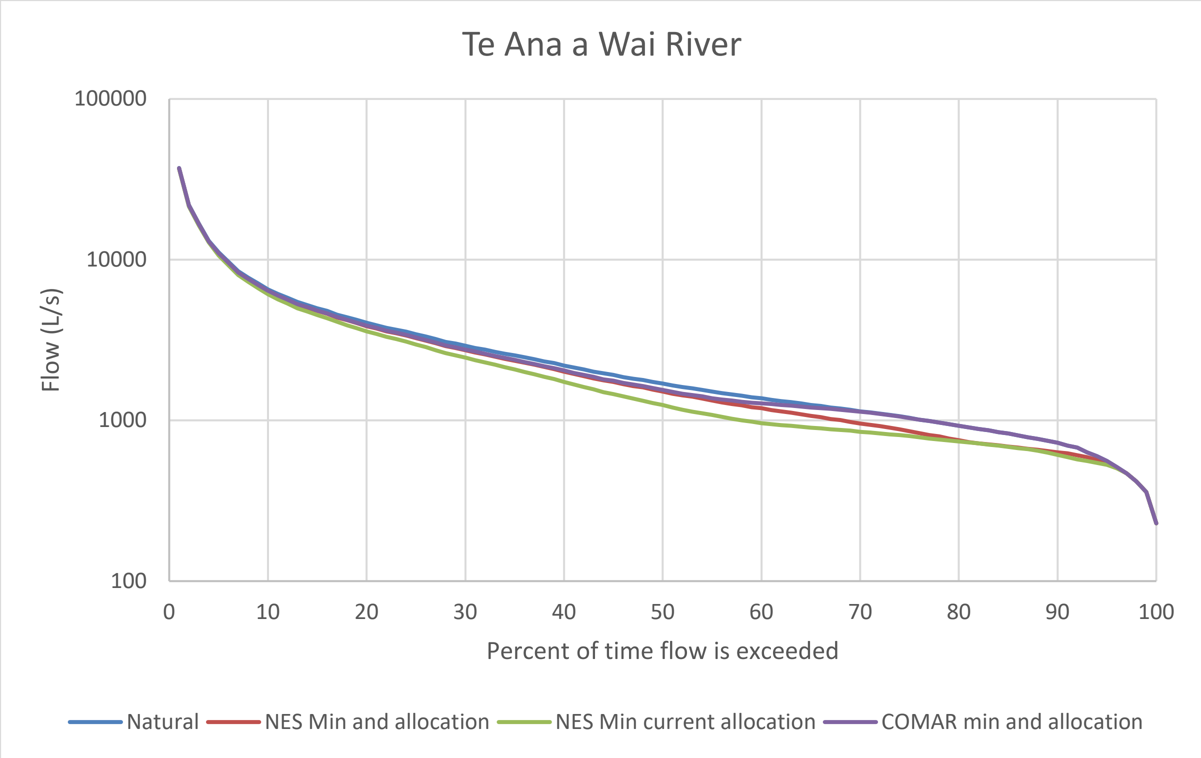

Figure 6. Flow duration curves for the differing minimum flow and allocation options compared to natural flow in Te Ana a Wai

Key decision areas

Minimum flows for the Te Ana a Wai River Catchment

The zone committee has indicated its preference to move to an ecological minimum flow in ten years, with a stepped increase in five years.

- **Option one – confirm the recommendation in Table** 8
- **Option two – following the further information in this paper, revise the minimum flow recommendations**

Allocation in the Te Ana a Wai River

The size of the allocation limit has impacts on both the reliability of consent holders within the allocation block and on the residual flows left in the river.

- **Option one - cap the current allocation as the limit**
- **Option two- Set the limit at the NES recommendation**
- **Option three- cap the allocation at current with a sinking lid, reducing over time with unused water being surrender and not reallocated until NES limit is reached.**

Opuha River and Lower Opihi River

Minimum flow site location for un-affiliated consent holders

As un-affiliated consents need to have a minimum flow condition which is not dependent on the management and activities of OWL, these consents are currently monitored using an un-modified flow calculation on the Opihi River at SH1. The un-modified flow calculation estimates the flow which would be in the river on a given day if Opuha dam was not in place. As the catchment has been modified this is the only practical way to manage these consents independently of the Opuha Dam. As mentioned earlier in this paper and previous discussions, setting appropriate minimum flows on the tributaries would mean that less consents would require the SH1 minimum flow.

Key Decision Area

- **Continue managing un-affiliated consents on the Opuha River and lower Opihi River using an un-modified flow calculation at SH1.**

Table 7 Minimum flow recommendations from Hayward (2017)

Surface water allocation zone	Minimum flow site location and site No.		Naturalised 7dMALF (L/s)	Naturalised Median flows	Common consent min. flows A block (L/s)	Common consent min. flows BN takes to storage (L/s)	ORRP minimum flow (L/s)	NES default minimum flow (L/s)	Ecological minimum flow recommendation (L/s)	Cultural minimum flow preferences (L/s)	NES default allocation	
											NES allocation as % of MALF (L/s)	Current allocation (L/s)
North Opuha	Clayton Rd (69615)	summer	826	1,843	850 Oct - Apr			743	740 - 850 (Oct - Apr)		248	A - 609 B - 393
		winter			1,000 Apr - Sep							
South Opuha	Monument bridge (69616)	summer	666	1,869	500 Sep - Apr	2,876		599	520 - 600 (Oct - Apr)		200	A - 159 B - 957 no block - 57
		winter			800 Apr - Aug							
Opuha River	Skiptons Bidge (69614)	summer	2,399				Recommended min. flows be established for these tributaries	1,919	2,000	2,000	1,200	A - 29 B - 1,500
		winter										
Upper Opihi -Rockwood	Rockwood (69618)	summer	1,291	3,396	790 Nov - Mar			1,033	1,000 Nov - Mar 1,200 - 1,500 Apr - Oct	1,500	684	A - 144 B - 896 no block - 46
		winter	2,003		1,280 Apr - Oct			1,602				
Te Ana a Wai River (Tengawai River)	Te Ana a Wai R at Picnic grounds (69635)	summer	616	1,824	400 Oct-Apr	1,100 (stacked min flow above this)		554	550 (Oct - Apr) 1,200 (May - Sept)	1,200	185	A - 467 B - 856 no block - 87
		winter	1,031		600 May-Aug							
					500 Sep							
Lower Opihi River catchment Non affliated takes	Opihi R at SH1 bridge (69607)	summer	2,685		2,500	15,000	2,500 (AN permits - unmodified flow) 15,000 (BN permits measured flow)	2,148	2,500	2,600	1,343	A - 5,431 B - 1,460 no block - 392
Temuka	Temuka R at Manse Bridge (69602)	summer (Oct - Mar)	1,664	4,048	700	1,600	700 (A permits) 1,600 (B permits)	1,335	1,400 Oct - Apr	1,500	832	A - 2,511 B - 650 no block - 215
		winter (Apr - Sept)	2,352		1,000	1,900	1,000 (A permits) 1,900 (B permits)					

Table 8 Initial thinking of the Zone Committee based on the workshop 11 Sept 2017

SWAZ	Current min. flow (L/s)	Step 1 (5 years) min. flow (L/s)	Step 2 (10 years) min. flow (L/s)	Allocation
North Opuha	S 850	Status quo as meeting NES		
	W 1000	+/- ecological flows		
South Opuha	S 500	520	600	
	W 800			
Upper Opihi	S 790	1000	1200	
	W 1280	1280	1500	
Te Ana a Wai	S 400	475	550	
	W 600	900	1200	
	Sept	500		
Lower Opihi	2500	Meets NES & Eco. flows (CF 2600)		
Temuka	700	1050	1400	
	1000	Aspire to 90% MALF winter		
Note: check best time periods for seasonal variations e.g. South Opuha have short irrigation season				

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Appendix 1: Flow and allocation for the Opihi Catchment, Tables and Figures

Water usage

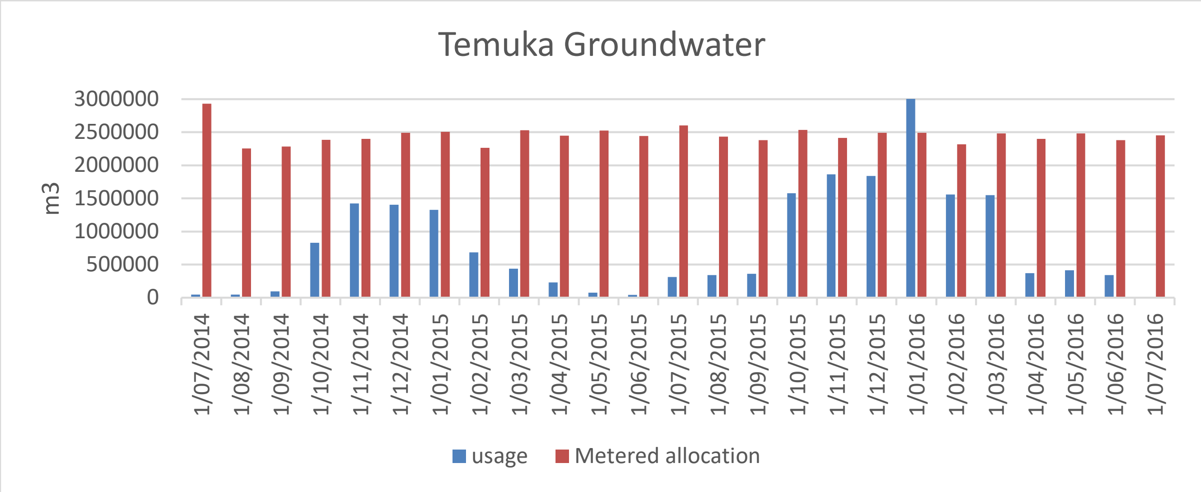

Figure 7. Water usage and allocation of groundwater in the Temuka catchment (2014-2016). (Monthly metered allocation is calcualted as the monthly average of the annual volumne allocated)

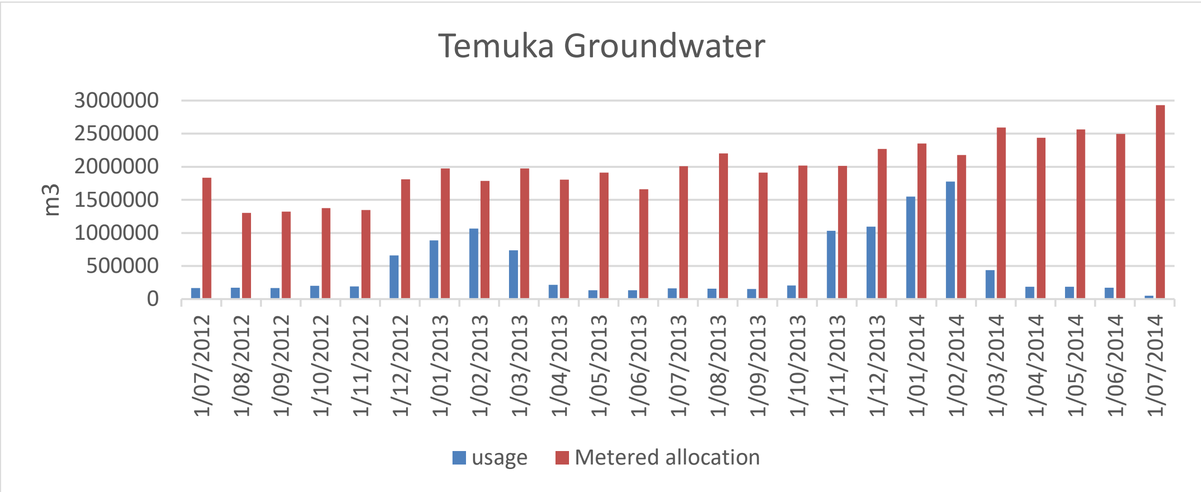

Figure 8. Water usage and allocation of groundwater in the Temuka catchment (2012-2014)

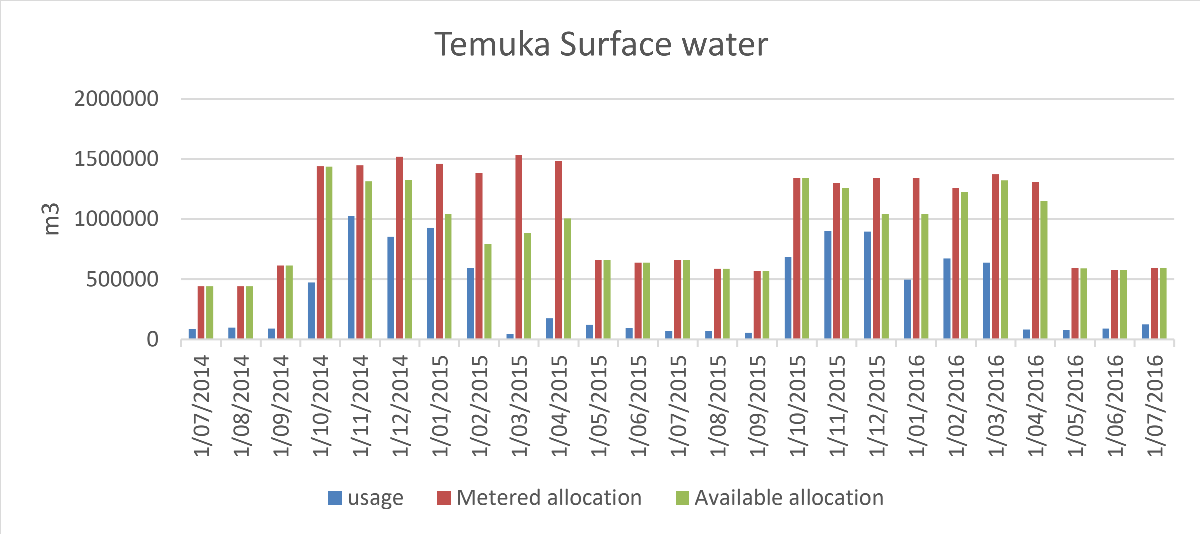

Figure 9. Water usage, allocation and availabile allocation (including restrictions) of surface water in the Temuka catchment (2014-2016)

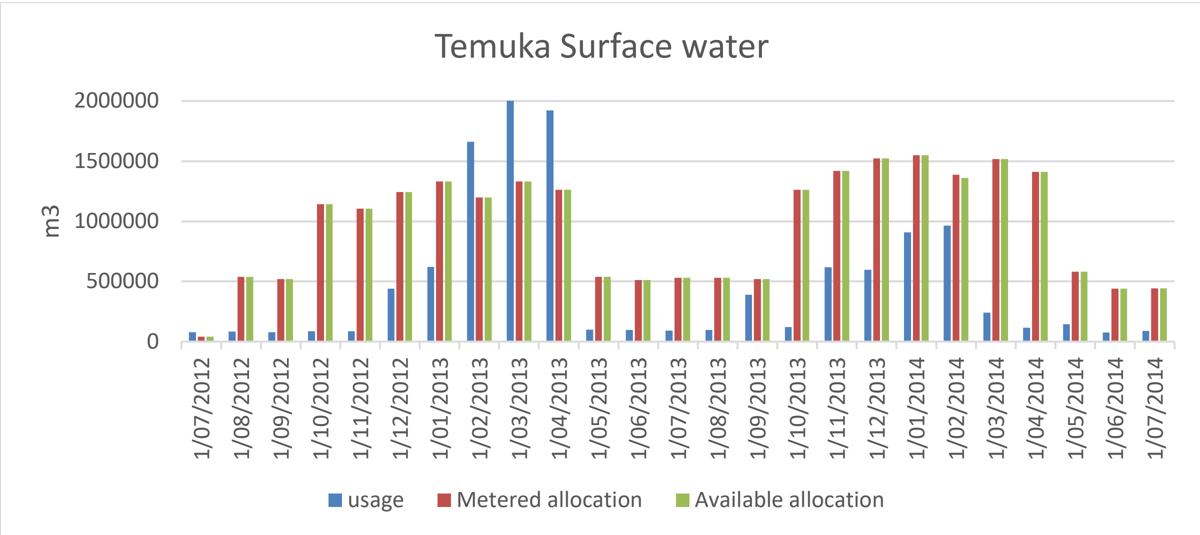

Figure 10. Water usage, allocation and availabile allocation (including restrictions) of surface water in the Temuka catchment (2012-2014)

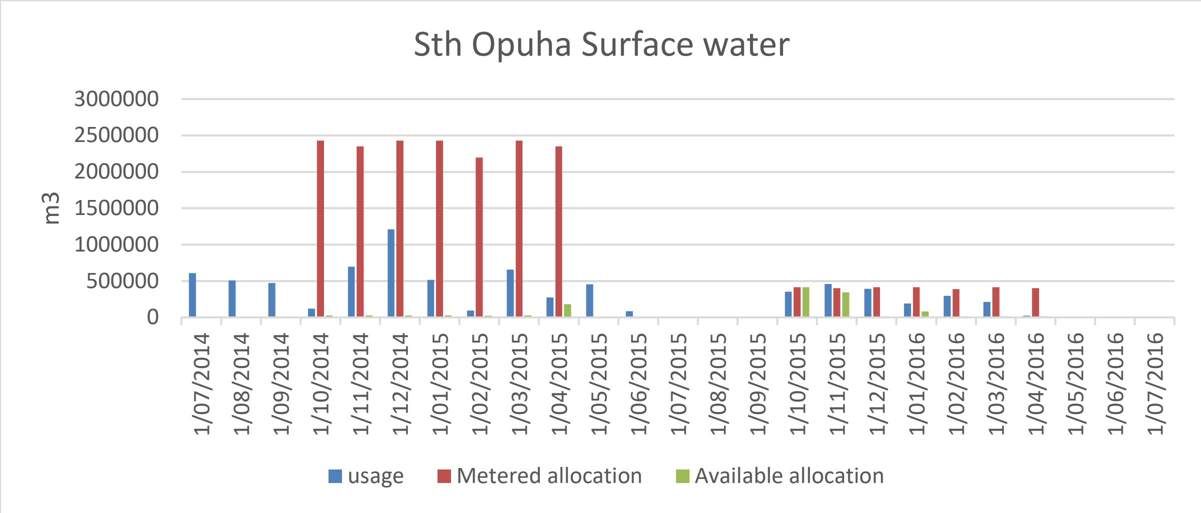

Figure 11. Water usage, allocation and availabile allocation (including restrictions) of surface water in the South Opuha catchment (2014-2016)

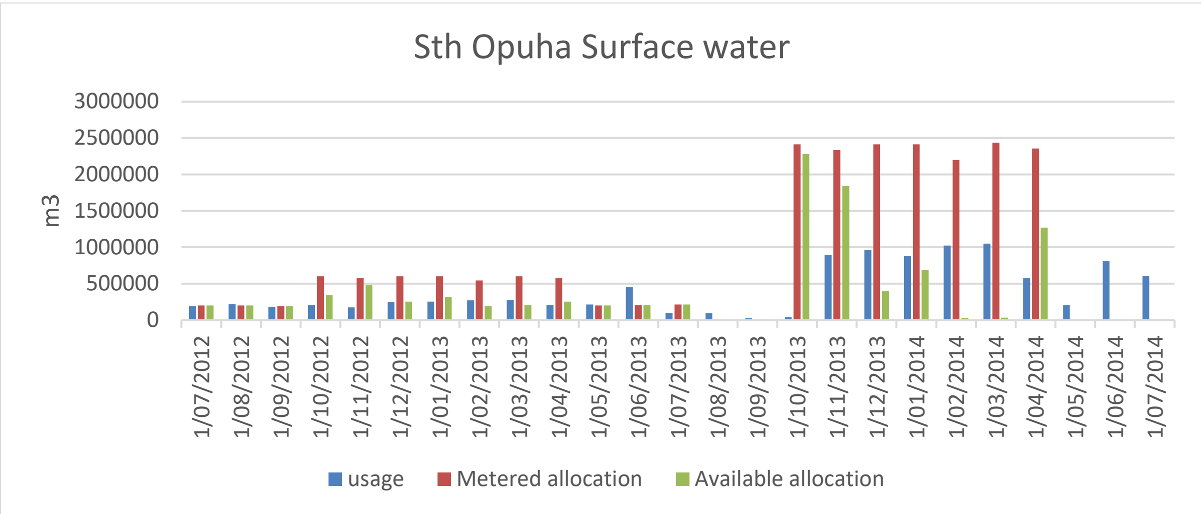

Figure 12. Water usage, allocation and availabile allocation (including restrictions) of surface water in the South Opuha catchment (2012-2014)

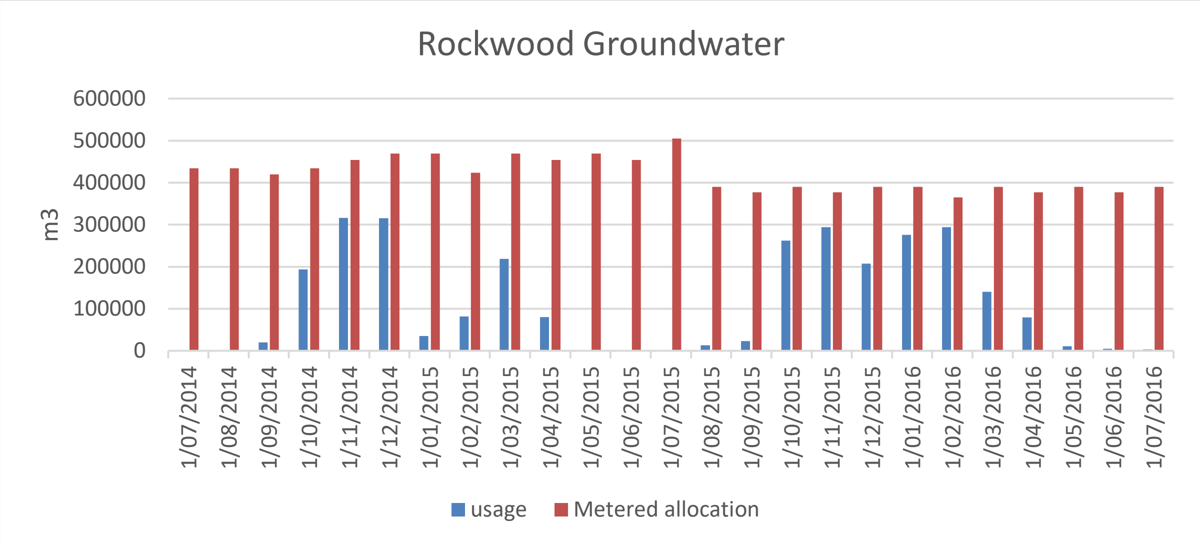

Figure 13 Water usage and allocation of groundwater in the Opihi (above Rockwood) catchment (2014-2016)

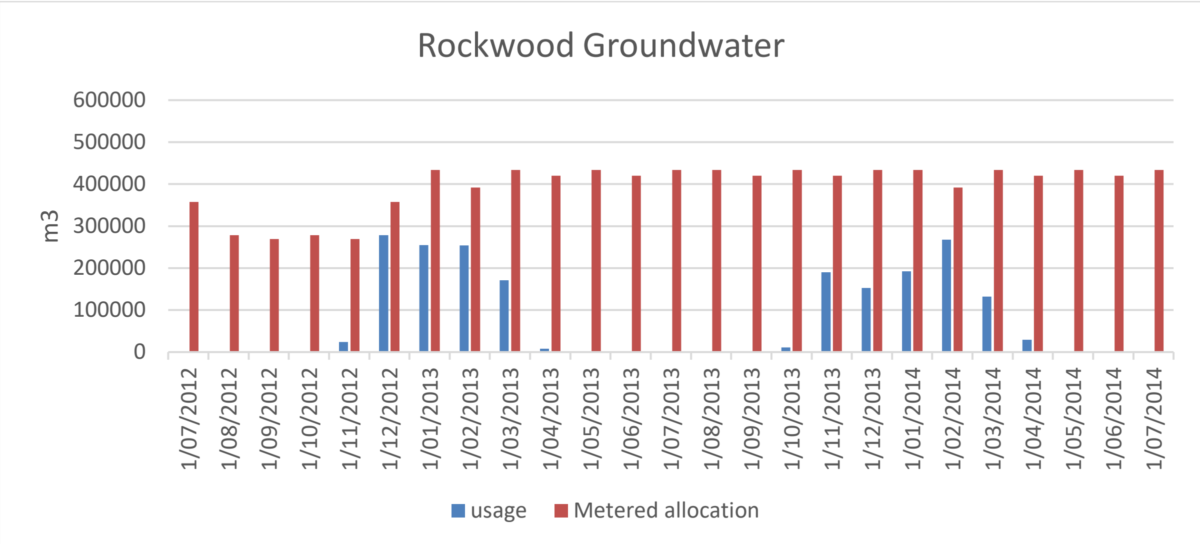

Figure 14 Water usage and allocation of groundwater in the Opihi (above Rockwood) catchment (2012-2013)

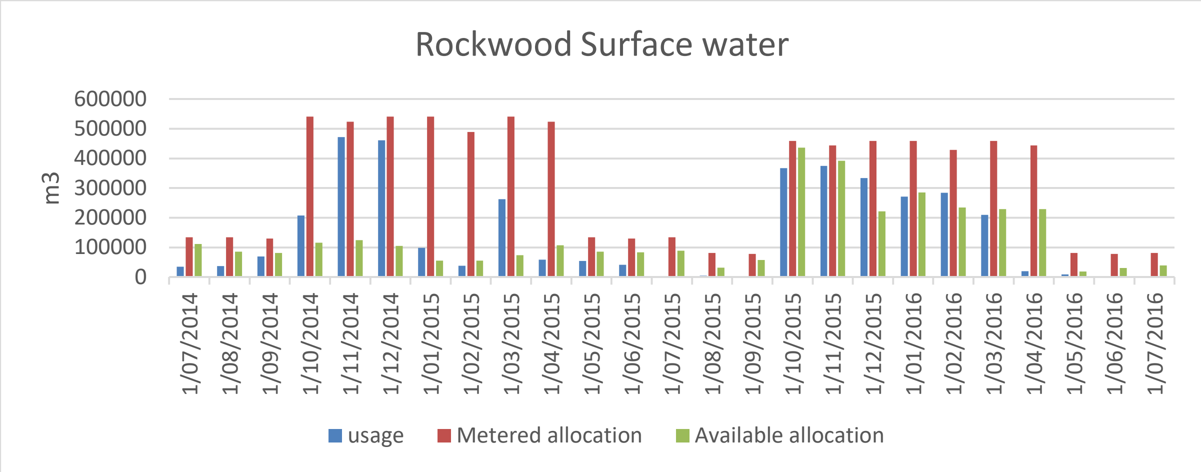

Figure 15 Water usage,allocation and available allocation(including restrictions) of surface water in the Opihi (above Rockwood) catchment (2014-2016)

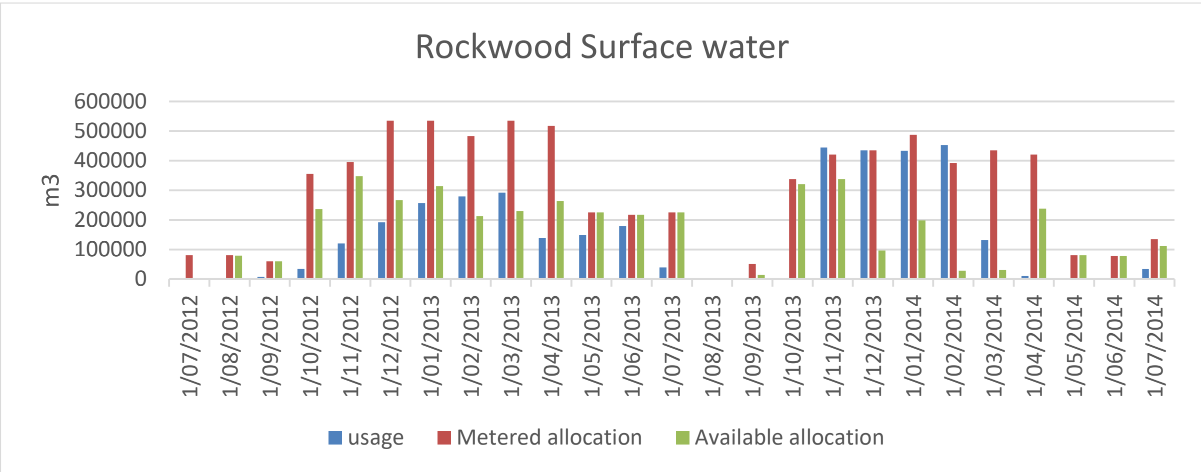

Figure 16 Water usage,allocation and available allocation(including restrictions) of surface water in the Opihi (above Rockwood) catchment (2012-2014)

Effects of flow and allocation on flows

Current plan rules

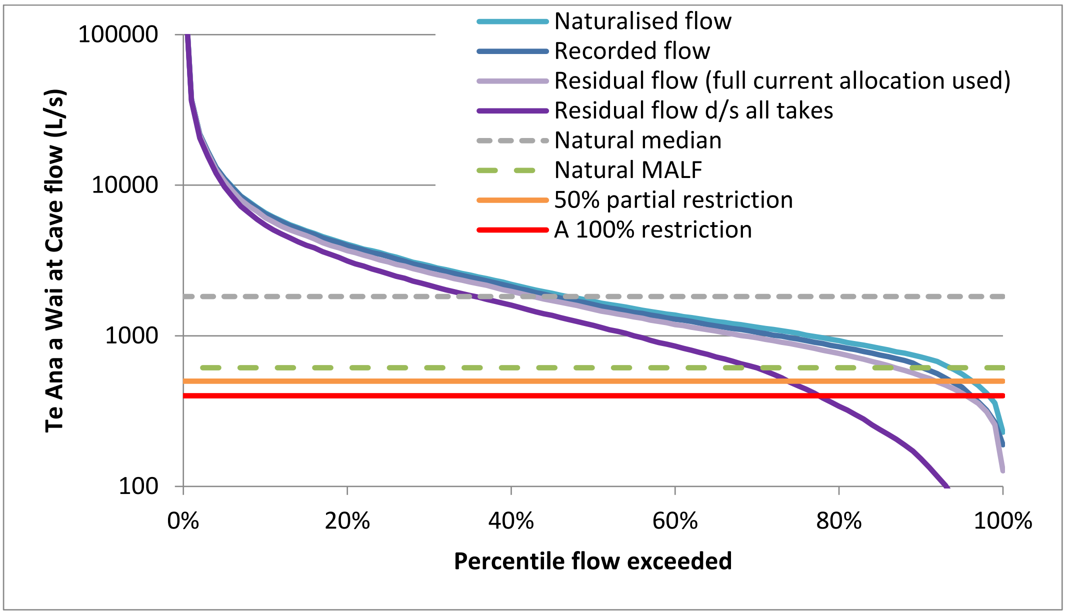

Figure 17. Flow duration curve of the Te Ana a Wai flows, including naturalised flows, recorded flows and estimates of flows if all of the allocation consented was abstracted, both at the recorder and downstream of all takes.

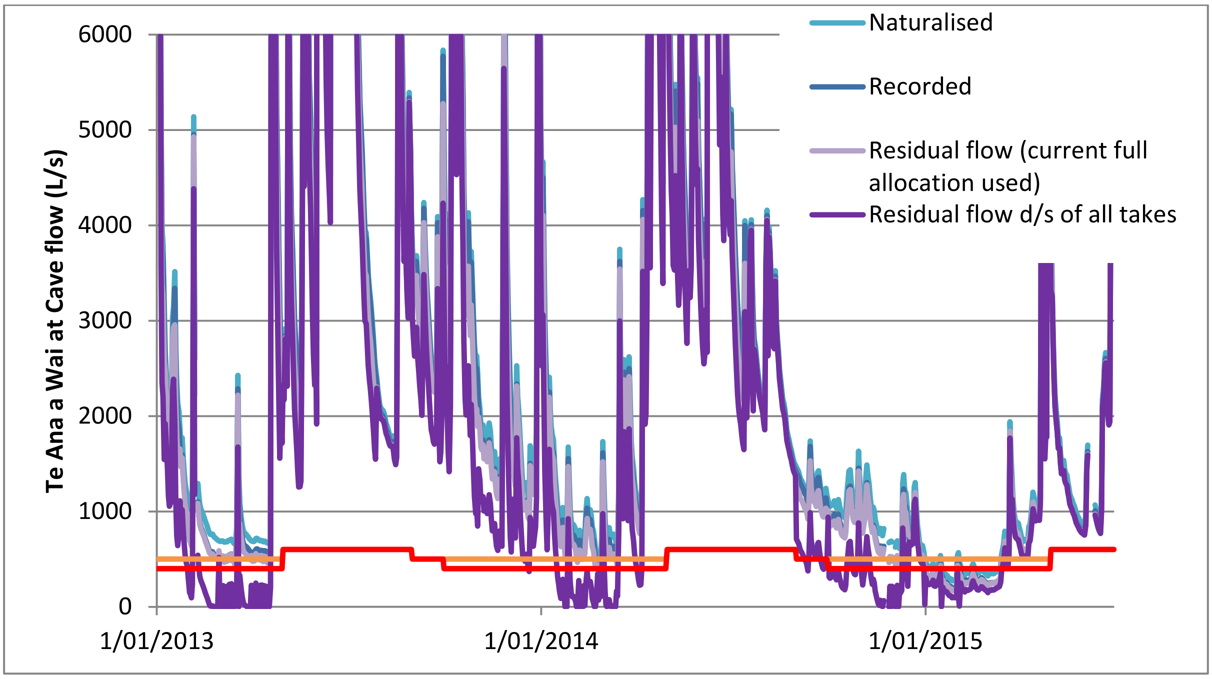

Figure 18. Hydrograph of naturalised, recorded and modelled flows if all consented abstraction occurred in Te Ana a Wai.

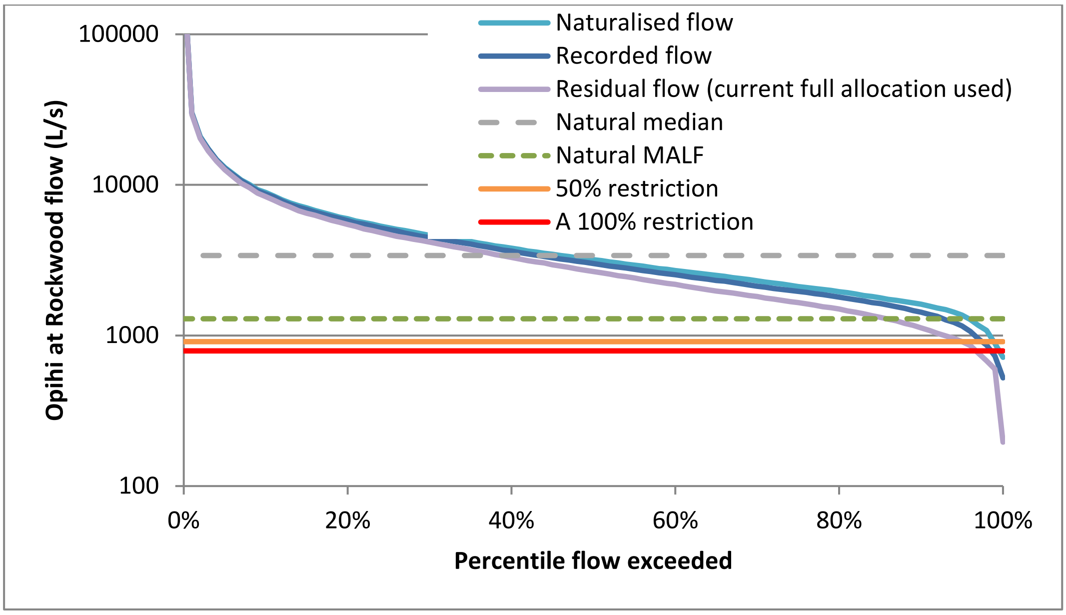

Figure 19 Flow duration curve for the Opihi River at Rockwood, showing naturalised flows, recorded and the residual flow if all consented abstraction occurred.

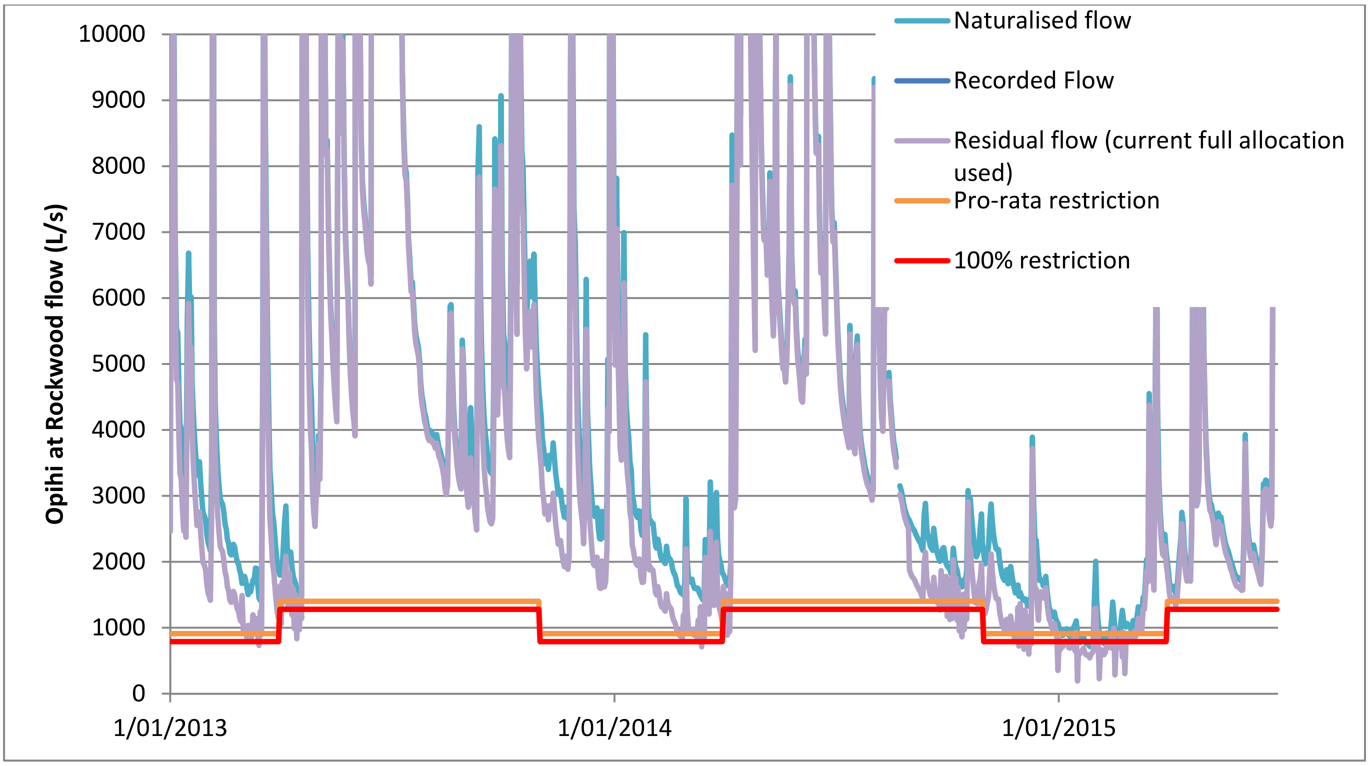

Figure 20. Hydrograph of naturalised, recorded and modelled flows if all consented abstraction occurred in Opihi River at Rockwood.

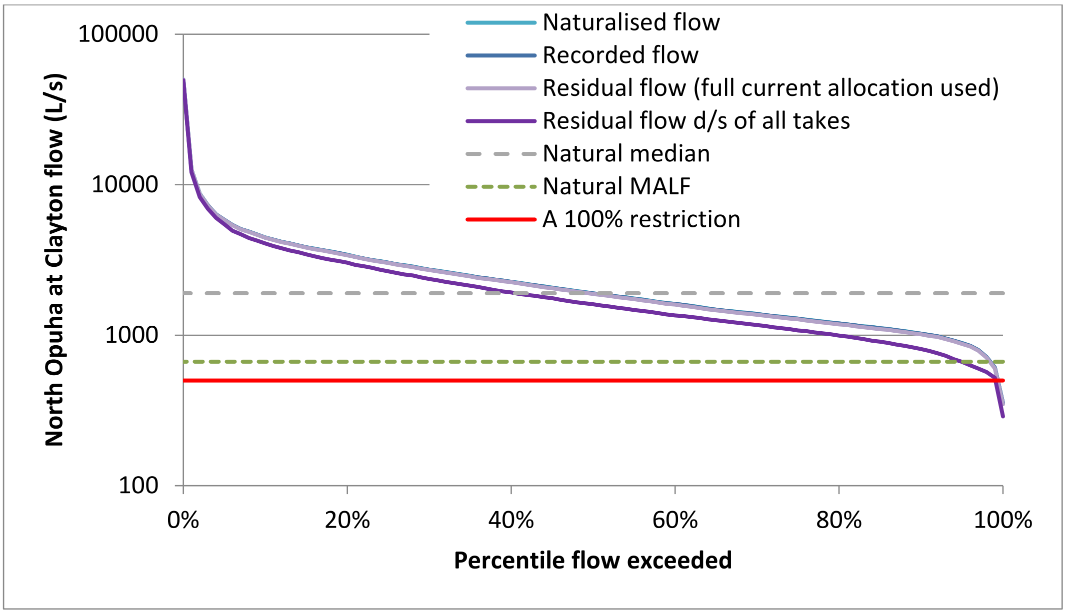

Figure 21. Flow duration curve for the North Opuha showing naturalised flows, recoded flows and residual flows is all consented abstraction was taken.

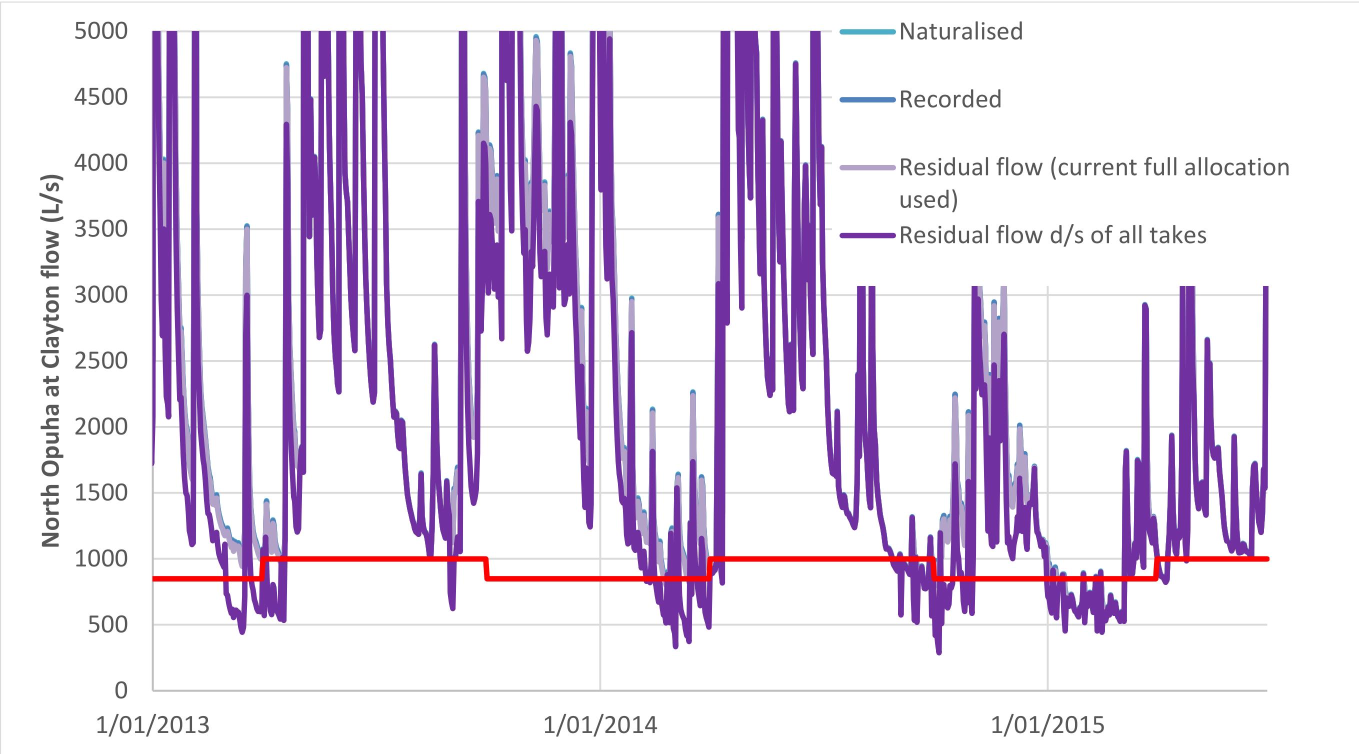

Figure 22. Hydrograph of naturalised, recorded and modelled flows if all consented abstraction occurred in North Opuha.

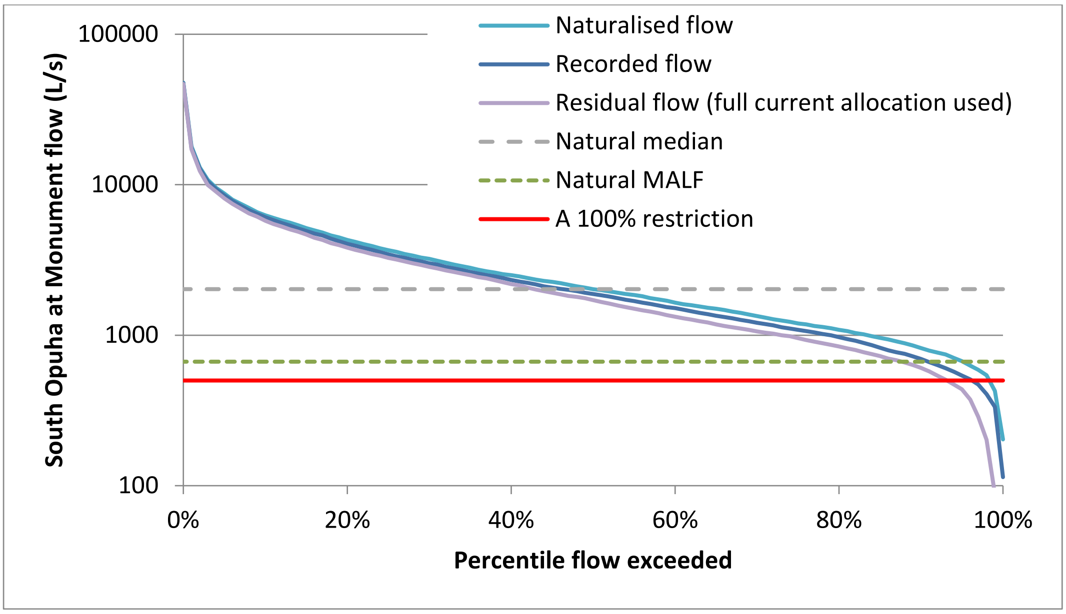

Figure 23 Flow duration curve for the South Opuha, showing the naturalised flow, recorded flow and the residual flow if all consented abstraction was taken.

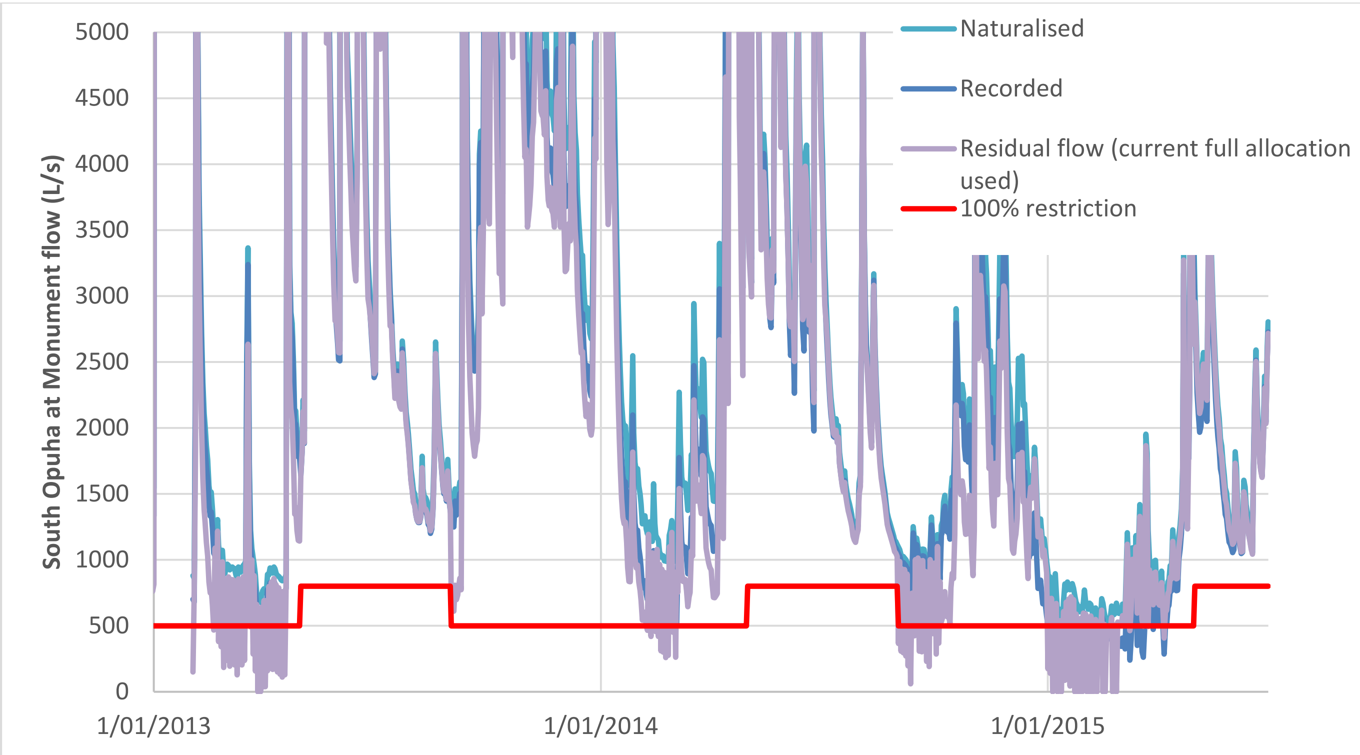

Figure 24. Hydrograph of naturalised, recorded and modelled flows if all consented abstraction occurred in South Opuha.

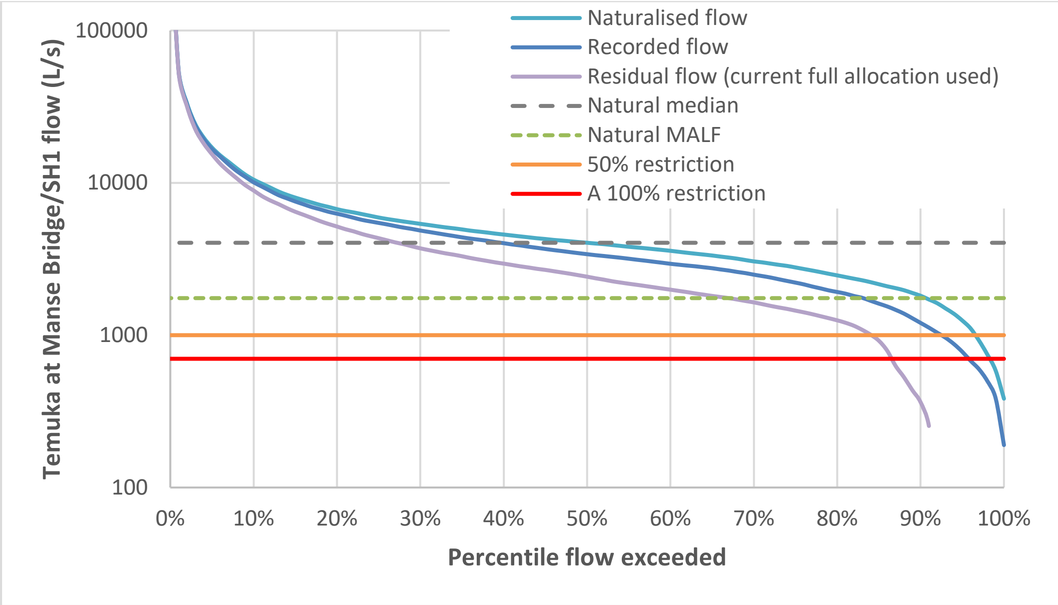

Figure 25 Flow duration curve for the Temuka River, showing the naturalised flow, recorded flow and the residual flow is all consented abstraction was taken.

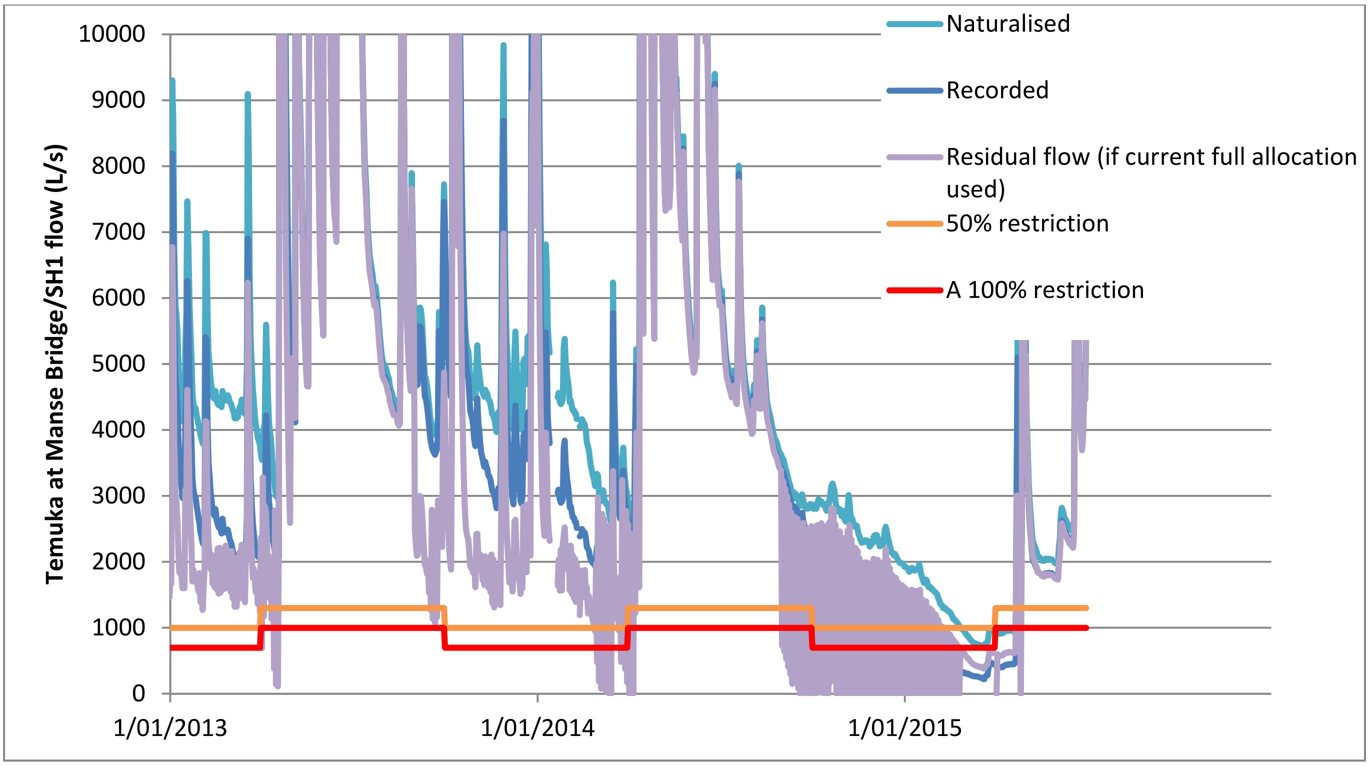

Figure 26. Hydrograph of naturalised, recorded and modelled flows if all consented abstraction occurred in Temuka River

Table 9 Current reliability of supply for the South Opuha, including restrictions based on the South Opuha and Opihi main stem.

S Opuha at Monument								
Reliability of supply								
Irrigation season	# days on full restriction S Opuha	# days on full restriction BA	# days combined S Opuha + BA	# days on full restriction BN (S Opuha)	# days on full restriction BN (SH1)	# days on partial restriction BN (S Opuha)	# days combined S Opuha BN +BN (SH1) full	# days combined S Opuha BN +BN (SH1) partial
1998-1999	5			173	224	12	227	1
1999-2000	0			112	117	18	154	6
2000-2001	39			132	157	1	164	1
2001-2002	4			123	149	4	163	4
2002-2003	0			147	220	6	220	1
2003-2004	0			122	176	4	178	2
2004-2005	13	1	14	138	148	12	172	8
2005-2006	11	9	20	202	203	1	228	0
2006-2007	18	3	21	107	177	2	178	0
2007-2008	27	11	38	141	229	3	229	0
2008-2009	54	0	54	142	192	8	198	2
2009-2010	54	1	54	171	207	3	216	3
2010-2011	4	0	4	182	160	2	221	1
2011-2012	29	4	32	157	164	3	183	0
2012-2013	29	20	49	111	123	4	147	3
2013-2014	11	0	11	122	174	7	176	3
2014-2015	54	75	123	233	240	4	240	0
Average	**21**	**11**	**38**	**148**	**180**	**6**	**194**	**2**

Table 10 Current plan reliability of supply for consents in the North Opuha, shows sub-catchment restrictions and Opihi restrictions separately and combined effect.

N Opuha at Clayton Road bridge							
Reliability of supply							
Irrigation season	# days on full restriction N Opuha	# days on full restriction AA and BA	# days combined Opuha + AA/BA	# days on full restriction AN	# days on partial restriction AN	# days combined Opuha +AN full	# days combined Opuha + AN partial
1998-1999	3			19	145	22	142
1999-2000	0			0	163	0	163
2000-2001	58			12	150	70	92
2001-2002	8			0	161	8	153
2002-2003	0			6	154	6	154
2003-2004	0			16	143	16	143
2004-2005	0	1	1	0	158	0	158
2005-2006	2	9	10	0	157	2	155
2006-2007	6	3	9	0	156	6	150
2007-2008	0	11	11	0	156	0	156
2008-2009	0	0	0	0	156	0	156
2009-2010	0	1	1	0	156	0	156
2010-2011	0	0	0	0	156	0	156
2011-2012	13	4	17	0	156	13	143
2012-2013	5	20	25	0	156	5	151
2013-2014	11	0	11	4	152	15	141
2014-2015	86	75	143	74	82	119	37
Average	**11**	**11**	**21**	**8**	**150**	**17**	**142**

Table 11 Current plan reliability of supply for consents in Opihi above Rockwood, shows sub-catchment restrictions and Opihi restrictions separately and combined effect.

Opihi at Rockwood							
Reliability of supply							
Irrigation season	# days on full restriction Rockwood	# days on full restriction BA	# days combined Rockwood + BA full restriction	# days on full restriction AN	# days on partial restriction AN	# days combined Rockwood + AN full restriction	# days combined Rockwood + AN partial
1998-1999	11			19	145	28	138
1999-2000	2			0	163	2	163
2000-2001	61			12	150	68	96
2001-2002	32			0	161	32	131
2002-2003	13			6	154	18	144
2003-2004	23			16	143	34	127
2004-2005	0	0	0	0	158	0	160
2005-2006	11	9	20	0	157	11	148
2006-2007	11	3	14	0	156	11	147
2007-2008	27	11	35	0	156	27	131
2008-2009	20	0	20	0	156	20	138
2009-2010	40	1	41	0	156	40	118
2010-2011	3	0	3	0	156	3	155
2011-2012	25	4	28	0	156	25	133
2012-2013	8	20	28	0	156	8	150
2013-2014	6	0	6	4	152	10	148
2014-2015	60	75	133	74	82	110	48
Average	**21**	**11**	**30**	**8**	**150**	**26**	**134**

Table 12 Current plan reliability of supply for consents in the Te Ana a Wai, shows sub-catchment restrictions and Opihi restrictions separately and combined effect.

Te Ana a Wai at Cave Picnic Grounds														
Reliability of supply														
Irrigation season	# days on full restriction Te Ana a Wai	# days on partial (50%) restriction Te Ana a Wai	# days on full restriction AA/BA	# days combined Te Ana a Wai + AA/BA full	# days combined Te Ana a Wai + AA/BA partial	# days on full restriction AN	# days on partial restriction AN	# days combined Te Ana a Wai +AN full	# days combined Te Ana a Wai +AN partial	# days on full restriction BN (Te Ana a Wai - lowest band)	# days on full restriction BN (SH1)	# days on partial restriction BN (Te Ana a Wai - lowest band)	# days combined Te Ana a Wai BN (lowest band) +BN (SH1) full	# days combined Te Ana a Wai BN (lowest band) +BN (SH1) partial
1998-1999	10	15				19	145	26	138	94	224	36	224	0
1999-2000	0	0				0	163	0	163	53	117	33	117	4
2000-2001	75	12				12	150	78	84	130	157	22	172	17
2001-2002	0	0				0	161	0	161	72	149	15	149	1
2002-2003	27	29				6	154	31	129	169	220	31	223	3
2003-2004	28	14				16	143	32	127	112	176	15	176	0
2004-2005	0	0	1	1	0	0	158	0	158	27	148	30	148	0
2005-2006	9	25	9	18	25	0	157	9	148	107	203	30	208	3
2006-2007	0	0	3	3	0	0	156	0	156	110	177	27	178	1
2007-2008	0	27	11	11	24	0	156	0	156	125	229	34	229	0
2008-2009	26	24	0	26	24	0	156	26	130	124	192	19	195	1
2009-2010	17	45	1	18	45	0	156	17	139	143	207	22	210	7
2010-2011	0	0	0	0	0	0	156	0	156	56	160	22	161	1
2011-2012	0	0	4	4	0	0	156	0	156	64	164	34	164	0
2012-2013	0	18	20	20	17	0	156	0	156	77	123	3	123	0
2013-2014	2	10	0	2	10	4	152	6	150	69	174	25	174	0
2014-2015	70	15	75	126	12	74	82	99	57	198	240	27	240	0
Average	16	14	11	21	14	8	150	19	139	102	180	25	182	2

Table 13 Current plan reliability of supply for consents in the Temuka Catchment.

Temuka at Manse Bridge				
Reliability of supply				
Irrigation season	# days on full restriction A	# days on partial restriction A	# days on full restriction B	# days on partial restriction B
1983-1984	14	4	65	27
1984-1985	126	6	183	21
1985-1986	1	2	48	22
1986-1987	36	5	72	13
1987-1988	98	9	126	20
1989-1988	110	18	147	27
1989-1990	72	15	122	20
1990-1991	N/A*	N/A*	N/A*	N/A*
1991-1992	62	10	135	28
1992-1993	21	4	55	13
1993-1994	9	1	37	27
1994-1995	61	15	118	25
1995-1996	0	0	6	13
1996-1997	0	0	23	21
1997-1998	57	4	98	119
1998-1999	69	2	117	39
1999-2000	0	6	43	15
2000-2001	61	5	111	36
2001-2002	37	1	67	22
2002-2003	57	12	131	37
2003-2004	45	3	85	26
2004-2005	18	7	59	25
2005-2006	50	3	88	41
2006-2007	18	7	80	19
2007-2008	79	8	134	22
2008-2009	50	3	100	23
2009-2010	46	11	123	29
2010-2011	2	1	63	61
2011-2012	10	5	41	24
2012-2013	4	3	32	38
2013-2014	14	8	52	30
2014-2015	143	9	170	8
Average	**44**	**6**	**88**	**29**

* No flow data available for this year.