Memo

Date	9 August 2018
To	OTOP zone committee
cc	Craig Davison, Dan Clark
From	Shirley Hayward

Subject: Assessment of flow allocation regimes on ecologically important flows of the Opihi River tributaries

Purpose

When considering environmental flow and allocation regimes, both minimum flows and total allocated instantaneous rates need to be considered together. It is the interplay of these two aspects of flow management that impact on ecological health of waterways.

This paper provides additional analysis of the combined effects of the minimum flows, partial restrictions and allocation limits of the various scenarios[1] on residual flows. Specifically, the effects on the duration of low flows and changes to mid-range flows and potential implications for instream ecological values is examined. This is intended to support the OTOP zone committee's deliberations on the flow and allocation workshops for the Opihi catchment.

Background

The zone committee have recommended in the draft ZIPA that surface water and groundwater allocation rates for the Opihi and Temuka catchments are capped at current levels and are ideally reduced over time.

The zone committee have also recommended that the flow restriction regimes includes partial restrictions of some form to ensure the applicable minimum flow is not breached due to abstraction.

The minimum flow determines how low a flow may go before abstractions have to cease and has historically been set with consideration of the minimum physical habitat that can sustain key fish species. The total rate of water abstracted influences how long the river stays at or near the minimum flow (beyond natural low flow conditions). The total allocation also influences mid-range flows. Mid-range flows broadly describe the flows that fall between flushing flow events and low flow events and are considered an important component of the flow regime for benthic invertebrate production, and consequently food availability for fish and birds (Larned et al., 2012).

If a river has a large allocation block which would greatly extend periods of low flows, setting minimum flows (and partial restrictions) at a level that can sustain a healthy ecosystem for prolonged periods is an important consideration.

Given the zone committee have recommended setting allocation limits at current levels and there are very few options currently available for reducing the allocated rate, understanding the effect of the water allocated on prolonging low flows and on mid-range flows for each of the scenarios is important when considering minimum flow options.

[1] ZIPA Step 1, ZIPA Step 2, Cultural Flow Preferences, and the Flow and Allocation Working Party's proposed regimes

Ecological importance of minimum flows and mid-range flows

New Zealand's native fish and invertebrates can generally tolerate short durations of low flows, but prolonged low flows have been shown to negatively impact on fish and invertebrate populations. Prolonged low flows can promote the growth of nuisance algae, with consequential negative impacts on stream health and aesthetic/recreational values. Low flows that extend for weeks to months potentially extend the period stream life is exposed to stressors such as elevated temperatures, severe diurnal fluctuations in pH and dissolved oxygen, and reduced food availability (especially for drift feeding fish) as well as a constrained physical habitat. A general rule of thumb has been suggested that increases in the duration of low flows for longer than 30 days could cause deleterious effects on aquatic ecosystem health (Beca 2008).

There is little specific guidance on the thresholds for managing impacts on mid-range flows. Generalisations that consider the degree of flow alteration can guide in assessing the risk of detrimental impacts. As a guide, flow alterations that result in less than 10% change in hydrological regimes are unlikely to have significant adverse ecological effects, while hydrological alterations of in the range of 10 to 40% could have varying impacts depending of on the sensitivity of species present and natural river flow regime. Hydrological alterations of more than 40% regardless of river size have a high risk of deleterious ecological impacts (Beca 2008).

Methodology

The approach taken for this analysis draws on the daily times series flow data generated by Clark (2018) for the current regime, draft ZIPA recommendations and FAWP recommendations. The time series data spanned from May 1998 to June 2015. Analysis is presented for each of the four main tributaries of the Opihi River; North Opuha, South Opuha, Upper Opihi and Te Ana Wai rivers.

For the Upper Opihi River and South Opuha sites, the minimum flow recorders are located downstream of all or near all takes, and therefore, the times series data for measured and modelled scenarios reflects residual flows downstream of takes. For the North Opuha River where the flow recorder is located upstream of almost all takes, all scenarios for the flow recorder site have very similar flow durations (see Clark 2018) because there is very little upstream abstraction that impacts on measured flows at the flow recorder. Therefore, a set of timeseries flow data were calculated in which the water available for abstraction was subtracted from the naturalised flow record for the Claytons Road site. This is a simple analysis of the impact on flows if flow abstractions occur immediately upstream of the flow recorder. This does not allow for any flow loss or gains downstream but does illustrate the magnitude of impacts of the total abstraction on low flow durations and mid-range flows.

Similarly, a timeseries flow dataset was generated for the Te Ana Wai River recorder site that accounts for all takes both upstream and downstream. Again, this does not account for flow losses and gains downstream but provides a simple and relative analysis of the impact of allocation on the duration of low flows relative to the flow recorder site.

Duration of low flows

For each scenario for each site, the percentage of time (number of days) that flows fell below the naturalised MALF was calculated and converted to the average number of days per year. These were compared to the number of days per year that flows naturally fell below MALF for the naturalised and measured time series data.

These estimates of low flow durations are not continuous low flow periods and the actual impact of the number of days per year at low flows will vary depending on the whether they are continuous periods or are interrupted with freshes or floods. Other factors, particularly climatic factors such as temperatures and sunlight hours will contribute the risks of detrimental effects.

Impacts on mid-range flows

The flow duration curves generated show the percentage change in median flow from the naturalised median flow statistic. This can be used to indicate the magnitude of change in mid-range flows for each scenario.

The analysis by Clark (2018) is based on the modelling abstraction of full allocated rate at all times that is available. While this doesn't generally occur routinely, it is representing the potential full impact (worse case) for each scenario.

South Opuha

The South Opuha flow recorder at Monument Bridge is located below all irrigation takes and therefore provides residual flow data. Flow duration curves for the naturalised flow indicate that flows fall below the naturalised MALF (666 L/s) around 18 days per year (5% of the time) (Figure 1). Based on the 1998 – 2015 measured flows, actual flows fall below the naturalised MALF for about 34 days per year (9%), indicating that current abstractions nearly double length of time the river falls below the naturalised MALF.

For the modelled current scenario (current consented minimum flows and allocation) if all water allocated was abstracted when available, the duration of time flows fell below MALF would extend for over 2 months (74 days) (Figure 1). While this does not generally happen based on measured flow data, it is a worse-case scenario indicating potential effects of the current consented regime. The modelled ZIPA Steps 1 and 2 (that include pro-rata partial restrictions) result in a smaller increase in duration of low flows (between 25 to 30 days per year) compared the modelled current regime.

The impact of current abstraction on median flows show a 7% reduction in mid-range flows compared to naturalised flows, indicating the current levels of abstraction are unlikely to have a significant impact on ecological processes influenced by mid-range flows (e.g. food production and delivery). However, the current scenario potentially could reduce median flows by 35% indicating a moderate to high degree of mid-range flow reduction. ZIPA Steps 1 and 2 could reduce the median flows by about 30%. This would only occur if full allocations were taken consistently.

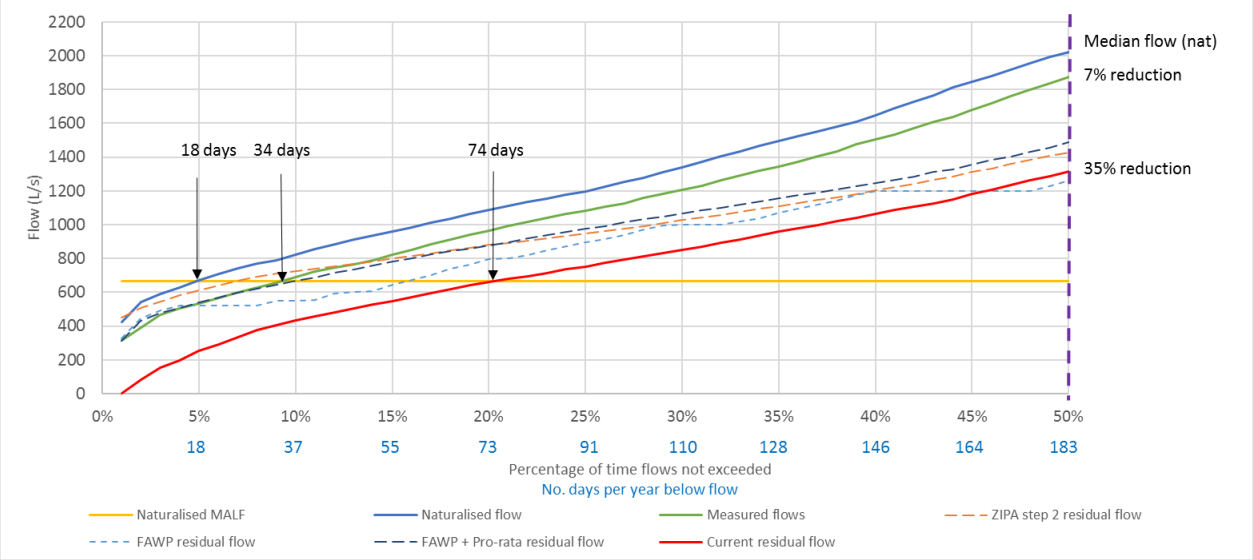

Figure 1 Flow duration curves for South Opuha River at Monument Bridge flow recorder for various flow and allocation scenarios (see Clark 2018 for explanation of scenarios).

Upper Opihi River

The upper Opihi flow recorder at Rockwood is located below nearly all irrigation takes and therefore provides residual flow data. Flow duration curves for the naturalised flow indicate that flows fall below the naturalised MALF (1,367 L/s) around 18 days per year (5% of the time) (Figure 2).

For the modelled current scenario (current consented minimum flows and allocation) if all water allocated was abstracted when available, the duration of time flows fell below MALF would extend for over 2½ months (76 days) (Figure 2). The ZIPA steps 1 and 2 (that include pro-rata partial restrictions) result in a smaller increase in duration of low flows (around 30 – 40 days per year) than the modelled current scenario. The COMAR flow regime would have a lesser impact on duration of low flows (27 days).

Based on the 1998 – 2015 measured flows, actual flows fall below the naturalised MALF for about 31 days per year (9%), indicating that current abstractions increase the time river falls below the naturalised MALF by about 70%. The extension of duration of low flows from 18 days to 31 days is about the upper threshold for avoiding detrimental impacts on instream ecology.

The impact of current abstraction on median flows show a 6% reduction in mid-range flows compared to naturalised flows, indicating the current levels of abstraction are unlikely to have a significant impact on ecological processes influenced by mid-range flows. However, the current scenario potentially could reduce median flows by 27% indicating a moderate to high degree of mid-range flow reduction. ZIPA Steps 1 and 2, FAWP and COMAR flow regimes could all reduce the median flows by about 25%. This would only occur if full allocations were taken consistently.

The measured flows for the Upper Opihi catchment indicate overall that current rates of abstraction have greater influence on the duration of low flows than on reduction in mid-range flows. The ZIPA steps 1 and 2, COMAR and FAWP+ pro-rata scenarios all have considerably lower impacts on low flow durations than current or FAWP modelled scenarios.

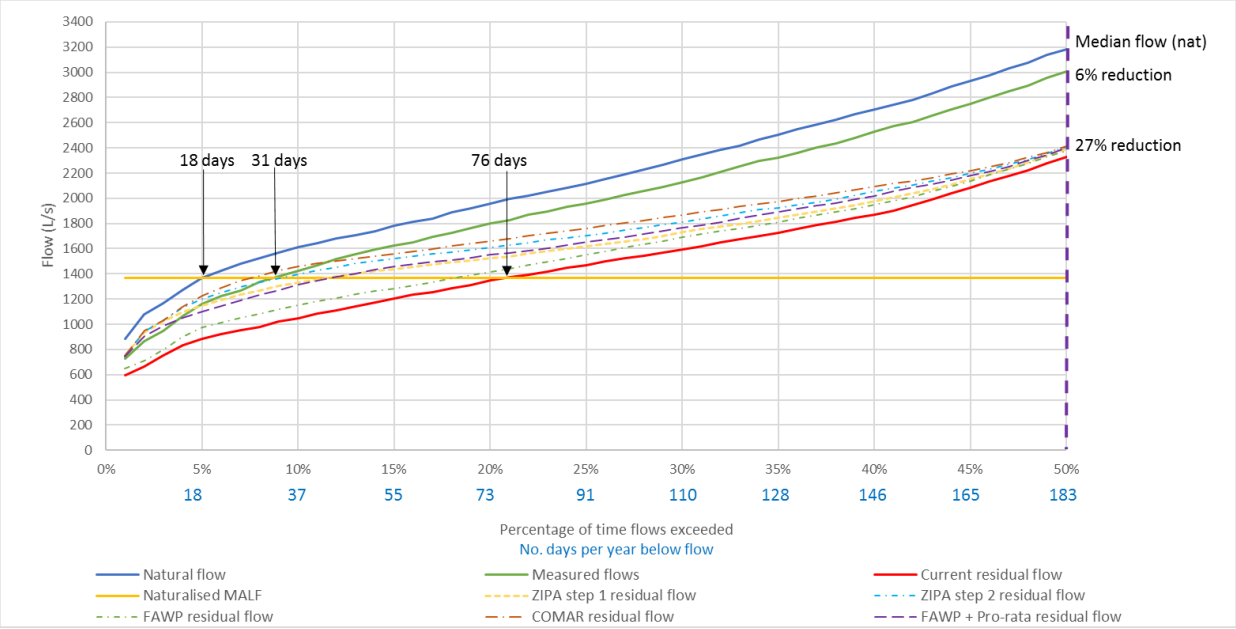

Figure 2 Flow duration curves for the Upper Opihi River at Rockwood flow recorder for various flow and allocation scenarios (see Clark 2018 for explanation of scenarios).

North Opuha

The flow recorder for the North Opuha River at Claytons Road is located above all irrigation takes.

The naturalised MALF for the North Opuha at the flow recorder at Clayton Road is 826 L/s (note FAWP records that their estimate of naturalised MALF is 906 L/s). Flows below this level occur about 3% of the time (about 12 days per year on average), indicating a relatively infrequent occurrence of low flows naturally.

If abstractions occurred immediately upstream of the flow recorder site and allocated water was taken at all times when available for each scenario, the duration of low flows could increase 3-fold (36 days). As we do not have a flow recorder downstream of abstractions, we do not know the actual downstream low flow durations, but it's unlikely that low flows of this duration would occur in most years.

The impact of full allocation could reduce median flows by around 15%, indicating a moderate degree of hydrological alteration. However, it is unlikely that this occurs, and it is likely that actual impacts of median flow will be less than 10% reduction.

The current summertime minimum flow for the North Opuha River is set at just above the naturalised MALF (826 L/s) and the allocated rate is just over 30% of MALF. In combination, these current limits are unlikely to have detrimental impacts on instream ecological health and functions.

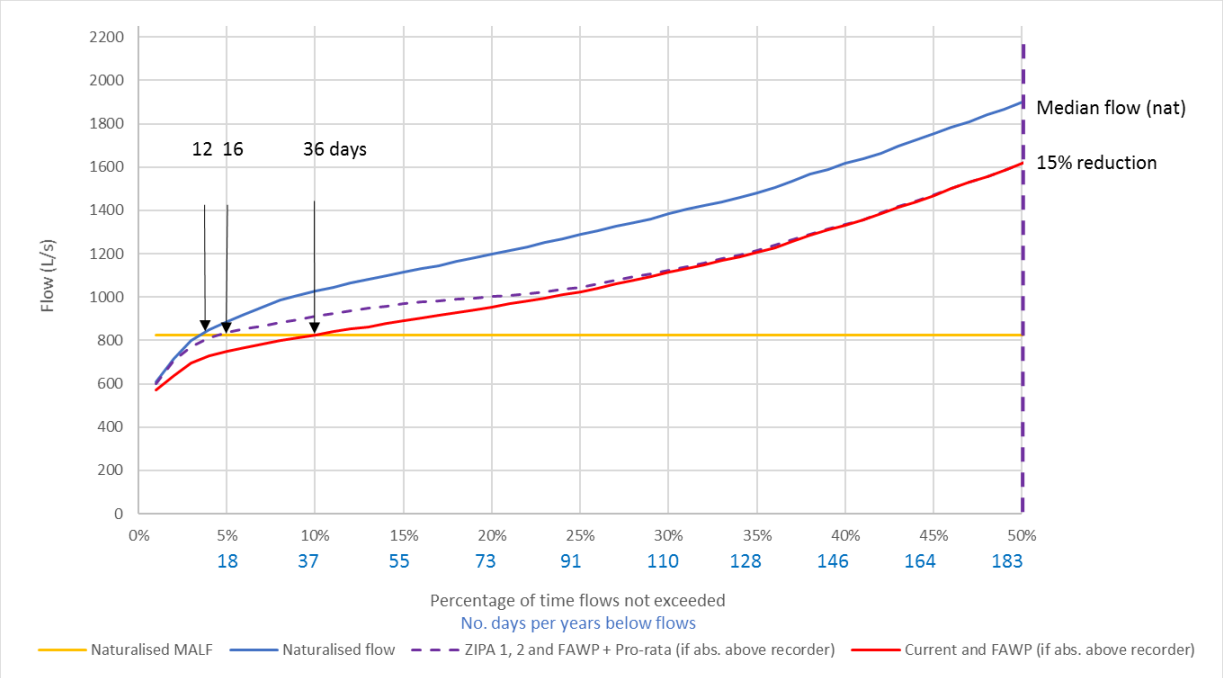

Figure 3 Flow duration curves for the North Opuha River at Claytons Rd flow recorder for various flow and allocation scenarios (see Clark 2018 for explanation of scenarios). The two scenarios are calculated as if the abstractions occurred immediately above the flow recorder site.

Te Ana Wai River

The flow recorder for the Te Ana Wai River is located at Cave in the middle of the catchment with some abstractions occurring above the site and some below.

The naturalised MALF for the Te Ana Wai River at Cave is 616 L/s. Flows fall below this level about 7% of the time (about 24 days per year on average), indicating a flow regime with naturally long duration of low flows.

Figure 4 shows the flow duration curves for measured flows at Cave and the flow and allocation scenarios showing impacts of only the abstractions that currently occur above the flow recorder. This does not reflect the impact of all abstractions in the catchment. This shows that based on measured flows at the Cave recorder site, flows below MALF increase to about 36 days per year. The full potential impact of the current allocation above Cave could result in low flows occurring for over 2 months.

Figure 5 shows the theoretical effect if all abstractions occurred immediately above the flow recorder at Cave. If all abstractions occurred immediately upstream of the flow recorder site and allocated water was taken at all times when available for each scenario, the duration of low flows could extend for over 3 months of the year. This illustrates the potential impacts of full abstraction relative to the flows recorded at the Cave recorder site. The potential severe extension of duration of low flows reflects the naturally extended low flow regime of this river combined with a comparatively high total allocation relative to MALF (A allocation block is 64% of naturalised MALF).

As we do not have a flow recorder downstream of abstractions, we do not know the actual downstream low flow durations, but it's unlikely that low flows of this duration would occur in most years.

The impact of current upstream abstractions on measured flows is relatively small (5% reduction in median flows) with up to 17% reduction if the upstream abstraction was whenever it was available. If all abstractions occurred upstream of the flow recorder, median flows could be reduced by up to 34% indicating a moderate degree of hydrological alteration.

This analysis indicates that current flow and allocation regimes are most likely to have far greater impacts on duration of low flows than on mid-range flows. The impact of full abstractions on the duration of low flows is potentially quite severe. Even the draft ZIPA and FAWP + pro rata scenarios are likely to extend the duration of low flows to more than twice the natural low flow duration.

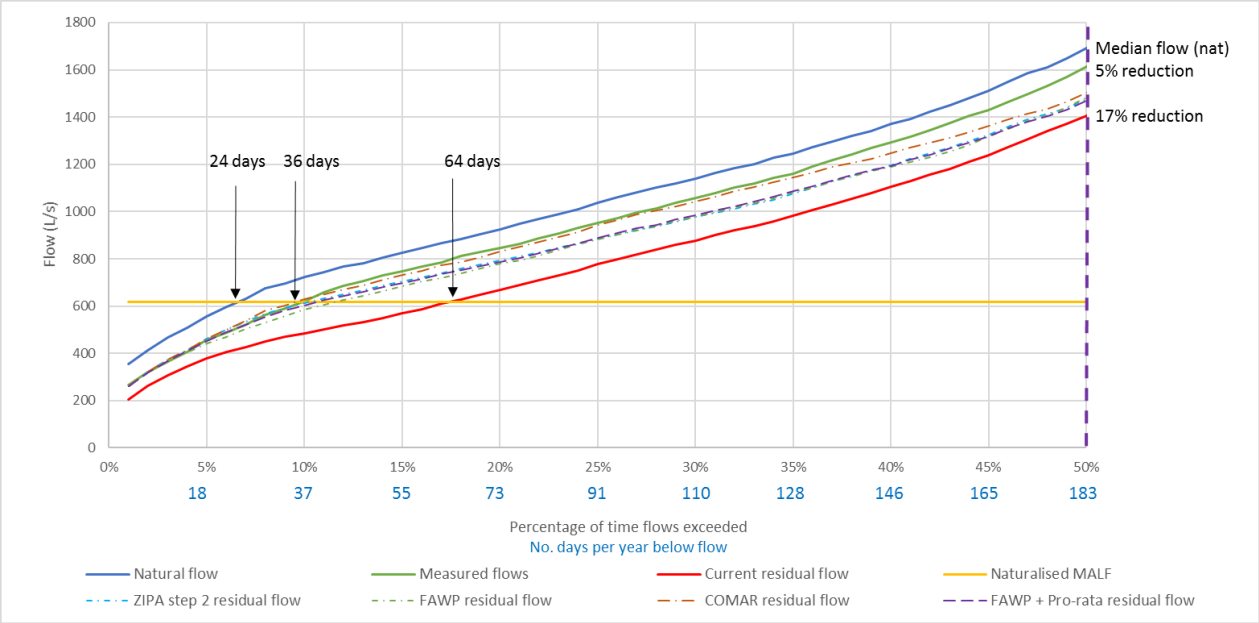

Figure 4 Flow duration curves for the Te Ana Wai River flow recorder at Cave for various flow and allocation scenarios (see Clark 2018 for explanation of scenarios). This graph shows the actual (measured) and potential effects of abstraction that occur above the Cave flow recorder only.

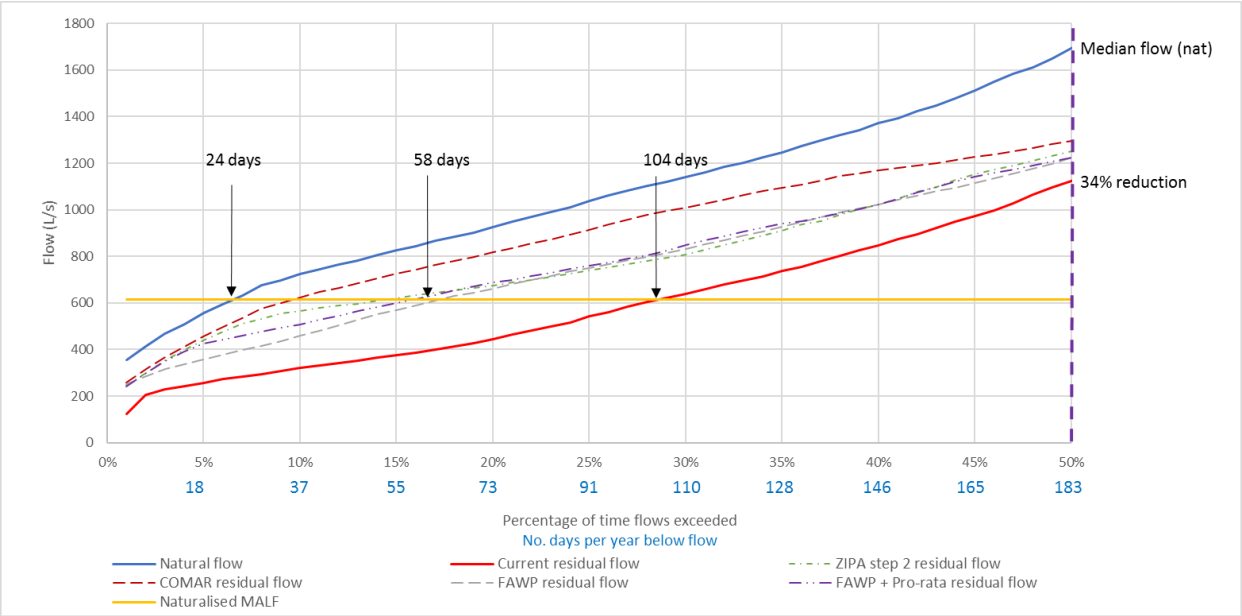

Figure 5 Flow duration curves for the Te Ana Wai River flow recorder at Cave for various flow and allocation scenarios (see Clark 2018 for explanation of scenarios). This graph shows the theoretical effects of all abstraction if all abstractions occurred immediately above the flow recorder.

Potential changes to current abstraction rates

In most cases, the measured flows (where downstream of abstractions) show a considerably lower impact on flow regimes (duration of low flows and reduction in median flows) than that modelled for full takes. There are multiple reasons for this and this is consistent with general patterns of actual takes being less than allocated takes for much of the time (Ritson and Steel 2017). Although at some times of the year (or some years) abstractions may take their full instantaneous rate (during hot dry summers) for at least short durations.

Of consideration is the potential increase in A Permit takes to storage, which may become more popular to assist with any loss of reliability through changing minimum flow regimes and/or climate change. Although limited by annual volumes and reasonable use tests, abstractions that take water to storage could increase the duration when full or near full instantaneous allocation rates are utilised. This is particularly relevant if the situation arises where irrigators operate under a Global Water User Group consent in the future. This potential change in abstractive patterns would likely to shift the residual flow duration curves towards the current worse case scenario illustrated in the above sections.

Options to consider are whether A takes to storage should be identified and managed separately from direct run-of river or stream depleting groundwater takes, with options for setting different minimum flows and/or partial restrictions or separate allocation blocks, or limiting period of abstraction to winter months only.

References

Beca. 2008. Draft Guidelines for the Selection of Methods to Determine Ecological Flows and Water Levels. Report prepared by Beca Infrastructure Ltd for MfE. Wellington: Ministry for the Environment.

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