Covering Memo

Date	29 June 2018 / 3 August 2018
To	Orari-Temuka-Orari-Pareora Zone Committee
CC	Flow and Allocation Working Party Technical Advisors
From	Craig Davison, Dan Clark, Shirley Hayward

Evaluation of the Opihi Flow and Allocation Working Party's (FAWP) Preferred Environmental Flow and Allocation Regimes for the Tributaries of the Opihi River

INTRODUCTION:

The Opihi FAWP has provided the OTOP Zone Committee with its preferred environmental flow and allocation regimes for the tributary rivers of the Opihi catchment. These proposals have been provided in the form of written feedback received[1] during the two consultation periods on the Draft Zone Implementation Programme Addendum (dZIPA) for the OTOP Zone to date[2].

The preferred regimes are to apply to AA, AN and BA water permits. It is understood these regimes have been developed in consideration of the ecological flow assessment work recently undertaken for the OTOP Zone Committee[3]. It is acknowledged that the draft economic assessment of proposed minimum flow changes included some anomalies to be addressed. It is reiterated that this assessment has undergone a significant amount of moderation and will be considered by the Zone Committee as part of their decision making on draft flow and allocation recommendations for the Opihi catchment. An update on the progress of the economic evaluation will be provided to the Zone Committee on 6 August.

Prior to this memo being circulated to the Zone Committee, it was provided to the FAWP's technical advisors on 29 June 2018 and form formed the basis of a meeting held on 3 July 2018. The FAWP's technical advisors are scheduled to present to the Zone Committee on 6 August 2018 in response to this evaluation.

[1] Opihi FAWP's Feedback on Draft Orari-Temuka Opihi-Pareora Zone Implementation Programme Addendum & First Addendum to the Opihi FAWP's Feedback on the Draft Orari-Temuka Opihi-Pareora Zone Implementation Programme Addendum

[2] 15 December 2017 – 2 March 2018 & 20 April 2018 – 4 May 2018

[3] Presented on 16 April 2018

STRUCTURE OF EVALUATION

The evaluation of the FAWP's preferred environmental flow regimes for the tributary rivers of the Opihi has three components:

- A planning evaluation in the context of the requirements of the National Policy Statement for Freshwater Management 2014 (as amended by 2017), and the architecture of the Land and Water Regional Plan, and, in particular, the scope for sub region plan changes;
- A hydrological evaluation in contrast with the current regime, the regimes proposed in the draft Zone Implementation Programme Addendum (ZIPA), and the cultural preferences;
- An ecological evaluation in the context of the ecological flow assessment completed by NIWA.

Memo

Date	29 June 2018
To	Orari-Temuka-Orari-Pareora Zone Committee
CC	Flow and Allocation Working Party Technical Advisors
From	Craig Davison

Planning Evaluation of the Opihi Flow and Allocation Working Party's (FAWP) Preferred Environmental Flow and Allocation Regimes for the Tributaries of the Opihi River

PURPOSE:

The purpose of this memo is to provide the FAWP's technical advisors an evaluation of the FAWPs preferred environmental flow and allocation regimes for the North and South Opuha, Upper Opihi and Te Ana Wai rivers from a planning perspective

INTODUCTION

The evaluation of the Flow and Allocation Working Party's (FAWP) preferred environmental flow and allocation regimes from a planning perspective has been undertaken in consideration of the obligations placed on councils under the Resource Management Act 1991 (RMA) including the National Policy Statement for Freshwater Management 2017 (NPSFM). Although the NPSFM focusses on water quantity and quality, only its obligations relating to water quantity have been considered in this evaluation. It also considers the framework of the Land and Water Regional Plan (LWRP), and the scope for sub region plan changes provided for under the LWRP

National Policy Statement for Freshwater Management 2017

The NPSFM requires water quantity limits to be set, including environmental flows and allocation limits[4] in all Freshwater Management Units (FMUs). The term "limit" is defined in the NPSFM as the maximum amount of resource available to be allocated. An environmental flow (type of limit) and allocation regime must be designed to ensure that a freshwater objective will be met. A "freshwater objective" is defined as an intended environmental outcome for an FMU. Of relevance to the FAWP's preferred environmental flow regimes is the Opihi FMU, which includes the North and South Opuha rivers, the Opuha mainstem, the Upper Opihi and Te Ana Wai rivers, the Opihi mainstem, and all tributaries.

In the context of the limits that are required to be set, including environmental flows, the NPSFM requires councils to "avoid" any further over allocation of freshwater and to phase out existing over

[4] Policy B1 of the NPSFM

allocation[5]. The NPSFM defines "over-allocation" as the situation where the resource has been allocated to users beyond a limit, or is being used to a point where a freshwater objective is no longer being met[6]. Over allocation is considered to have occurred in either or, both, of those circumstances.

The NPSFM does not define the term "avoid". However, when planning documents do not define a term that comes under scrutiny as to its definition and application, it is normal practice to turn to the ordinary meaning of the word. Case law also provides guidance as to the interpretation of a term. The meaning of the term "avoid" was considered by the Supreme Court in an appeal on the High Court's decision in *Environmental Defence Society Inc v New Zealand King Salmon Company Limited*[7]. In its findings the Supreme Court considered the word "avoid" to have its ordinary meaning of "not allow" or "prevent the occurrence of".

Under the RMA, any plan or plan change that relates to management of freshwater resources is required to 'give effect to' (to implement) the NPSFM[8]. In this context the NPSFM compels Council to set freshwater objectives, establish limits to achieve those freshwater objectives, and implement methods (including rules) to avoid over allocation. Given the definitions afforded to these terms under the NPSFM and established through case law, councils have no option but to implement these two key outcomes of the NPSFM with respect to water quantity.

Land and Water Regional Plan and the National Policy Statement for Freshwater Management

The NPSFM was originally gazetted in 2011. Since then, it has evolved through changes to it in 2014 and 2017. However, two of its key outcomes of setting limits, including environmental flows, and avoiding over allocation have remained constant in all three iterations. When the Land and Water Regional Plan (LWRP) was developed, it gave effect to, at that time, the NPSFM 2011. The LWRP addresses two of the key outcomes of the NPSFM relating to setting limits and avoiding over-allocation. However, there are some gaps with its approach at a region wide scale meaning the that the LWRP does not fully give effect to the NPSFM as amended in the 2014 and 2017 versions. It is noted that the guidance from case law for the term "avoid" was not present at the time the LWRP was developed. However, any future plan change to the LWRP, including a sub region plan change, is required to give effect the NPSFM. Sub region plan changes are used as platforms to ensure the LWRP, overall, better gives effect to the NPSFM by incorporating collaboratively set limits and methods for achievement.

Application of Limits and Over-Allocation under the Land and Water Regional Plan

The LWRP defines a "limit[9]" as any environmental flow and/or allocation limit in Sections 6 to 15 of the plan. The application of limits under the LWRP has two tiers. Firstly, from a water quantity

[5] Objective B2 of the NPSFM

[6] NPSFM – Page 8 (Interpretation)

[7] *Environmental Defence Society Incorporated v New Zealand King Salmon Company Limited [2014] NZSC 38*

[8] Section 55 of the Resource Management Act 1991

[9] LWRP Section 2.9

perspective, limits are set to define the maximum amount of a freshwater resource available for abstraction within a catchment (similar to the definition of a limit under the NPSFM). Secondly, the limits are then used to regulate abstractions of freshwater by either prohibiting activities that would result in a limit being breached, or by requiring a resource consent for some abstractions that would result in a limit being breached on a case by case basis, for example, abstractions for community water supplies. This is one example where, at a region wide scale, the LWRP does not fully give effect to the NPSFM.

The LWRP does not define the term over-allocation. However, for the purposes of the plan[10], over allocation of a resource is considered to have occurred when a resource has been allocated to a user or users beyond a limit set in the plan (similar to the definition of over allocation under the NPSFM). With reference to water quantity, the LWRP avoids over-allocation, in most instances, (as required by the NPSFM) through its application of limits described above. The LWRP is explicit in not allowing any new abstractions where a catchment is over allocated, or where the abstraction would cause a catchment to become over allocated, with some exceptions as noted above. However, it is important to note that the region wide framework of the LWRP is, for the most part, considered a holding pattern until collaborative limit setting processes have been undertaken for each of its ten sub-region sections. When they become operative, the LWRP will, overall, better give effect to the NPSFM.

Plan Change 7 to the Land and Water Regional Plan

PC7 to the LWRP is intended to be notified in mid-2019 in response to the recommendations contained in the Zone Implementation Programme Addendum (ZIPA) for the OTOP Zone. It will include amendments to sub region Section 14 of the LWRP. The scope for the review of sub region sections is set out at a strategic policy level in the LWRP[11]. These strategic policies require that particular regard is had to collaboratively developed outcomes and methods to better achieve the objectives of the LWRP, but must not make any changes to these. Therefore, there will be no scope within PC7 to deviate from setting limits, and only ensuring water is available for abstraction within these limits to avoid over allocation occurring.

The FAWP's preferred environmental flow regimes, if incorporated into PC7 as proposed, have the potential to draw the subject rivers below the proposed minimum flows; in other words, beyond the limit of the environmental flow and allocation regime. This would result in PC7 being in direct conflict with the requirements of the NPSFM as freshwater resources would be allocated to abstractors beyond a limit (being the environmental flow), resulting in over-allocation of the freshwater resources. It would also be in direct conflict with the objectives of the LWRP and frustrate attainment of outcomes for the OTOP Zone.

The proceeding sections of this paper explain in detail the effects of the proposed FAWP regime for the North Opuha and South Opuha rivers, and the Upper Opihi and Te Ana Wai rivers.

[10] LWRP Section 2.5

Memo

Date	29 June 2018
To	Orari-Temuka-Orari-Pareora Zone Committee
CC	Flow and Allocation Working Party Technical Advisors
From	Dan Clark

Hydrological evaluation of the flow regime proposed by the Flow and Allocation Working Party for the Opihi River sub-catchments

This paper provides a hydrological evaluation of the Flow and Allocation Working Party's (FAWP) proposed regimes for the tributary rivers of the Opihi catchment. This evaluation compares the FAWP regime to the current regime, proposed ZIPA step 1, proposed ZIPA step 2 and COMAR (cultural flow preference) regimes. As the FAWP proposal provides flow regimes for the North Opuha, South Opuha, Upper Opihi and Te Ana A Wai, the scope of the evaluations is limited to these sub-catchments.

How does this evaluation fit this previous reliability assessments and flow evaluations?

This evaluation focuses on the water availability rather than demand and abstraction is modelled to occur whenever flow is sufficient irrespective of demand on that day. This availability data is provided to Aqualinc Research to do their demand modelling, which forms the basis of the economic assessment. This hydrological assessment shows a worst-case situation where abstraction is only controlled by flow, and this would result in the lowest flows in the rivers.

Previous flow evaluations have been focused on minimum flows within the irrigation season and when flows were modelled, abstractions were limited to the irrigation season. As the FAWP are making recommendations including winter minimum flows, we have changed to model to allow abstraction to occur outside of the irrigation season. This reflects what may happen when water is taken to storage under each of the flow regimes. The Opuha Water Limited (OWL) agreement states an irrigation season and share volumes reflect water being taken at 25mm per week for 22.5 weeks. If the evaluation was limited to the irrigation season there would be no modelled difference when winter minimum flows change.

This evaluation also reflects the final allocation numbers as reviewed by Irricon and Environment Canterbury and agreed with OWL in March 2018.

Dual minimum flows

The Opihi River Regional Plan (ORRP) sets minimum flows in the Opihi River mainstem and recommends that sub-catchment minimum flows are set through consenting processes. This results in consent holders being restricted by both the flows in the sub-catchment in which they are abstracting water and in the mainstem. This results in consent holders being restricted based on the most restrictive of the two minimum flows which apply to them on that day. The FAWP proposal

recommends keeping dual minimum flows despite this resulting in lower water availability for tributary abstractors compared to having the single sub-catchment minimum flow as they see the "offset" to the mainstem being of environmental benefit.

The FAWP however also propose a conflicting view that BN takes from the Te Ana A Wai should have a higher sub-catchment minimum flow and a reduced mainstem minimum flow to allow takes from the Te Ana A Wai when it's flow is higher but the mainstem is not high. The FAWP have advised ECan that their technical advisors are working on developing recommendations for B block recommendations, but these have not yet been completed and are not included in this assessment.

A and B allocation on tributaries

The ORRP has a different way of assigning A and B priority to abstraction as compared to other catchment plans. The priority is based upon when the consent was granted, pre- or post Opuha Dam construction. As the ORRP did not set minimum flow in the sub-catchments the A or B minimum flows are based on the Opihi River mainstem. The catchments generally do not have catchment specific B (or high flow take) minimum flows. The FAWP has suggested that it intends to provide further feedback on sub-catchment specific B minimum flows, but has not yet completed this work, so all analysis assumes that all catchment abstractors are managed with the same sub-catchment minimum flow trigger and the corresponding mainstem minimum flows, dependant on if they are an AA, AN, BA or BN take.

Partial restrictions

Partial restrictions are a part of a flow regime and are put in place to stop flows being drawn below the minimum flow level. Properly set partial restrictions prevent consents being turned on and off every second day in a 'yo-yo' effect. When no partial restrictions apply consents can abstract all their allocation, provided the flow is above the minimum flow trigger, if the flow is less than the minimum flow plus the allocation, flow can be drawn below the minimum, when this happens consents must cease abstraction. When the abstraction stops the flow recovers to above the minimum flow and abstraction can resume.

Types of Partial Restrictions

Pro-rata

Pro-rata restrictions are the proportional reduction in take between the flow at which the take is required to start reducing and the minimum flow.

To prevent the minimum flow from being breached pro-rata restrictions apply from the top of the allocation block down to the minimum flow trigger. Reliability of supply and time on partial restriction is influenced strongly by the size of the allocation block. As allocation block size increases more flow is required above the minimum flow to allow full abstraction to occur.

Stepped restrictions

As pro-rata can result in any percent of the allocation block being available on a given day, partial restrictions are sometime simplified by using a stepped regime. The stepped regime generally has a

number of trigger flows, above the minimum flow, at which predefined partial restrictions apply e.g. 25%, 50% or 75% reductions in rate of take. While a stepped regime can provide greater simplicity of partial restrictions, it provides lower reliability of supply for abstractors. This is due to needing to set steps in a way which prevents the minimum flow being breached.

Self-management

Self-managed partial restrictions are when a consent holder or consent holders reduce their rate of take to ensure that a downstream minimum flow is not breached. Self-management is only possible if the minimum flow site is located below all abstractions as it relies on the 'feedback' effect of abstractions being fully captured in the residual flow. Self-management is like pro-rata but allows the consent holders to take all the available allocation above the minimum flow and allows for flat-lining of the river at the minimum flow.

Setting partial restrictions to protect minimum flows

To prevent the minimum flow from being breached by the effect of abstractions, the sum of the abstractions should not be greater than the flow on the day of abstraction minus the minimum flow. Figure 1 shows how a partial restriction and stepped regime should be implemented to prevent the minimum flow being breached. This shows that pro-rata provides the highest availability but a stepped regime can provide more convenience, particularly when abstractors are not part of a Water Users Group (WUG).

Figure 1 Example of how partial restrictions are applied to prevent the minimum flow from being breached

Minimum flow site locations

There are no recommendations in the ZIPA to move the location of the minimum flow monitoring point in any of the catchments included in this assessment. The FAWP also propose retaining these minimum flow monitoring points. These sites are deemed to be appropriate monitoring sites, where flow can be reliably monitored and allows Environment Canterbury to build on learnings from existing work.

The location of the minimum flow monitoring point influences how flow regimes should be set to protect the minimum flow. If the monitoring site is at the top of the catchment above the abstractions, the abstraction of water does not influence the measured flow. This means that partial restrictions are essential to ensure that flows in the river below the abstraction are protected. If partial restrictions do not apply in a catchment with an upstream minimum flow monitoring point, any time the flow is 1l/s or more above the minimum flow level abstractors can take their full allocation. The North Opuha is an example where most of the abstraction occurs below the minimum flow monitoring point.

When the minimum flow monitoring point is at the bottom of the catchment, below the abstractions, the flow measured are a result of the natural flows and the effect of the abstraction occurring upstream. This means that if no partial restrictions apply and abstractors take more flow than is available above the minimum flow trigger they will draw the flow below the minimum flow, resulting in them being restricted the next day. The South Opuha and Upper Opihi are examples of a downstream monitoring point.

A more complex situation is where the best site to measure flow occurs in the middle of the catchment and abstraction occur above and below the minimum flow monitoring point. This is the situation in the Te Ana A Wai catchment.

North Opuha

The ZIPA acknowledges that the current minimum flow is close to the desktop ecological flow recommendation for the North Opuha River, and recommended keeping the status quo minimum flow trigger. The ZIPA also recommended setting appropriate partial restrictions as part of all flow regimes. The FAWP proposal recommends keeping the status quo minimum flow and absence of partial restrictions. This means that whenever the flow is above the minimum flow all the allocation can be taken. Figure 2 shows a schematic of the catchment highlighting that most abstraction occurs below the minimum flow monitoring point. As most of the abstraction occurs below the minimum flow there is not any 'feedback' of abstraction on whether the minimum flow is breached or not. There is not currently a cultural flow preference for the North Opuha so this has not been included in the assessment. The FAWP regime suggest that as Claytons Stream enters the North Opuha below the minimum flow site, that this offsets the need for partial restrictions. However, as allocation and minimum flow are being considered to be in-line with the draft National Environmental Standard (NES) this justification does not hold true. If the flow effects of Claytons Stream are to be included in the flow regime, they should also be included in setting the minimum flow, this would likely result in a higher minimum flow as more natural flow is being accounted for within the catchment.

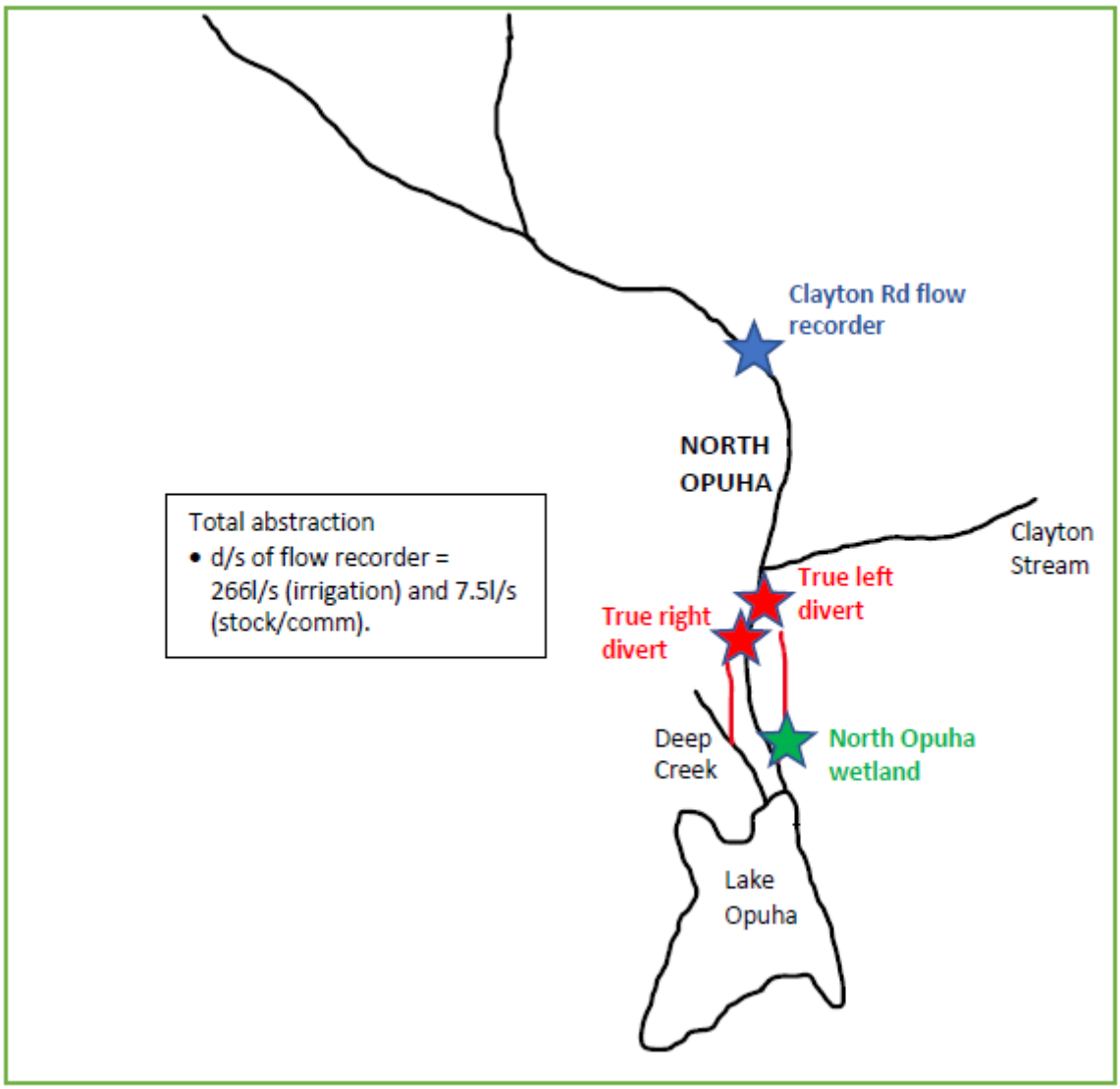

Figure 2 Schematic of the North Opuha catchment from the FAWP feedback

There is very little difference in the flows at the minimum flow monitoring point between the different flow regimes. This is shown in the flow duration curves in Figure 3. However, setting partial restrictions results in a decrease in water availability. Table 1 shows that the ZIPA flow regimes have a reduction in average reliability. This is due to pro-rata restrictions being modelled from the top of the A allocation block. The FAWP regime keeps the same availability as the current regime by allowing the full allocation to be taken any time flow is above the minimum flow.

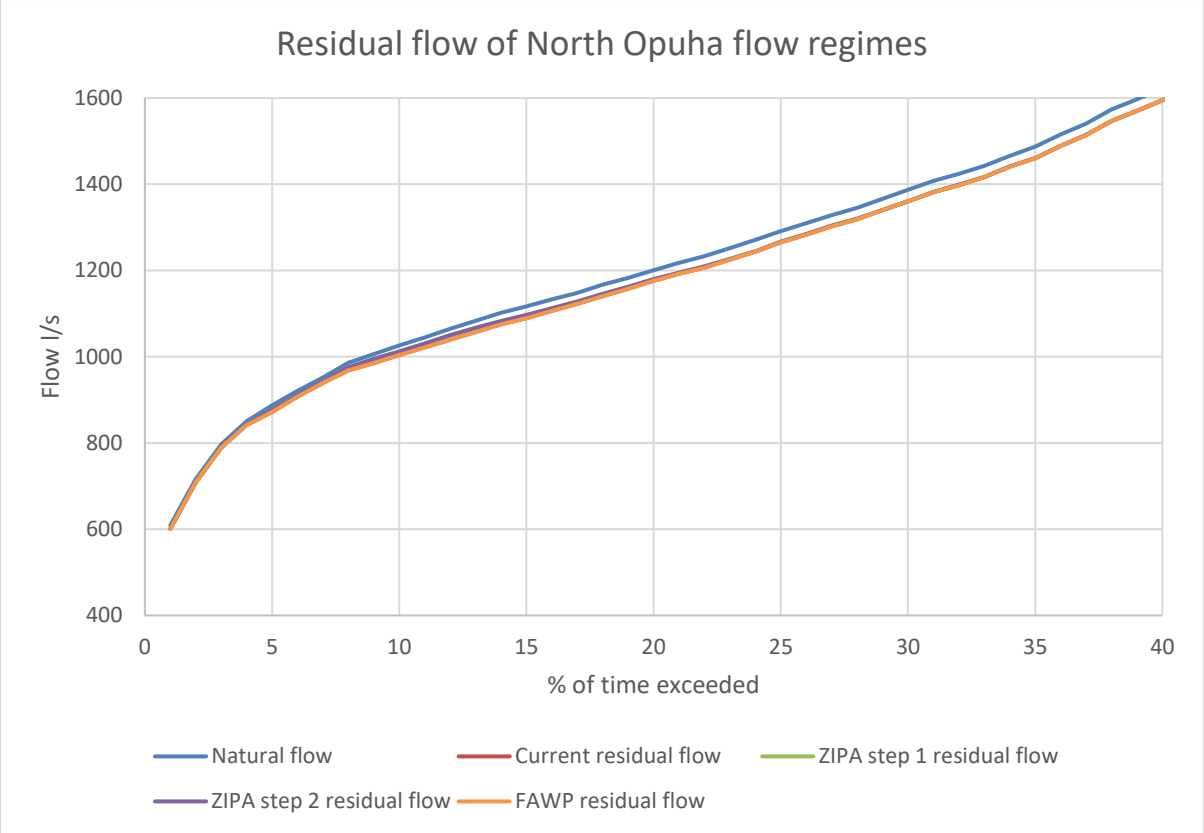

Figure 3 Flow duration curve of flows in the North Opuha under each of the evaluated flow regimes.

Table 1 Summary of average reliability for allocation blocks in the North Opuha under different flow regimes

	Percent availability
Average of Current AA + BA	**91**
Average of Current AN	**67**
Average of ZIPA 1 AA + BA	**84**
Average of ZIPA 1 AN	**65**
Average of ZIPA 2 AA +BA	**84**
Average of ZIPA 2 AN	**65**
Average of FAWP AA + BA	**91**
Average of FAWP AN	**67**

South Opuha

Figure 4 shows a schematic of the South Opuha catchment, with abstraction occurring above the minimum flow monitoring point. Under the current consents there are no partial restrictions on the South Opuha. The Cascade Irrigation scheme self-impose restrictions to operate in a way to maintain a residual flow at the minimum flow monitoring point. In this evaluation the current rules are modelled which allows full abstraction to occur whenever the recorded flow is above the minimum flow level. This abstraction results in flows dropping below the minimum flow level and restrictions being imposed the next day. While this may not be what is happening due to the self-management of abstractors, this is the current regime which applies and is modelled to reflect the worst case of what is permissible under current rules. The ZIPA steps increase the minimum flow levels and include pro-rata partial restrictions occurring from the top of the allocation block. The FAWP proposal seeks to formalise the self-management partial restriction regime above the minimum flow.

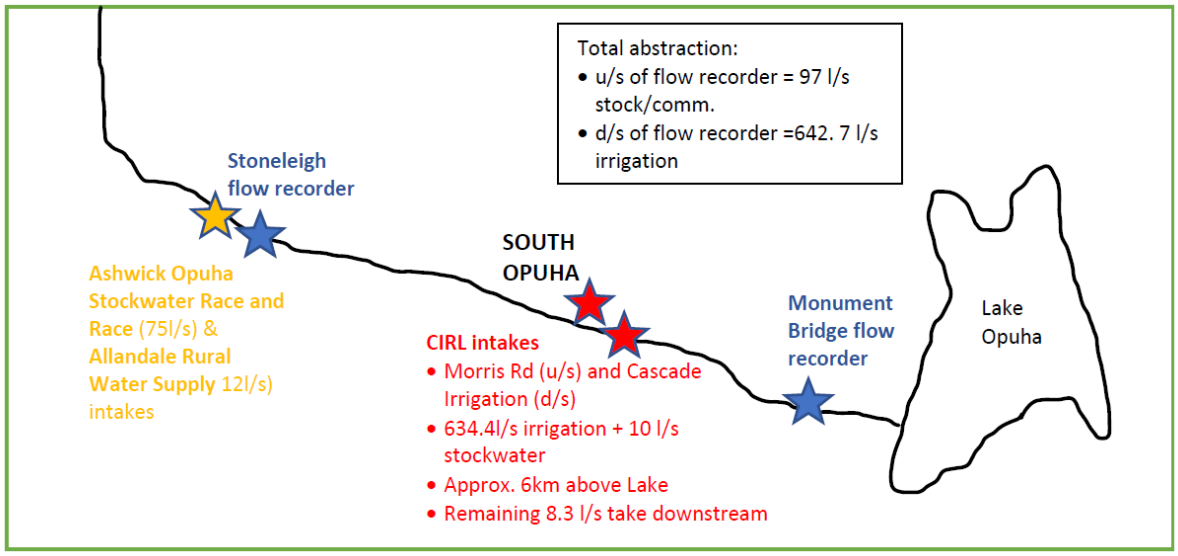

Figure 4 Schematic of the South Opuha catchment from the FAWP Feedback

Figure 5 shows that all the evaluated regimes result in higher residual flows at the minimum flow site, compared to the current regime, this is due to increased minimum flows and varying approaches to partial restrictions. The pro-rata regime included in the ZIPA regimes result in a flow duration curve with a similar shape to the natural regime. The self-management proposed by the FAWP results in longer periods of flatlined flows, and this is reflected as the stepped flow duration curve.

Applying a self-managed partial restriction provides less certainty on a day to day basis but results in a greater volume being able to be taken over the course of a season. This is due to the timing at which restrictions must be applied. Ordinary partial restrictions are based on the preceding days flow, whereas self-managed restriction allows all the available water above the minimum flow being available on the day. This can result in periods where abstractors outside of the Cascade Scheme being able to abstract due to yesterdays flow, while Cascade Scheme irrigators are restricted, this is only likely to occur in periods when flow is dropping.

Table 2 shows that the FAWP regime provides greater availability than either of the ZIPA regimes, but les availability than the current regime. When looking at the Monthly availability in Appendix 1, the

FAWP regime provides the highest availability during the summer months with lower availability and abstraction occurring in the winter months. This results in the annual average being skewed lower by winter availability.

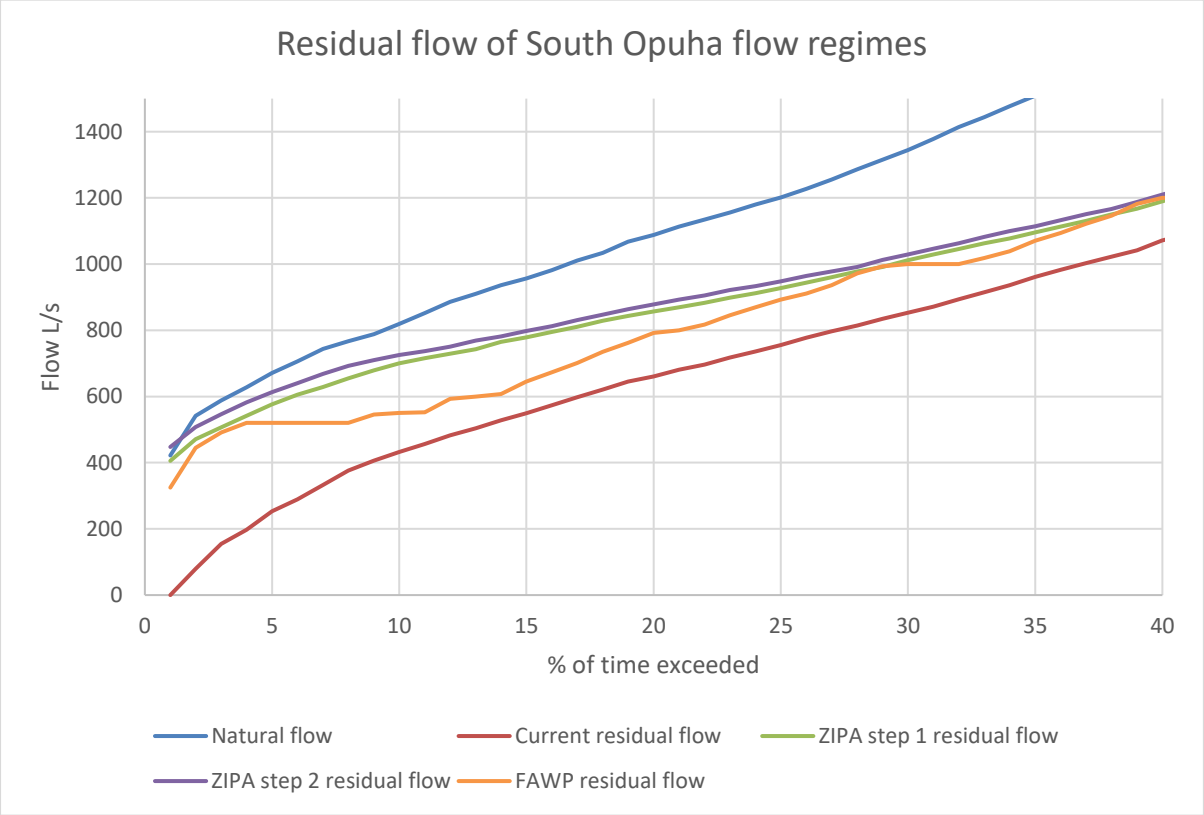

Figure 5 Flow duration curve of flows in the South Opuha under each of the evaluated flow regimes.

Table 2 Summary of average reliability for allocation blocks in the South Opuha under different flow regimes

	Percent availability
Average of Current AA +BA	**80**
Average of Current AN	**62**
Average of Current BN	**25**
Average of ZIPA 1 AA + BA	**64**
Average of ZIPA 1 AN	**54**
Average of ZIPA 1 BN	**23**
Average of ZIPA 2 AA +BA	**62**
Average of ZIPA 2 AN	**53**
Average of ZIPA 2 BN	**22**

Average of FAWP BA	**72**
Average of FAWP BN	**25**
Average of FAWP Cascade	**71**

Upper Opihi

The Upper Opihi Catchment covers the Opihi River above the confluence with the Opuha River. Figure 6 shows that most of the abstraction occurs above the minimum flow monitoring point located at Rockwood. This means that the recorded flows reflect the abstraction occurring. The modelled ZIPA step 1, Step 2 and COMAR regimes have been modelled with pro-rata partial restrictions occurring from the top of the allocation block down to the minimum flow trigger. The FAWP regime recommends minimum flows which are lower than ZIPA step 1 in the summer months and a 50% stepped reduction occurring at 100 l/s above the minimum flow.

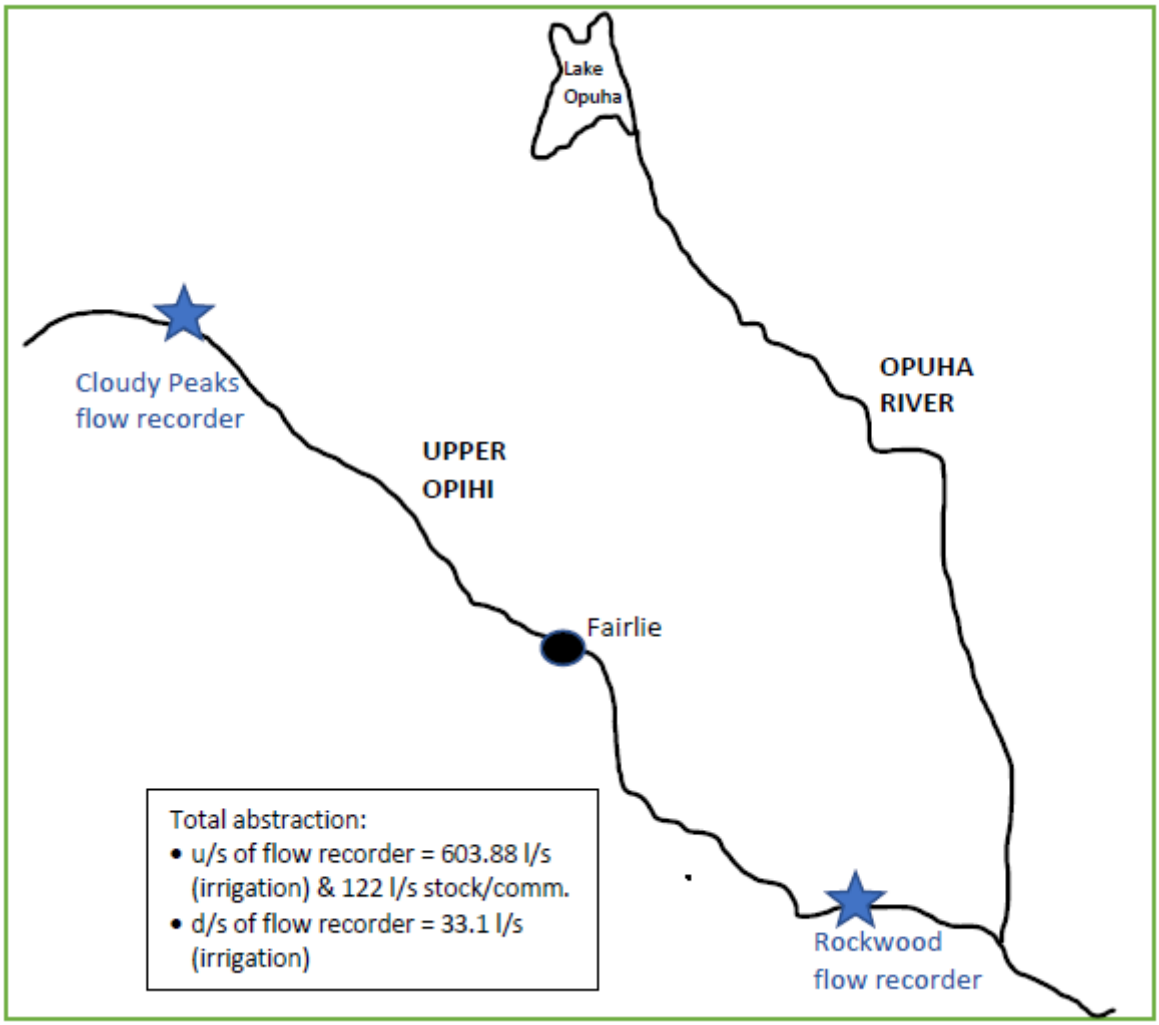

Figure 6 Schematic of the Upper Opihi from the FAWP feedback

This stepped regime allows the minimum flow level to be breached due to abstraction. To prevent this occurring the stepped reduction would need to occur at a significantly higher flow to protect the minimum flow. This would also result in a further reduction in reliability. Flows at Rockwood under the different regimes are shown in Figure 7. The residual flows from the FAWP regime show an increase from current but spend more time at lower flows than the other regimes with higher minimum flows and partial restrictions which prevent the minimum flow being breached.

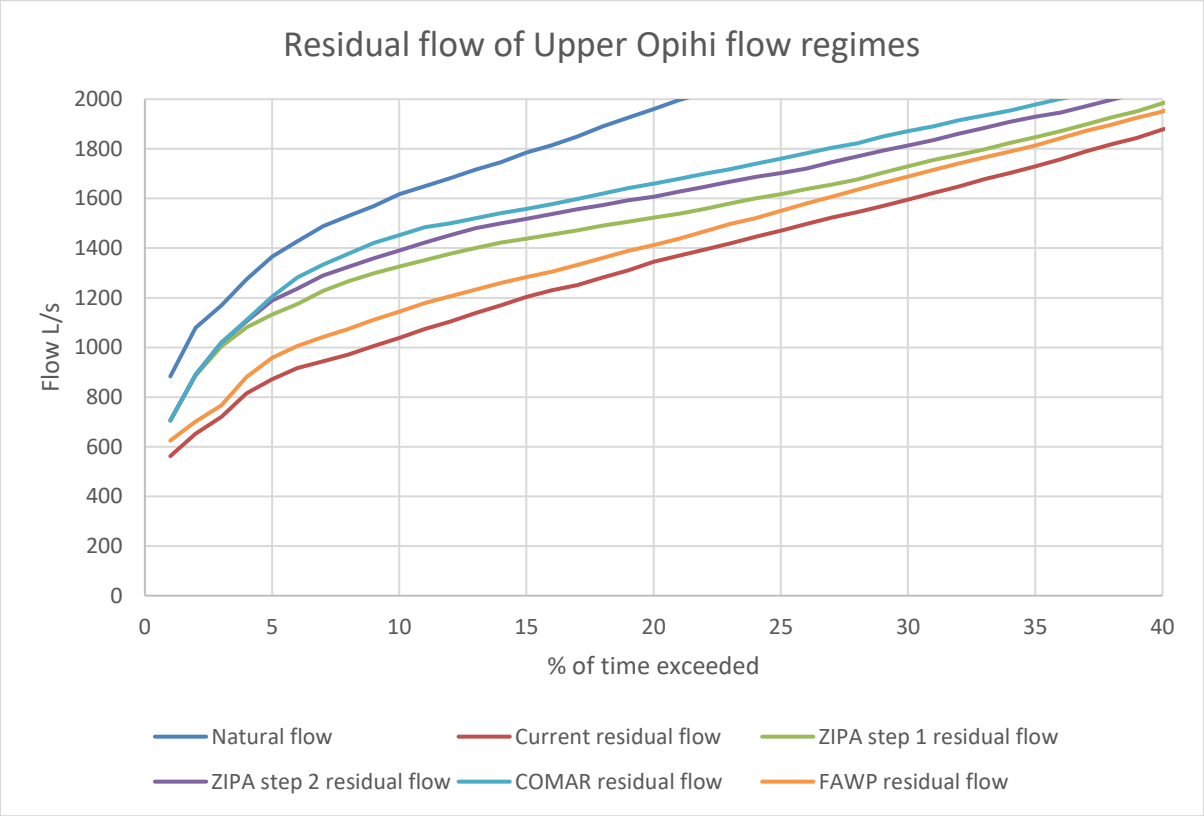

Figure 7 Flow duration curve of flows in the Upper Opihi under each of the evaluated flow regimes.

The average seasonal availability in Table 3 shows that the FAWP regime retains almost the same availability as the current regime, this is driven by the high availability during the summer months. Due to the FAWP partial restrictions being set only 100l/s above the minimum flow, the minimum flow level can be breached resulting in abstraction ceasing every second day at times of low flow.

Table 3 Summary of average reliability for allocation blocks in the Upper Opihi under different flow regimes

	Percent availability
Average of Current AA + BA	**87**
Average of Current AN	**67**
Average of Current BN	**26**

Average of ZIPA 1 AA + BA	**75**
Average of ZIPA 1 AN	**65**
Average of ZIPA 1 BN	**26**
Average of ZIPA 2 AA + BA	**70**
Average of ZIPA 2 AN	**61**
Average of ZIPA 2 BN	**26**
Average of COMAR AA + BA	**67**
Average of COMAR AN	**59**
Average of COMAR BN	**26**
Average of FAWP AA+ BA	**84**
Average of FAWP AN	**66**
Average of FAWP BN	**26**

Te Ana A Wai

The Te Ana A Wai catchment has the minimum flow monitoring point located in the middle of the catchment, with abstraction occurring above and below (Figure 8). The catchment also has a community supply take in the upper part of the catchment, which is not subject to minimum flows in this assessment.

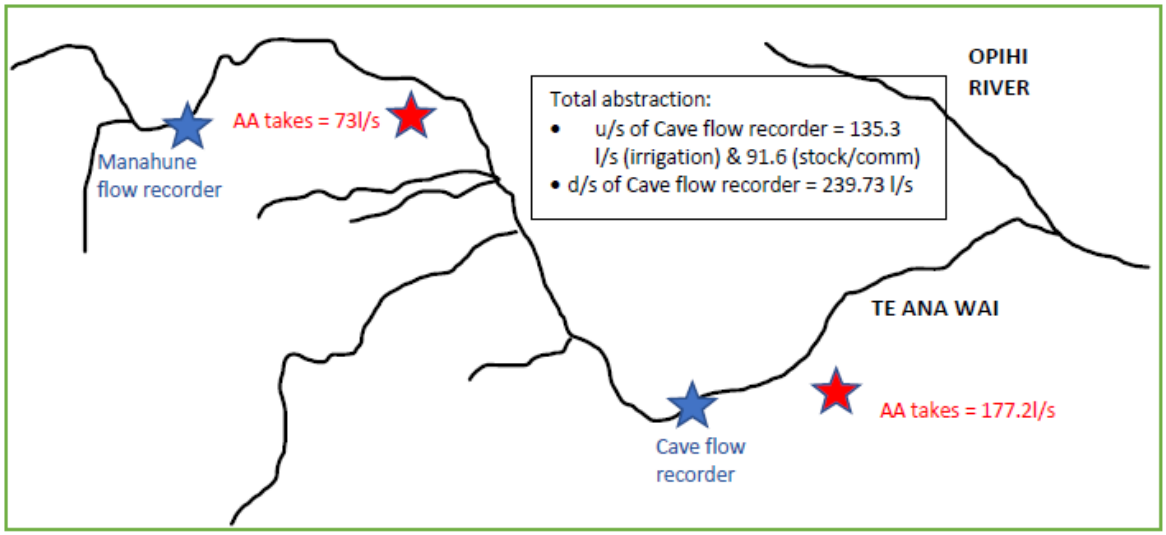

Figure 8 Schematic of the Te Ana A Wai from the FAWP feedback

Four abstractors in the Te Ana A Wai catchment are part of a Water Users Group (WUG) which is consented to have a 50% reduction when flows are 100 l/s above the minimum flow. This 50% of their combined allocation is greater than 100l/s and the FAWP acknowledges this has an impact below these abstractions. The FAWP however state that this was understood at the time of the consent being granted. Abstractors in the WUG are located above and below the minimum flow monitoring point, which means the flow at the recorder and the amount of water they can abstract from the river varies depending on how this group operates. In this evaluation it has been assumed that the water user group applies the same restrictions to all members. The flows resulting from this regime are shown in Figure 9 alongside the flows from the other regimes. This show the FAWP regime results in flows at Cave which are higher than current, but have lower flows than the other regimes assessed.

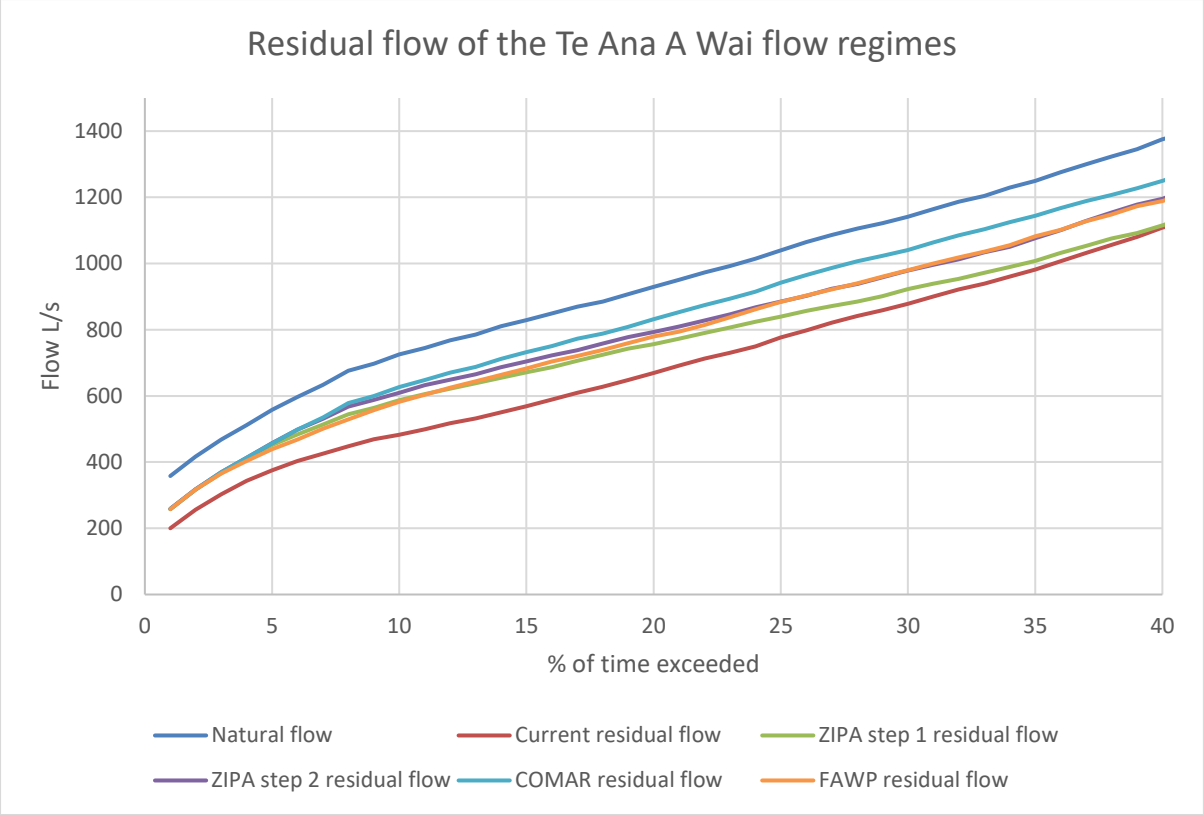

Figure 9 Flow duration curve of flows in the Te Ana A Wai under each of the evaluated flow regimes.

As the Te Ana A Wai WUG abstract water from above and below the minimum flow monitoring point they can share water in ways which impact on both their availability of water and flows in the river. If this group give preference to the abstractor upstream of the minimum flow monitoring point, these abstractions would influence the flows at Cave and therefore could result in flow dropping below the minimum flow level. Whereas abstractors downstream of Cave, do not have any impact on flows at the minimum flow monitoring point and their impact is only seen in the lower reaches of the river. If the WUG operates in a way which prioritises the downstream users they are able to take more water from the river over the season and have a higher water availability

Table 4 shows the percent availability for the evaluated regimes the FAWP regime has been modelled here assuming that the WUG shares evenly between upstream and downstream abstractors, If the upstream abstractors are prioritised the WUG would result in lower residual flows at the Cave and the lower water availability, The FAWP proposal for the Te Ana A Wai WUG to manage down to the minimum flow level provides the greatest benefits to downstream users, who are able to abstract without their impacts being captured by flows at the minimum flow monitoring point. E.g. with the FAWP stepped regime at 1 l/s above the minimum flow 50% of the allocation can be taken from the river downstream of the minimum flow site.

Table 4 Summary of average reliability for allocation blocks in the Te Ana A Wai under different flow regimes

	Percent availability
Average of Current AA + BA	**91**
Average of Current AN	**68**
Average of Current BN	**26**
Average of ZIPA 1 AA + BA	**74**
Average of ZIPA 1 AN	**62**
Average of ZIPA 1 BN	**25**
Average of ZIPA 2 AA + BA	**70**
Average of ZIPA 2 AN	**60**
Average of ZIPA 2 BN	**25**
Average of COMAR AA + BA	**53**
Average of COMAR AN	**46**
Average of COMAR BN	**25**
Average of FAWP AA+ BA	**78**
Average of FAWP AN	**37**
Average of FAWP BN	**24**

Summary

As this evaluation focuses on the hydrological components of the FAWP regime and compares these to the Current regime, ZIPA step 1 ZIPA step2 and COMR regimes, it solely provides information on what can happen to flows under these regimes. This evaluation show that in the South Opuha, Upper Opihi and Te Ana A Wai Catchment the FAWP regime results in higher flows than could occur under the current regime. The FAWP regime maintains water availability in the summer months, very close to that experienced under the current regime. While the FAWP regime sets higher minimum flow in most catchments, it does not set partial restriction regimes to sufficiently protect these minimum flows.

Appendix 1: Monthly summaries of water availability under each of the evaluated flow regimes

North Opuha average monthly percent availability

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Current AA + BA	96	94	88	94	86	83	82	90	86	98	100	97
Current AN	58	66	54	50	61	55	63	71	70	87	93	82
ZIPA 1 AA + BA	93	88	82	71	74	69	72	79	81	97	100	97
ZIPA 1 AN	57	65	53	47	57	51	60	65	69	87	93	81
ZIPA 2 AA +BA	93	88	82	71	74	69	72	79	81	97	100	97
ZIPA 2 AN	57	65	53	47	57	51	60	65	69	87	93	81
FAWP AA + BA	96	94	88	94	86	83	82	90	86	98	100	97
FAWP AN	58	66	54	50	61	55	63	71	70	87	93	82

South Opuha average monthly percent availability

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Current AA +BA	84	75	70	64	73	71	69	72	83	97	100	96
Current AN	54	59	47	45	54	48	51	57	67	87	93	81
Current BN	28	19	19	16	32	33	23	23	23	29	28	28
ZIPA 1 AA + BA	70	57	49	46	56	53	50	53	55	93	99	87
ZIPA 1 AN	51	52	41	39	46	40	37	42	51	85	92	78
ZIPA 1 BN	27	17	17	15	29	28	19	19	19	29	28	28
ZIPA 2 AA +BA	61	54	46	43	56	53	50	53	55	92	98	86
ZIPA 2 AN	45	50	39	36	46	40	37	42	51	85	92	77
ZIPA 2 BN	25	16	16	14	29	28	19	19	19	29	28	28
FAWP BA	84	76	69	51	57	56	49	56	73	98	100	98
FAWP BN	28	18	19	16	32	33	23	23	23	29	28	29
FAWP Cascade	84	76	66	49	57	56	49	56	68	96	100	96

Upper Opihi average monthly percent availability

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Current AA + BA	87	89	82	64	83	81	91	93	85	91	98	95
Current AN	56	66	53	45	62	54	66	72	70	84	91	81
Current BN	28	19	19	16	32	33	25	26	23	29	28	29
ZIPA 1 AA + BA	72	73	63	54	73	70	81	86	73	86	89	85
ZIPA 1 AN	55	64	51	46	62	55	66	72	67	81	85	77
ZIPA 1 BN	27	19	19	16	32	33	25	26	23	29	28	29
ZIPA 2 AA + BA	67	67	57	48	67	64	75	81	67	82	84	80
ZIPA 2 AN	52	63	49	41	57	51	63	69	62	77	80	74
ZIPA 2 BN	27	19	19	16	32	33	25	26	23	29	28	29
COMAR AA + BA	60	59	48	48	67	64	75	81	67	82	76	74
COMAR AN	46	56	43	41	57	51	63	69	62	77	72	68
COMAR BN	27	19	19	16	32	33	25	26	23	29	27	29
FAWP AA+ BA	87	89	80	59	78	76	86	91	79	91	97	94

FAWP AN	**56**	**66**	**53**	**43**	**60**	**53**	**65**	**71**	**67**	**84**	**91**	**81**
FAWP BN	**28**	**19**	**19**	**16**	**33**	**33**	**25**	**26**	**23**	**29**	**28**	**29**

Te Ana A Wai average monthly percent availability

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Current AA + BA	**80**	**79**	**72**	**78**	**100**	**100**	**100**	**100**	**95**	**97**	**96**	**91**
Current AN	**55**	**65**	**51**	**48**	**65**	**58**	**68**	**74**	**73**	**87**	**89**	**79**
Current BN	**28**	**19**	**19**	**16**	**33**	**33**	**25**	**26**	**23**	**29**	**28**	**29**
ZIPA 1 AA + BA	**69**	**66**	**57**	**61**	**64**	**61**	**75**	**90**	**90**	**90**	**83**	**82**
ZIPA 1 AN	**51**	**59**	**46**	**46**	**55**	**48**	**61**	**73**	**71**	**82**	**79**	**74**
ZIPA 1 BN	**27**	**18**	**19**	**16**	**30**	**33**	**25**	**26**	**23**	**29**	**27**	**29**
ZIPA 2 AA + BA	**67**	**64**	**55**	**58**	**57**	**50**	**65**	**82**	**91**	**89**	**82**	**81**
ZIPA 2 AN	**50**	**58**	**45**	**45**	**50**	**41**	**55**	**69**	**72**	**81**	**78**	**73**
ZIPA 2 BN	**27**	**18**	**19**	**16**	**29**	**32**	**25**	**26**	**23**	**29**	**27**	**29**
COMAR AA + BA	**47**	**41**	**33**	**33**	**57**	**52**	**65**	**83**	**50**	**63**	**54**	**60**
COMAR AN	**35**	**38**	**28**	**31**	**50**	**42**	**55**	**69**	**45**	**58**	**51**	**54**
COMAR BN	**27**	**17**	**19**	**16**	**29**	**32**	**25**	**26**	**23**	**29**	**26**	**28**

FAWP AA+ BA	**80**	**79**	**69**	**58**	**62**	**58**	**71**	**92**	**85**	**91**	**94**	**91**
FAWP AN	**32**	**35**	**25**	**26**	**37**	**31**	**38**	**45**	**32**	**49**	**43**	**46**
FAWP BN	**26**	**17**	**18**	**16**	**26**	**29**	**24**	**25**	**23**	**28**	**26**	**27**

Memo

Date	29 June 2018
To	Orari-Temuka-Orari-Pareora Zone Committee
cc	Flow and Allocation Working Party Technical Advisors
From	Shirley Hayward

Subject: Evaluation of the Flow and Allocation Working Party (FAWP) recommended minimum flows on instream ecological values

Introduction

This memo provides an evaluation of the FAWP's recommended minimum flow regimes[12] to assist the zone committee in their deliberations on flow and allocation options for the Opihi catchment. This evaluation draws primarily on the ecological flow assessment completed by NIWA (Jellyman 2018). It is important to note that ecological values are not the only instream values that are important because aesthetic values, landscape values, Māori cultural and traditional values can also be influenced by flow changes.

Evaluation of FAWPs recommendations by Dr Ryder

The FAWP feedback included a report by Dr Greg Ryder in which he provided his analysis and interpretation of the FAWP recommendations. The approach used by Dr Ryder to evaluate FAWPs recommended minimum flows differs to NIWA's approach to evaluating ecological flow needs. Dr Ryder compared habitat availability (as WUA[13] as provided by NIWA) at the proposed minimum flow to the habitat available at naturalised MALF for each species/life stage. This was presented as percentage of WUA at naturalised MALF (on a monthly basis). In comparing WUA as a percentage of habitat available at MALF, Dr Ryder indicated a desirable target of retaining 90% of the WUA. This approach focusses on the recognition of the role that MALF plays as a natural bottleneck to habitat availability, which typically occurs during summer months. However, using the percentage of WUA at MALF for months outside the low flow period has less relevance. Flow regimes of the hill-fed Opihi catchment typically have their lowest flows during summer months (Dec to March) with flows increasing from autumn through winter, and typically peaking during spring (often because of snow melt) before decreasing again through summer months. Therefore, assessment of ecological flow

[12] As outlined in FAWP's First Addendum to the Opihi Flow and Allocation Working Party's feedback on the draft OTOP ZIP addendum dated 2nd March 2018.

[13] WUA – 'weighted usable area' is an aggregate measure of the usable area of a river reach based on physical habitat quality and quantity. WUA is specific to a particular species/life stage for that reach and varies with flow. The units are m^2/m and can be thought of as the area of suitable habitat per m length of the river reach.

needs outside the summertime period need to consider specific habitat needs for that period, such for fish migration and spawning, rather than indexing the habitat availability to summertime low flows.

NIWA's approach examined how the habitat availability (as WUA) varied across the modelled flow range (minimum to median flows). WUA were presented as a percentage of the maximum WUA available over the modelled flow range (Jellyman 2018). This approach recognises that maximum habitat availability varies for each species/life stages and the maximum habitat availability may occur at flows either higher or lower than MALF. This approach does not compare habitat availability to one index flow (eg MALF), and can be used to compare habitat availability over a range of flows and seasons.

The NIWA assessment used a general threshold of retaining at least 80% of maximum WUA as a level of habitat retention that is considered to provide adequate protection for most fish species. However, it was also acknowledged that for particular high value or flow sensitive species/life stage, retaining a higher percentage of maximum habitat may be desirable (e.g., 90% or 100% of maximum habitat). This approach of retaining a particular percentage of maximum habitat for varying degrees of ecological value has been used widely in ecological flow assessments in Canterbury and elsewhere (e.g., Wilding et al 2004, Golders Associates 2008). My evaluation of the FAWP recommended minimum flows draws on NIWA's approach of assessing the percentage of maximum habitat available for relevant species/life stages.

Use of *Phormidium and Didymo* habitat suitability curves

The NIWA report included assessments of habitat availability for different forms of periphyton including the undesirable forms; long filamentous algae, didymo (*Didymosphenia geminata)* and the toxin producing cyanobacteria *Phormidium.* These were included because habitat suitability criteria (HSC) are available for these periphyton types and these forms are prevalent in parts of the Opihi catchment. However, although HSC are available for *Phormidium* based on a detailed instream habitat study of *Phormidium* in the Hutt River, the authors of this study found that *Phormidium* had large hydraulic habitat tolerance ranges (Heath et al. 2015). That means *Phormidium* was found over a wide range of habitat conditions. Furthermore, they concluded that based on their study and other recent research, frequency of flushing flows and water chemistry were the more important determiners of *Phormidium* blooms than changes in base flows.

Similarly, didymo can grow in a wide range of hydraulic conditions, and the frequency of flood flows and concentrations of dissolved reactive phosphorus have been found to be major determinants of didymo biomass in rivers (Jellyman 2018).

Therefore, while it is useful to examine how the availability of both didymo and *Phormidium* habitat can change under different flows, it should be realised that minimum flows may not be the critical determinant of their abundance.

Monthly variable minimum flows

The FAWP recommendations include considerably more monthly variable minimum flows than currently occurs in the ORRP, ZIPA recommendations or consented minimum flow regimes. There are

benefits to instream ecological values by providing for seasonally/monthly varying flows, particularly providing for migratory and spawning needs.

Setting appropriate minimum flows and allocation volumes for takes that occur outside the irrigation season such as community/stock water supplies and takes for storage that account for seasonally variable flow needs is a sensible approach. However, it is worth noting that setting higher minimum flows in the shoulder and winter periods does not negate or offset the need to set appropriate minimum flows during critically low flow periods.

Minimum flows and partial restrictions

Minimum flows are set on the basis that they will provide for adequate protection of aquatic species and overall ecosystem health. They are generally set on the premise that abstractions (other than some essential takes for community and livestock water supplies) will cease once the minimum flow is reached. This does not mean that a river will stay at that minimum flow, and at times flows may naturally drop below minimum flows. It does mean that abstractions are managed so that they do not exacerbate the magnitude, duration or frequency of low flow conditions.

Minimum flows are generally established at a flow recorder site, and may be above or below abstractions. Flows in rivers will naturally change along their length, increasing with tributary and groundwater inputs and decreasing with flow losses to groundwater. Setting a minimum flow at the flow recorder does not imply that the specific flow will be maintained along the length of the river, rather the minimum flow at the flow recorder represents flow and habitat conditions that adequately provides for instream life and other values along the length of the river accounting for natural variations in flows along the length of the river.

Partial restrictions apply to abstractions to ensure that as flows decline towards a minimum flow limit, abstractions are reduced to ensure that the minimum flow is not breached as a result of abstractions (although this may occur naturally). For minimum flow sites which are located above abstractions, setting partial restriction thresholds need to account for abstractions that occur downstream to ensure that minimum flow is not breached, and that the rivers flows are adequately protected.

South Opuha River

FAWP recommends a minimum flow of 520 l/s from December through to February, with an increase to 600 l/s in March. These flows provide for at least 80% of maximum habitat availability for the native fish species modelled, with these flows being near the lower end of the 80% range for Alpine galaxias and Canterbury galaxias at 520 l/s (Figure 1). Just over 70% of maximum habitat for juvenile trout is provided for by these flows (Jellyman 2018). Habitat for adult trout is limited over the full flow range modelled by NIWA. Figures 2 and 3 illustrate the monthly flow ranges for both naturalised and recorded flows. Flows at or below these proposed minimum flows occur around 1% of the time in December and up to 16% of the time in February (based on recorded flows) (see Figures 2 and 3).

FAWP recommendations include monthly or fortnightly stepped increases in minimum flows over the autumn period. The existing consented flow regime also has a stepped increase in minimum flow from 500 L/s to 800 L/s as the end of April. FAWPs proposal starts increasing minimum flows earlier (starting with increases in March). These stepped increases in flows provide improved habitat conditions, particularly for trout migration from Lake Opuha into the river reaches where they spawn, which starts around mid-April.

Wintertime flows recommended by FAWP of 1,200 l/s provide about 90% of maximum habitat for trout spawning, although habitat availability for adult trout and spawning was overall low. The wintertime recommended flow provides >80% habitat for all the native fish species modelled.

The springtime flows recommended by FAWP are a stepped reduction between winter and summer minimum flows. This period is generally a spawning time for native non-migratory species. While the recommended flows still provide for at least 80% of the maximum habitat modelled for native species, the minimum flows are lower than the lowest recorded flows for October/November. This could be result in a significant drop in flows over this period when flows in the river are typically elevated from spring melt, although it is also considerable improvement over the existing minimum flow for this period of 500 l/s.

Overall, the FAWP recommended set of minimum flows are an improvement over the existing minimum flows, and provide for at least a minimum of 80% of habitat for native species that are known or expected to occur in the river.

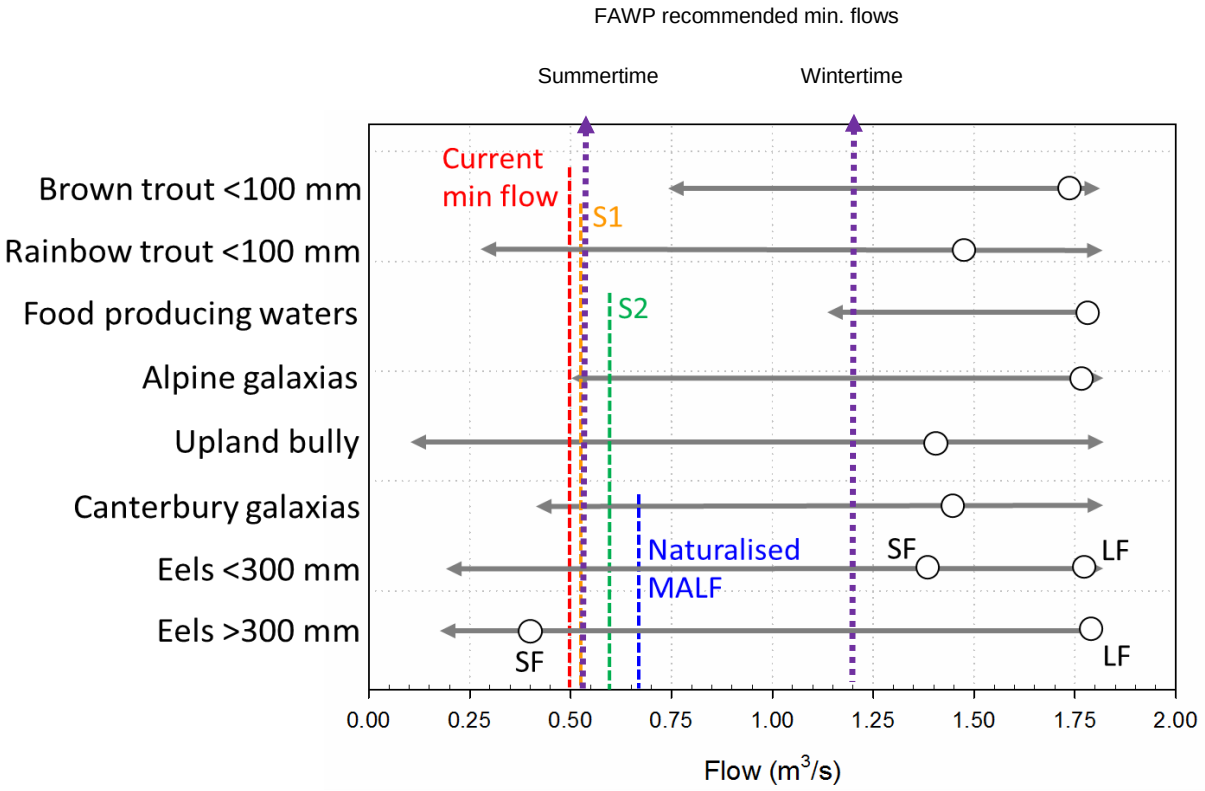

Figure 1 NIWA's summary results for selected aquatic values in the South Opuha River from physical habitat modelling. The grey horizontal arrows indicate the flow range over which 80% of the maximum available habitat is retained. The vertical purple dashed lines are FAWP's summertime and wintertime recommended minimum flows.

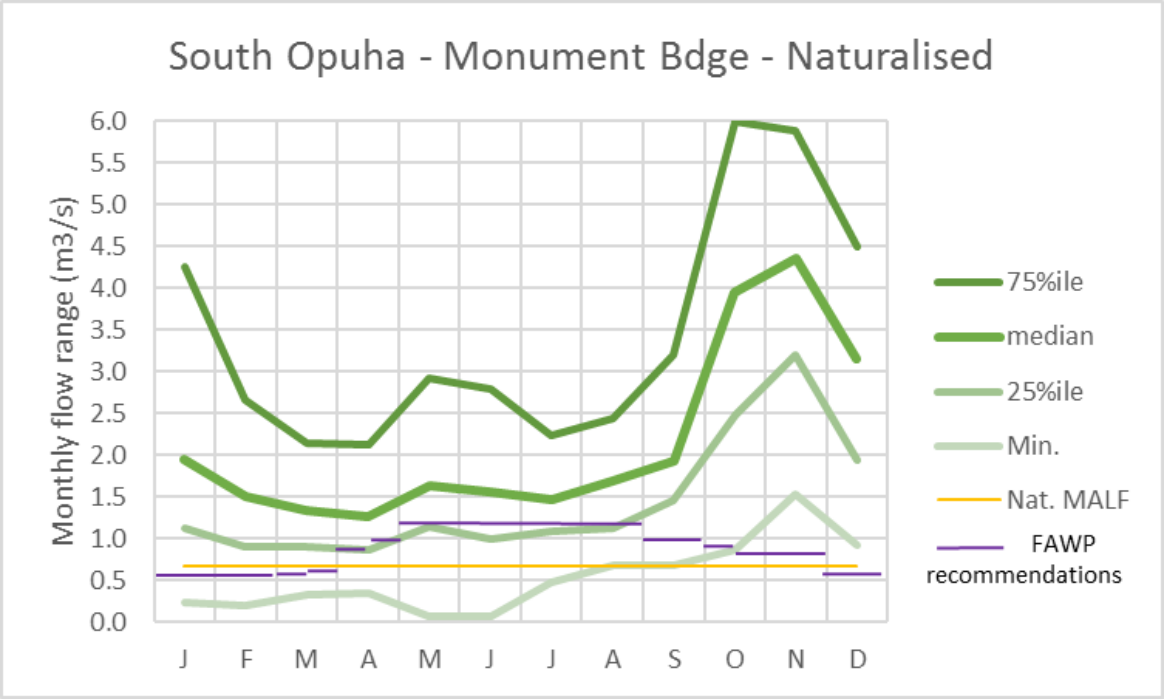

Figure 2 Monthly flow range statistics for naturalised flows at the South Opuha Monument Rd site; for the period Sept 1997 to June 2015.

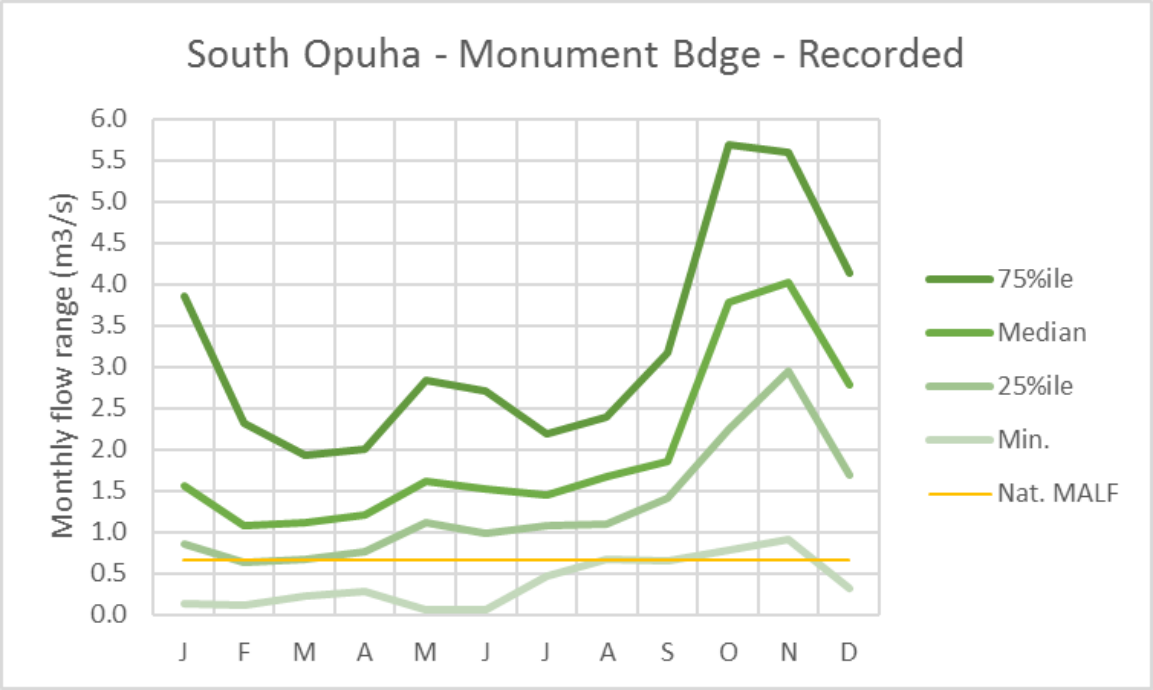

Figure 3 Monthly flow range statistics for recorded flows at the South Opuha Monument Rd site; for the period Sept 1997 to June 2015.

North Opuha River

FAWP has recommended that the existing minimum flow regime for the North Opuha catchment is retained in its current form. Ecological habitat assessments were not able to be completed for the North Opuha river.

The existing minimum flow for the irrigation period (October to mid-April) is close to the naturalised MALF flow (>90% of MALF) (Figure 4), and therefore, in the absence of more information is likely to adequately provide for existing ecological values and recreational fish species. The minimum flow for the non-irrigation period is higher at 1 m^3/s. Flows below this value occur about 7-17% of the time over these months (Figure 4).

Under the existing regime, water abstractors have minimum flow conditions but there are no partial restrictions on takes as flows approach the minimum flow threshold. The minimum flow recorder in this catchment is located above all irrigation takes. This means that abstractors can abstract their full allocation of water below the flow recorder site down to flows of 851 l/s in summer, thus causing downstream flows to drop well below the minimum flow. FAWP argued that the inflow from Claytons Stream generally exceeds the allocation volume. What is important and is discussed in Section 1.4 is that a minimum flow limit set at the flow recorder site does not necessarily mean that the same flow will be retained along the length of the river. In the case of the North Opuha River, the minimum flow at the Clayton Road site of 850 L/s will equate to a higher flow downstream of the Claytons Stream confluence, and ideally the higher downstream flow will also be maintained through appropriate setting of minimum flows and partial restrictions.

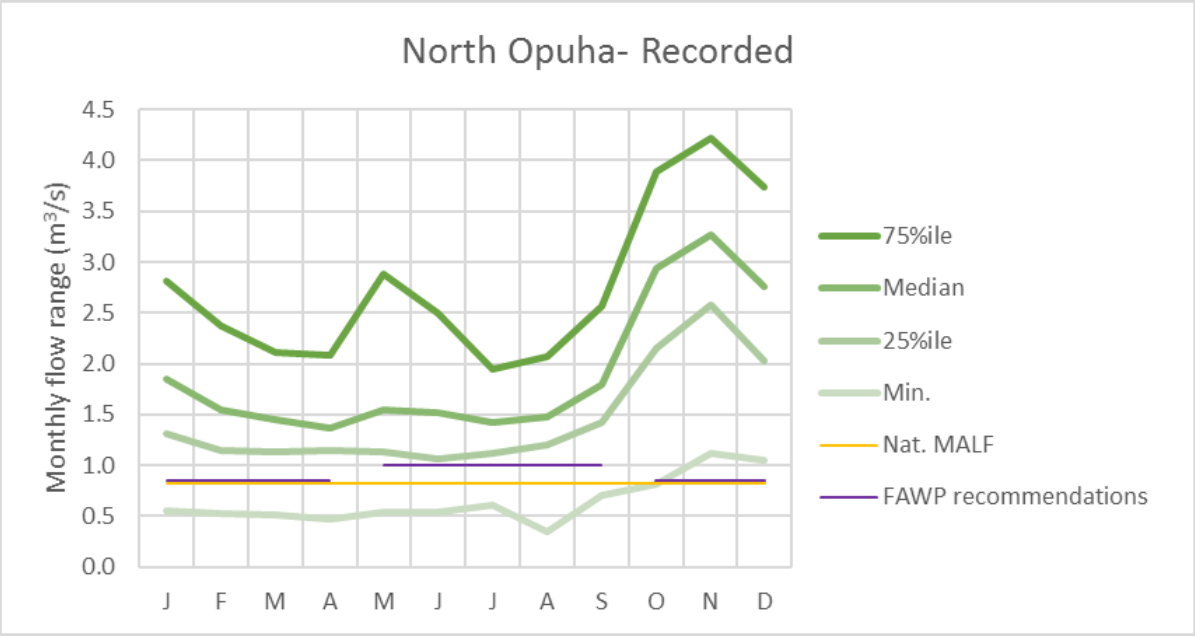

Figure 4 Monthly flow range statistics for naturalised flows for the North Opuha site; for the period 1998 to June 2015.

Upper Opihi River - Rockwood

FAWP recommends a summertime (Dec, Jan, Feb) minimum flow of 850 l/s. This is an increase over the existing minimum flow of 790 l/s. Their recommended minimum flow provides for greater than 80% of maximum habitat for small eels but does not reach the 80% habitat threshold for large eels. Of the other native fish species found in the Upper Opihi River (Kilroy and Jellyman 2018), 850 l/s provides over 80% of maximum habitat for Canterbury galaxias, upland bullies and common bullies, and 73% for torrentfish (Jellyman 2018). Over 80% of habitat for juvenile trout is provided at this flow, but ideal habitat for adult trout is provided at much higher flows ranges (2,500 to 3,500 L/s) (Figure 5).

For the salmon and trout spawning period (late autumn to early spring), FAWP's proposed minimum flows fall within the 80% of maximum habitat ranges, and would be expected to be sufficient for salmonid spawning needs. The wintertime recommended minimum flows (1,500 l/s) provide at least 80% of maximum habitat for large longfin and shortfin eels.

FAWPs monthly flow regime follows the typically seasonal variability of the river flows (Figures 6 and 7). The November proposed minimum is less than the lowest recorded flows for this month, but is an improvement over the existing minimum flow regime.

Overall, FAWPs proposed minimum flows are an improvement over the existing minimum flow regime, for both summer and winter periods, and should general provide adequate protection for many native species and salmonids. Large eels and torrentfish have less than 80% of maximum habitat availability during summertime proposed minimum flows but greater than 80% of maximum habitat at wintertime flows.

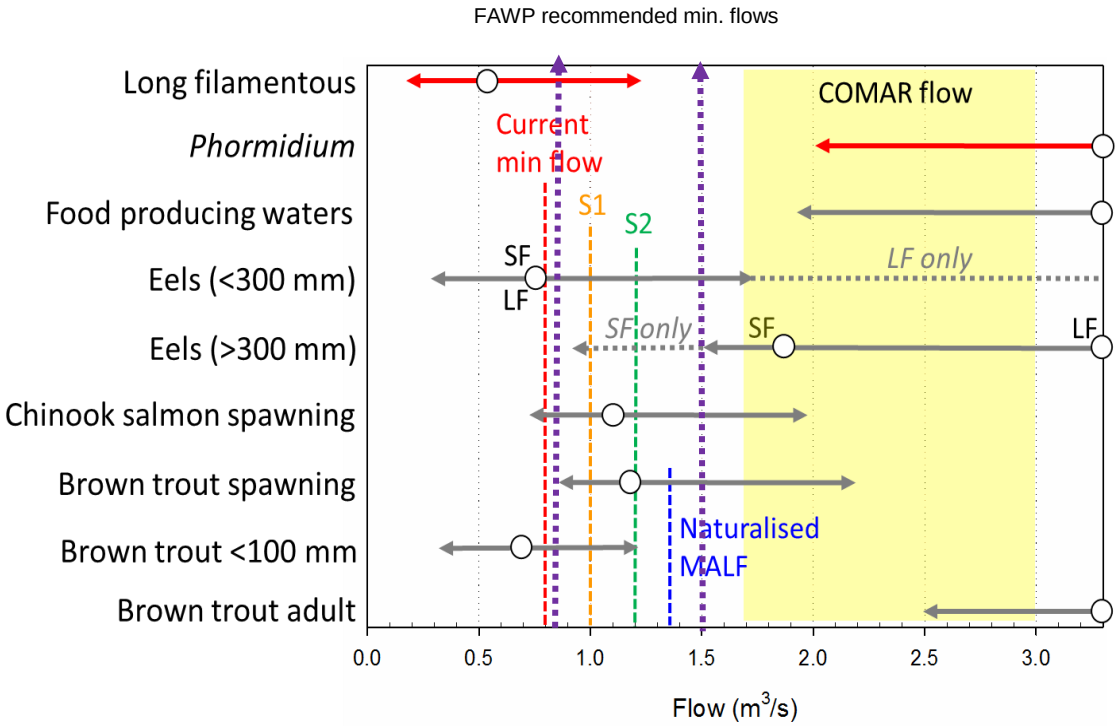

Figure 5 NIWA's summary results for selected aquatic values in the Upper Opihi River from physical habitat modelling. The grey horizontal arrows indicate the flow range over which 80% of the maximum available habitat is retained. The purple dashed lines are FAWP's summertime and wintertime recommended minimum flows.

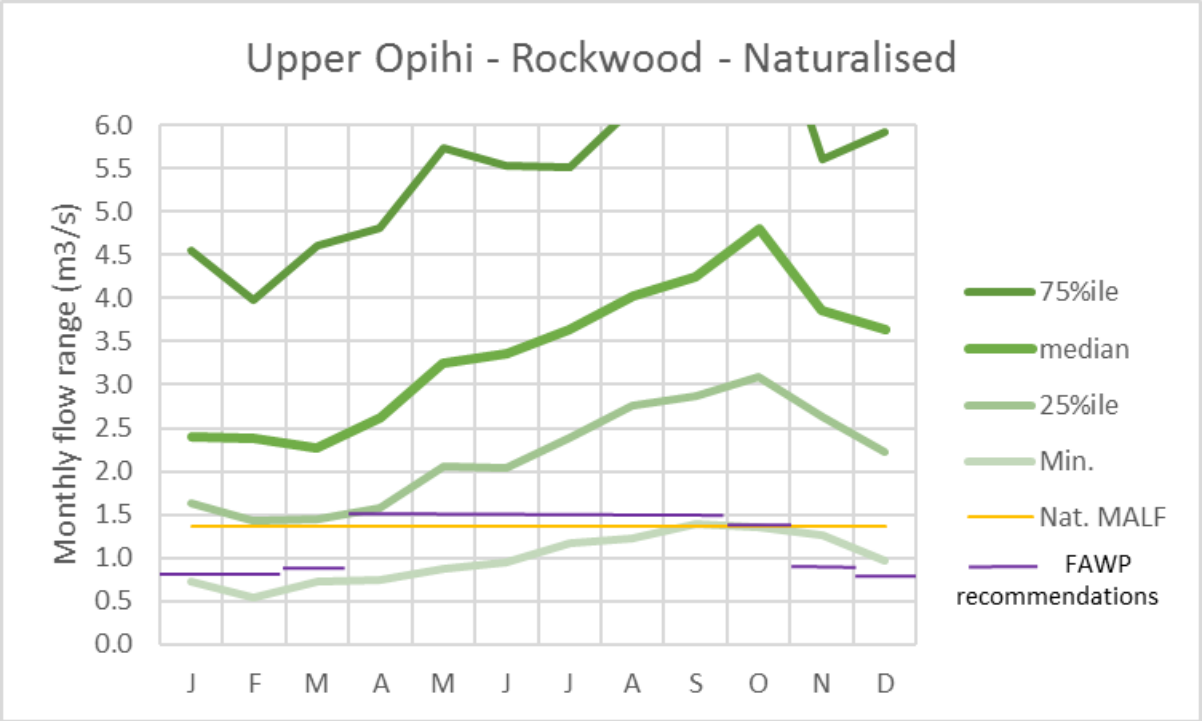

Figure 6 Monthly flow range statistics for naturalised flows for the Upper Opihi at Rockwood site; for the period 1972 to June 2015.

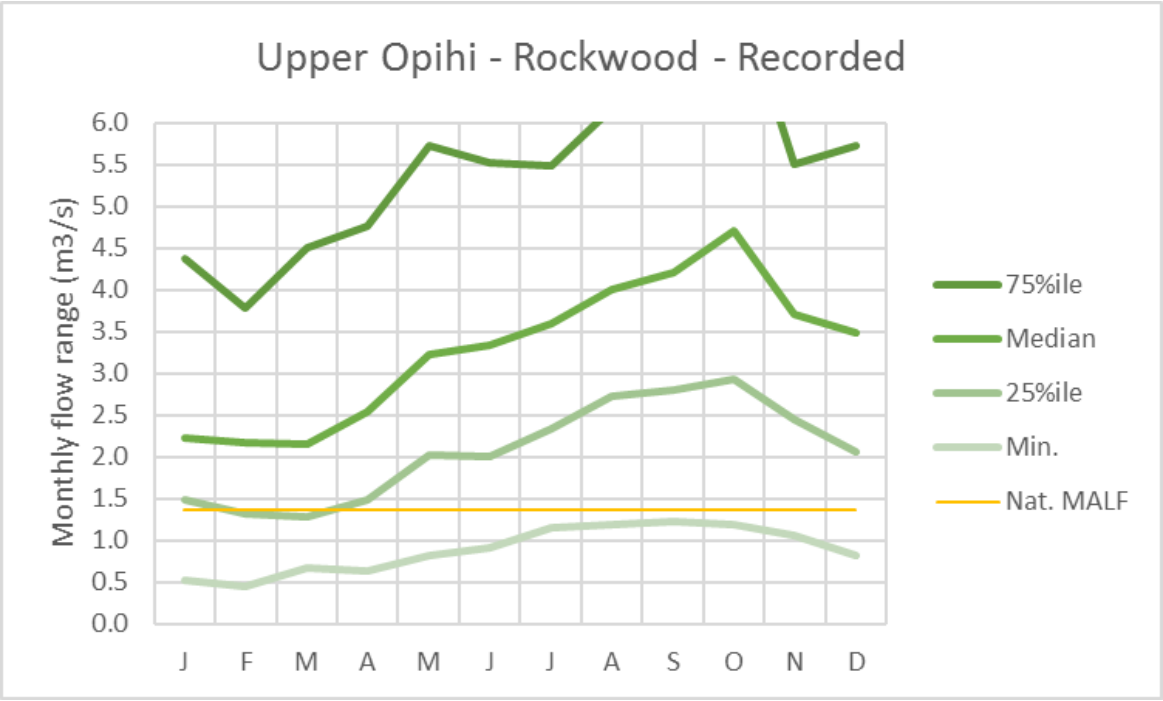

Figure 7 Monthly flow range statistics for recorded flows at the Upper Opihi at Rockwood site; for the period 1972 to June 2015.

Te Ana Wai River

FAWP propose increasing summertime (Dec, Jan, Feb) minimum flows from 400 l/s to 450 l/s, which would provide at least 80% of maximum habitat for small eels, upland bullies and Canterbury galaxias (Figure 8). This flow also provides 80% habitat for juvenile trout (Figure 8). Habitat for invertebrates is generally low across the low flow range including up to naturalised MALF, but any increase in minimum flows provides incrementally improved habitat availability.

The proposed stepped increase/decrease in minimum flows for autumn through to spring provide at least 70% of habitat for salmonid spawning, and generally follows the natural seasonal variation in flows (Figure 9). The proposed minimum for May to July of 1,500 l/s improves the habitat availability for most native fish and invertebrate species.

The hydrology of the Te Ana Wai River is characterised by extended periods of low flows but also frequent high flow events (Kilroy and Jellyman 2008). Because there is little snow accumulation in its catchment, it does not generally experience high spring flows associated with snow melt and flows can drop rapidly in early summer, thus having potential for extended summertime low flows. Because of this, minimum flows would ideally be set at a level that can sustain healthy ecosystems for prolonged periods over summertime. The FAWP proposed summertime minimum flow is an improvement on the current minimum flow and will provide incrementally improved habitat availability.

The Te Ana Wai River loses flow as it travels across the valley from Cave to its confluence with the Opihi River. At times through summer, flows can become discontinuous in some reaches, and while this may occur naturally at times, water abstraction exacerbates the frequency, duration and extent of dry reaches. Dry reaches or stagnant pools do not provide quality habitat for fish and invertebrates, and where possible flow and allocation regimes should aim to minimise the worsening of drying reaches. Because of the high summer rainfall, we were not able to evaluate the extent or duration of dry reaches this summer in relation to the ecological flow assessment site. However, this remains an important consideration in this catchment.

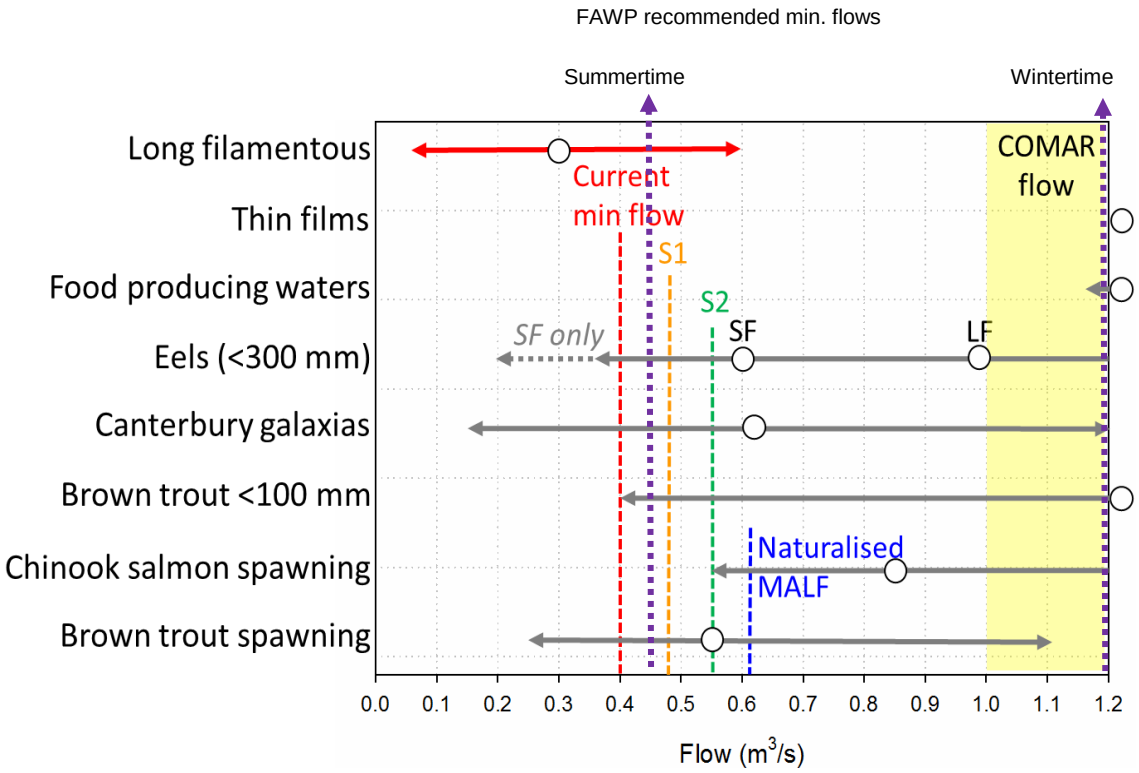

Figure 8 **NIWA's summary results for selected aquatic values in the Te Ana Wai River from physical habitat modelling.** The grey horizontal arrows indicate the flow range over which 80% of the maximum available habitat is retained. The purple dashed lines are FAWP's summertime and maximum wintertime recommended minimum flows.

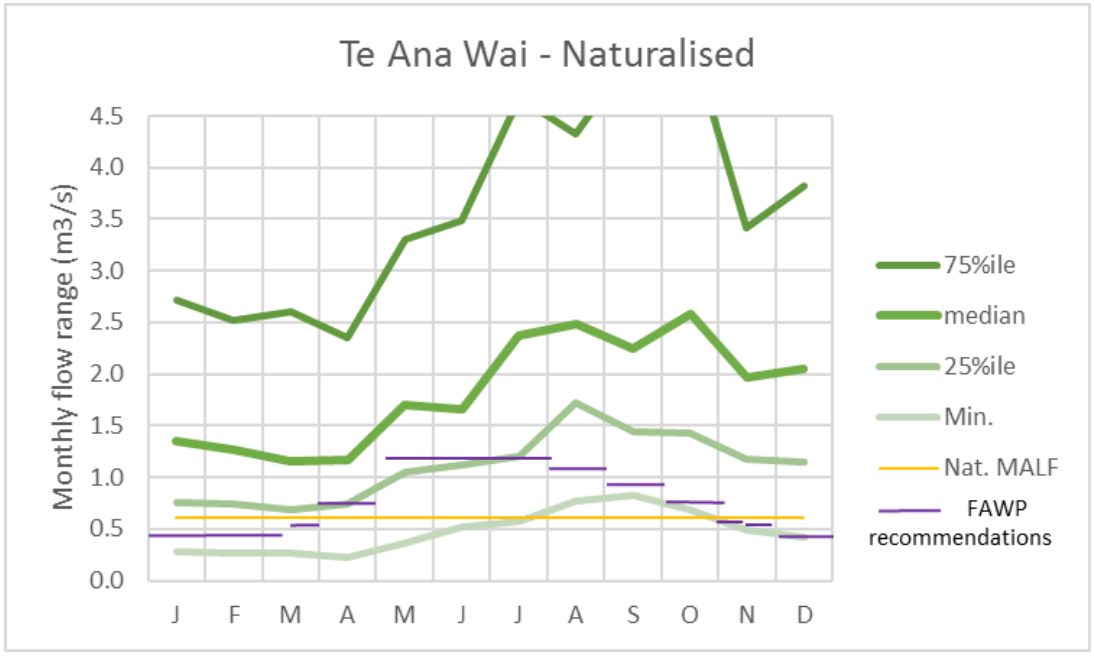

Figure 9 Monthly flow range statistics for naturalised flows for the Te Ana Wai Cave site; for the period 1982 to June 2015.

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