Setting Environmental Flows in Water Management Areas

This information pack has been prepared for engagement with iwi, hapū, community groups, stakeholders and general public when working towards setting environmental flows in Water Management Areas. It provides a brief introduction to:

1. Natural river flows and their influence on in-river values;
2. Effects of take, use, damming and diversion activities on natural river flow regimes, and particularly why low flow management is important (p.4);
3. How we can estimate effects of changes in low flow on in-river values using habitat protection levels for indicator species (p.5);
4. How we will determine minimum flows and allocation limits, using EFSAP modelling to help us (i.e., the Environmental Flow Strategic Assessment Platform model) (p.10);
5. How EFSAP works and how it can support discussions and decision making (p.10).

1. What is river flow and why is it important?

River flow is the volume of water that moves past a point in a given time, usually measured in cubic metres per second (m^3/s). The size and variability of flow within a river influences in-stream and out-of-stream values such as: ecosystem health and habitat for key species, mahinga kai, river aesthetics, water quality, recreational opportunities, and the amount of water available to take and use.

Changes to flow, and in particular minimum flow size and duration, influences the diversity and abundance of fish and invertebrate species, as flow sensitive species can find themselves with less available habitat to live in and species that are better adapted become more dominant. The Department of Conservation report entitled 'Conservation Status of New Zealand Freshwater Fish, 2013' states that 74% of New Zealand's resident native fish taxa are considered to be 'Threatened' or 'At Risk'[1]. Poorly managed water allocation is thought to be a significant contributor[2], emphasising the importance of considering their flow needs when setting minimum flows and allocation limits. The following table explains how different parts of a flow regime influence specific in-stream values. Figure 1 depicts this flow profile in a time series. Figure 2 is a flow duration curve, which plots the amount of time that a river is at a particular flow level.

Key point to remember:

- At low flows, aquatic ecosystems can be under stress and key species are most likely to have constrained habitat and/or competition for space.

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[1] Goodman, J.M.; Dunn, N.R.; Ravenscroft, P.J.; Allibone, R.M.; Boubee, J.A.T.; David, B.O.; Griffiths, M.; Ling, N.; Hitchmough, R.A.; Rolfe, J.R. 2014: New Zealand Threat Classification Series 7. Department of Conservation, Wellington. 12 p.

[2] http://www.doc.govt.nz/documents/about-doc/concessions-and-permits/conservation-revealed/nz-native-freshwater-fish-lowres.pdf

Table 1. Key aspects of natural river flow regimes and how they influence in-stream values.

Aspect of flow regime	Influence on in-stream values
Large floods e.g., a flood we might expect only once a year or less often	• Influence overall form of channel • Maintain the channel • Affects the nature of the river corridor - floodplain surface, vegetation cover, and the need for river control measures (e.g., planting, groynes, stop banks) • Substantially disturb and disrupt ecosystems • Spring floods may be needed to open river mouths and enable migratory fish to travel in and upstream from the sea
Smaller floods and freshes e.g., happen a few times per year and remain contained within the channel)	• Mobilise sediment in some parts of the river bed • Remove periphyton and other aquatic vegetation • Assist juvenile salmonids and larvae of migratory native fish to get to the sea • Flush and refresh the river – remove silt and algal coatings, and inhibit vegetation from colonising on exposed gravel beds in the river • Also disturb and disrupt parts of the ecosystem • Timing between freshes is important as different species take different lengths of time to recover (e.g., MCI within weeks vs. trout may take years)
Flow recession that is, when the river is declining after a flood or fresh	• Can provide enhanced kayaking/white water rafting opportunities • May restrict angling
Low flows	• Greatest competition for water "space" - Wetted Useable Area is lowest • Aquatic ecosystem stress likely to be at its highest (other than catastrophic stress of high flood)[3] • Low disturbance - high biological productivity permits recolonization by MCI and fish after flood • Re-establishment of aquatic vegetation • Good native fish and bottom dwelling invertebrates may occur in small streams at low flow, but higher flows are required for juvenile salmonids, and adult trout need even more.
Flow variability the pattern of highs and lows during the year, including the magnitude of change and the duration/frequency	• Key element of natural character of a river • Seasonal variation may have important biological functions • Long periods of low flow (4-6 weeks) can start to affect native fish and periphyton growth

[3] Although in some cases this is not the biggest driver of reduction in fish species, e.g., commercial harvest may be more so.

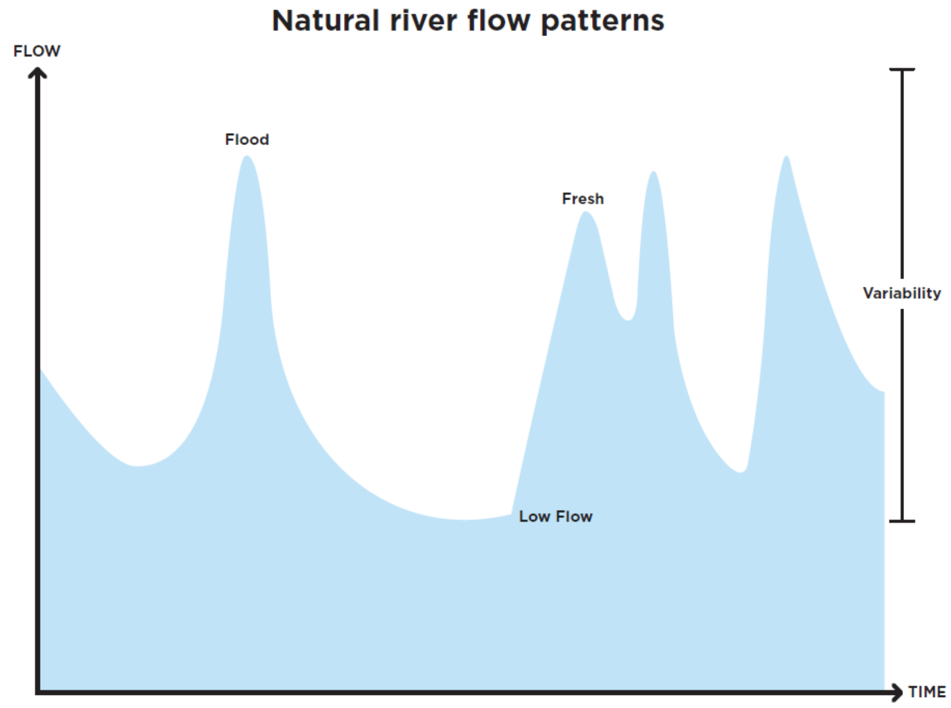


Figure 1. Key aspects of a natural river flow regimes.

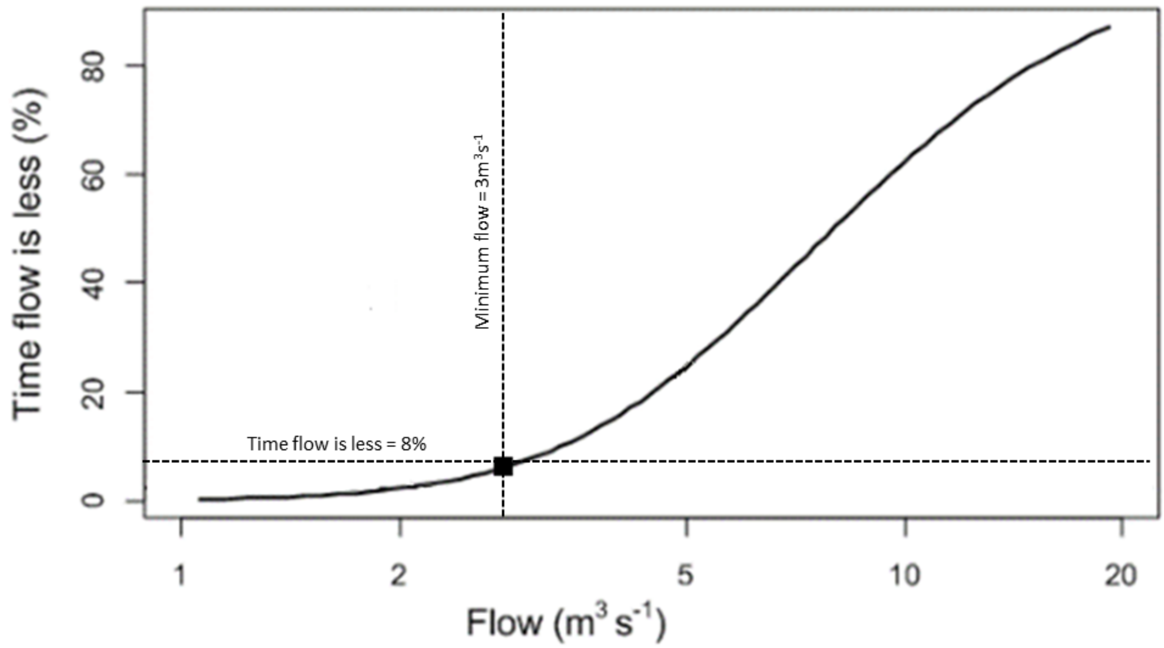


Figure 2. Flow duration curve show the percentage of time that the river is at or below certain flows

2. Effects of activities on natural river flow regimes

Generally:

- damming is the only activity that affects channel forming floods.
- large scale diversion can increase the duration and decrease the magnitude of low flows significantly, and can also reduce the frequency of freshes.
- water take/abstraction (individually or cumulatively) reduces flows significantly during periods of low flow, and can extend periods of low flow, but usually has little effect on frequency of floods or freshes.
- in-river values of small rivers are more susceptible to adverse effects of taking water than large rivers.

The main ways Council can manage effects of water take/abstraction (individually or cumulatively) are to:

- set minimum flows in a regional plan and restrict/stop abstraction when river is below this flow. Restrictions can also begin as the river flow falls close to minimum flow.
- set a total allocation limit in a regional plan and allow no more than that to be taken, or require more detailed assessments of effects if more water is sought.
- require resource consents for most damming and diversion activities, and larger takes of water, to ensure appropriate conditions can be set to provide for minimum flow, seasonal variation, flushing and channel forming flows.

Key point to remember:

- Council *must* set minimum flows and total allocation limits to manage the effects of many water takes on in-river values.
- The region-wide interim allocation limit for rivers 10% of Q5 and the minimum flow is 90% of Q5, unless the existing allocation is already more than this. **Q5** is the 7 day mean annual low flow that has a 20% chance of occurring in any year.
- New minimum flow and allocation limits will be set within each Water Management Area, involving the community, iwi and hapū.

3. How can we measure effects of altered low flows on in-river values?

As a good start, we can estimate effects of altered low flows on key indicator fish species and this can indicate effects on ecosystem health, other significant species, mahinga kai and fishing. Effects on other values, like recreation, and sites of cultural significance will need other assessments.

Weighted Usable Area (WUA) and Mean Annual 7 day Low Flow (MALF) are important surrogate measures for space and food for fish species in rivers. It is assumed that WUA at MALF is the natural limiting flow in rivers. Scientists have developed WUA curves for several indigenous fish species as well as trout and salmon. The shape of these curves differs between species, reflecting different flow preferences as shown in Figure 3.

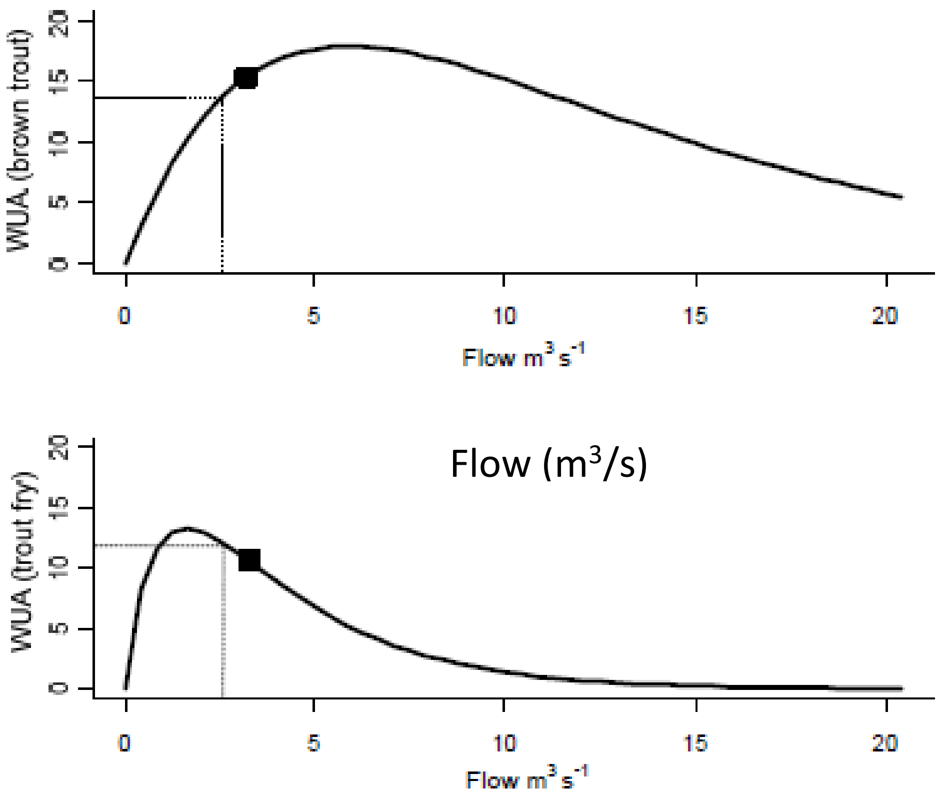


Figure 3: Examples of Weighted Useable Area curves for two fish species, demonstrating that fish have different optimal and sub-optimal flow preferences

The key fish species present in each Water Management Area (WMA) have been identified, and the most flow hungry species can be used as indicator species. When minimum flows provide sufficient habitat protection for indicator species, other species are also protected.

Indicator species selected for Kaituna-Pongakawa-Waitahanui WMA are rainbow trout, longfin eels, and koaro. While trout are not native species, they are one of the most flow hungry, and providing flow for these is likely to provide for all others, but will mean less water would be available for use.

Indicator species selected for Rangitāiki WMA are longfin eels, shortfin eels, redfin bully

We will explore how natural flows in large and small rivers in each WMA provide for habitat protection and what might happen to this **habitat protection level** if we apply different minimum flow and allocation limits.

What habitat protection level is good enough?

Scientists have recommended general habitat protection levels that will ensure detrimental effects are unlikely. These are conservative, because a change in available habitat will only result in a population change if all available habitat is in use. This is often not the case because other factors have reduced the population (e.g., fishing, obstacles to fish passage, high temperatures, habitat loss, or poor water quality).

If we apply lower protection levels (in order to make more water available for use), we will need to look in more detail at the implications for each species. In some cases, a species can live in a wide variety of flow conditions, e.g., adult eels, whereas other species are more sensitive to flow conditions, e.g., trout. Habitat protection levels should not be reduced for species on DoC threat status of 'declined' or 'at risk'.

Table 2: Recommended habitat protection levels, being the % of habitat that would exist at MALF. Species in red rows have a Department of Conservation threat status of declining or at risk.

Target Species	Protection level (% of habitat at MALF)
Shortjaw Kokopu	100
Giant Kokopu	100
Other Kokopu	95
Dwarf galaxias	95
Koaro (adult)	90
Inanga	90
Trout angling	95
Trout spawning/rearing	90
Bullies, excl. bluegill	90
Smelt	80
Eels juvenile	80
Eels adult	75
Torrentfish	60
Bluegill bullies	60

4. What are minimum flows and allocation limits

The **minimum flow** is the flow at which most water takes (and some diversions) will be required to stop. Some critical takes may be restricted but not stopped. If minimum flow provides for optimal habitat (usually the same or more than annual natural MALF) then extending duration of minimum flow will have less effects whereas, if minimum flow provides less than optimal habitat then the effects of extended duration may be higher.

Management flow is the minimum flow plus the allocation limit. If everyone took their full allocation of water at once, the remaining flow in the river would reach minimum flow. For this reason, management flow is the river flow level where we should consider starting to restrict water takes in order to avoid breaching minimum flows.

Reliability is measure of the percentage of time a water user can expect to take their full water allocation without being subject to water take restrictions and/or be required to stop taking water.

The total **allocation limit** is the most water that can be taken (when the river is above minimum flow) and ensures sufficient flow variability is maintained (e.g., maintain freshes, and low flow is not too long).

Harvesting allocation is a potential additional total water allocation that would only be available for harvest when river flow is above a specified high flow. This is a less reliable water supply.

Figures 4 and 5 illustrate these concepts.

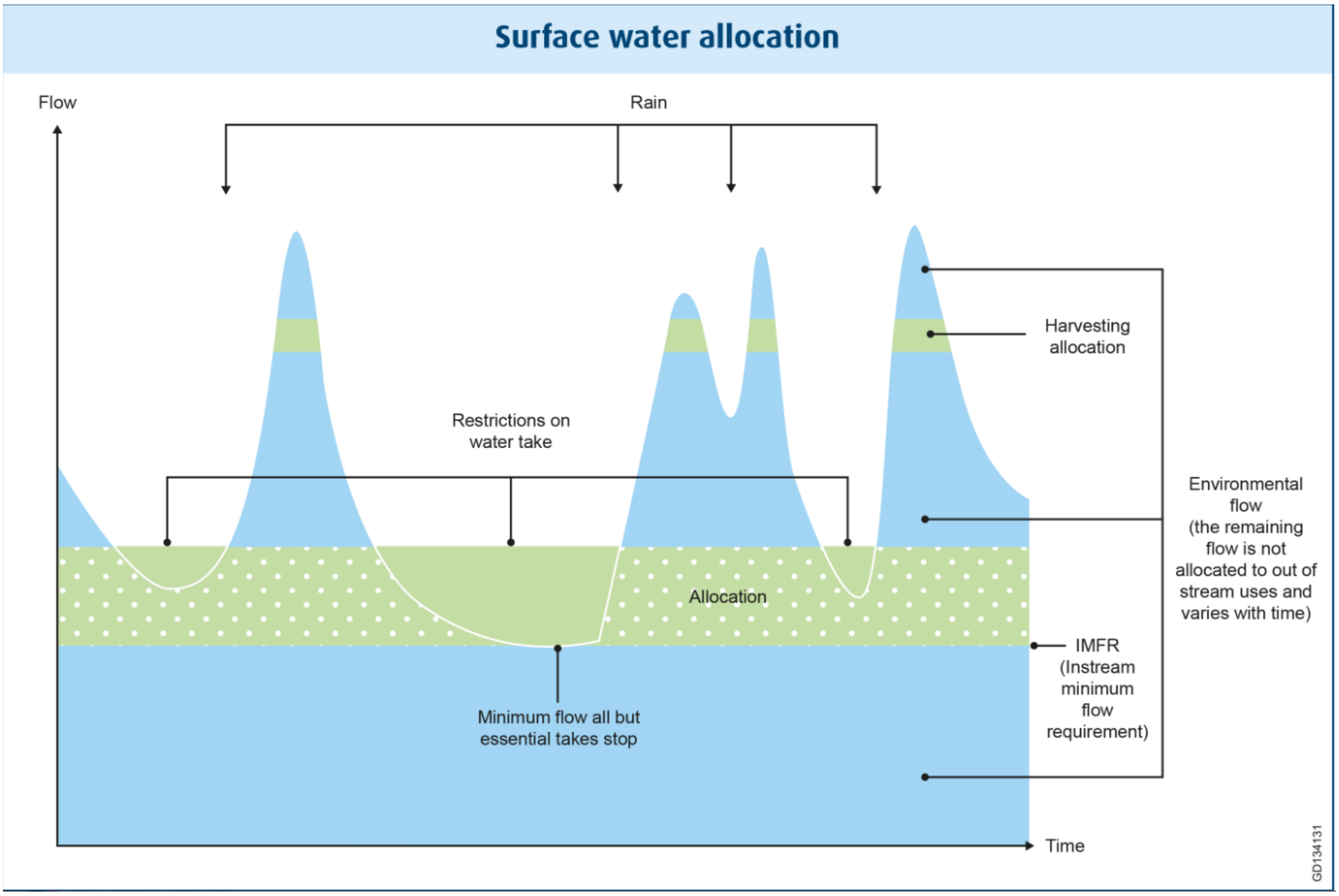


Figure 4: Surface water allocation diagram illustrating how minim flows and allocation limits relate to in-river flows

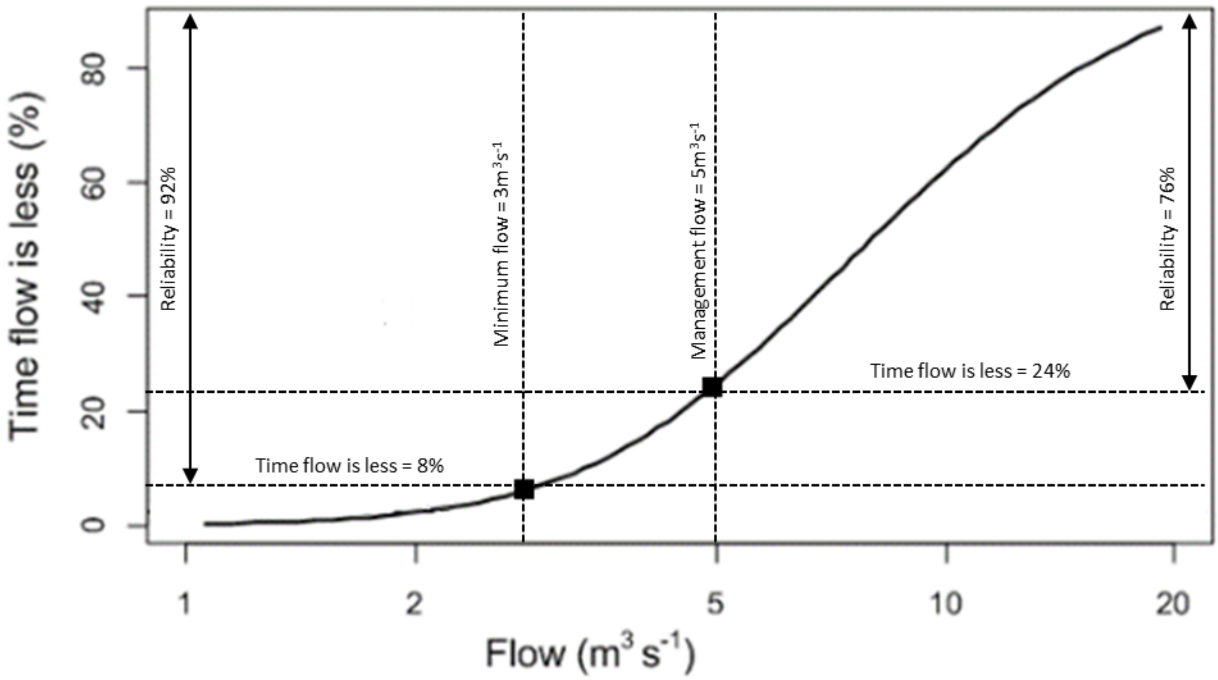
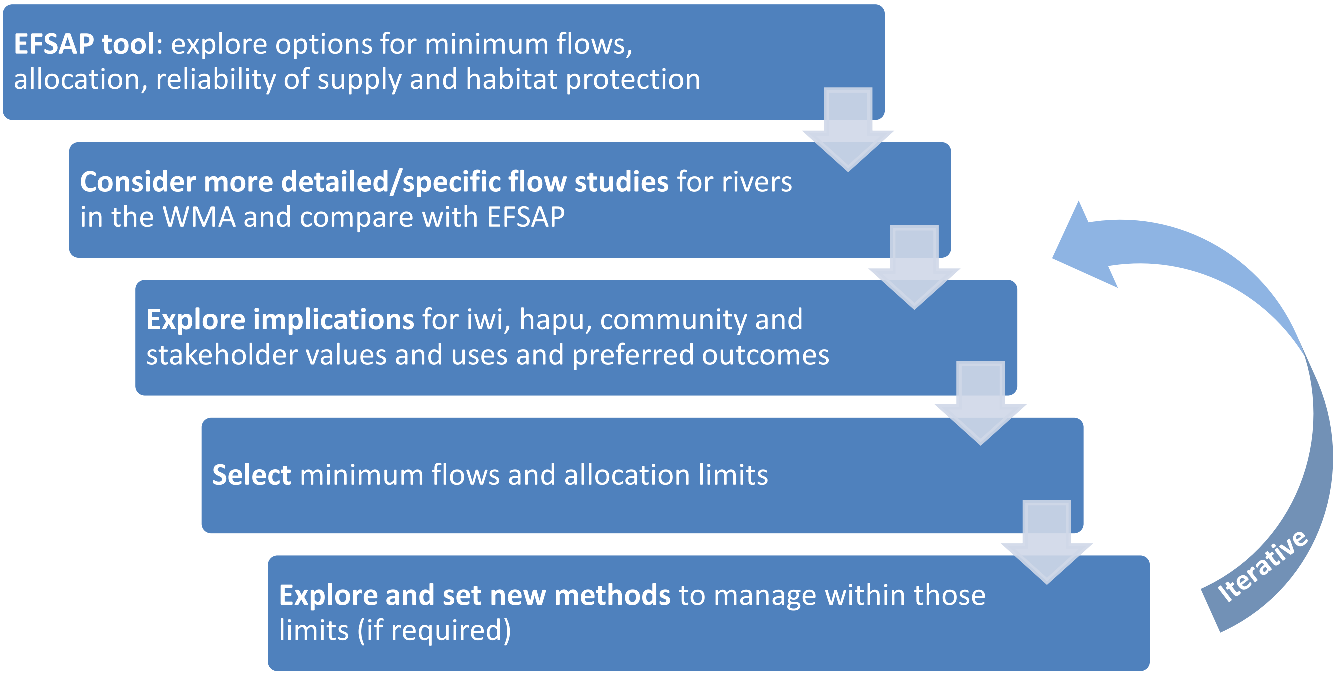


Figure 5: Flow duration curve demonstrating the relationship between minimum flow, management flow and reliability

5. How minimum flows and allocation will be identified in WMAs



- The EFSAP model results will be used to inform the discussion around setting water quantity limits, not to set limits directly.
- Existing information (e.g. detailed flow studies, including those for resource consent applications) will provide more resolution and may also provide information about flows needed for values other than fish (e.g., cultural and recreation values)
- There will be opportunities for the community to have their say through the community engagement process.
- If the new allocation limits are not currently met (i.e., the water is over-allocated) we will need to identify how we will "claw back" on water use to achieve them.
- Flow limits will be set by BoPRC councillor's after all previous steps have been satisfied and adopted in to a proposed regional plan change. This will be subject to public submissions, hearings and appeals.

6. What is EFSAP and how does it work?

The EFSAP model simulates the consequences of different flow management decisions for fish habitat, and the supply of water for out-of-stream purposes. This tool helps people to understand how different water allocation and reliability might affect fish habitat and also how habitat protection might affect water available for use.

EFSAP incorporates three other types of model:

1. The **River Environment Classification (REC)** is a spatial model which comprises a digital representation of the entire New Zealand river network. Within the Bay of Plenty Region there are 28,384 segments with an average length of 704m. Each segment contains information such as: catchment area, stream order, as well as climatic, topographical, geological, and land cover characteristics of the upstream catchment. EFSAP uses the REC model as a spatial framework with which to operate.

2. **TopNet** is a calibrated hydrological model developed by NIWA scientists that provides flow duration curves, mean flow, and MALF for each segment of the REC.

3. **Habitat flow models** link predicted flow to habitat availability for every reach in the REC framework. These are specific to species and, in some cases, life stage.

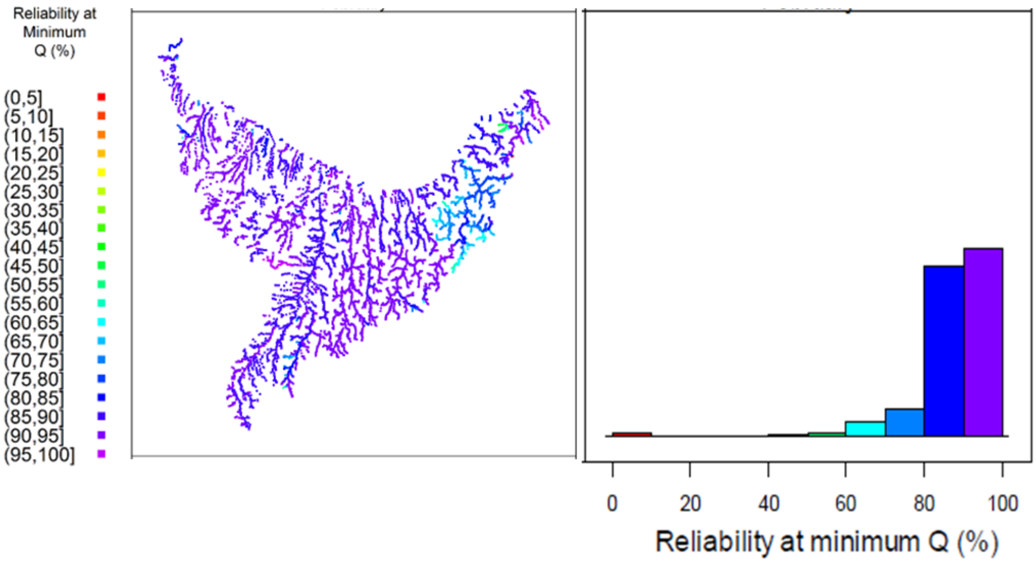
EFSAP is based on the analysis and simulation of four key variables:

- Flow changes relative to total allocation (ΔQ)
- Minimum flow (Qmin)
- Reliability of supply (R)
- Habitat change (ΔH)

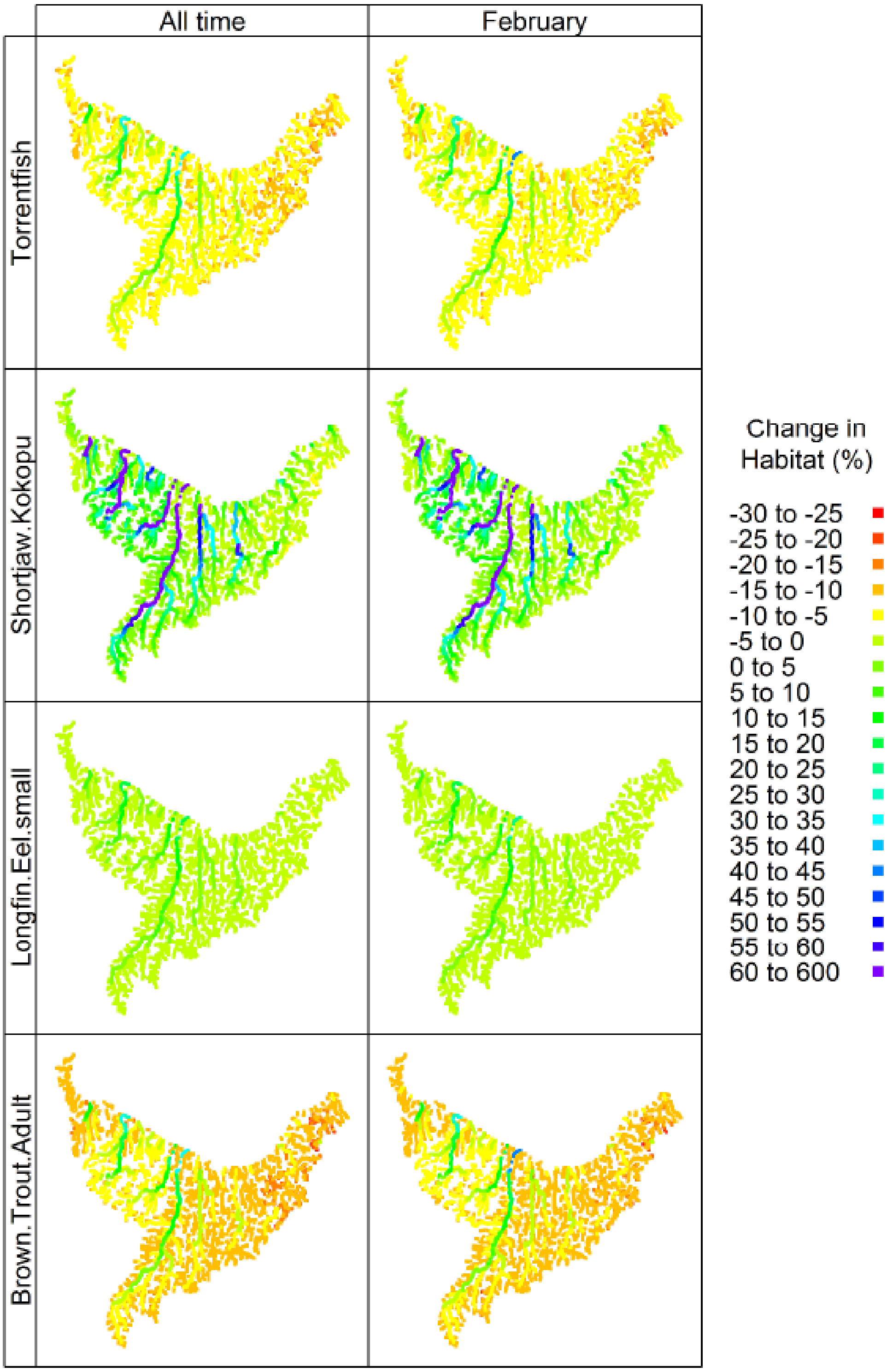
Simulations can be carried out using any two of these variables to specify the other two at all locations on the river network. For example, Qmin and ΔQ could be input to determine R and ΔH for any reach in the modelled network. Simulations can be run where calculations for each reach are independent of each other (i.e. upstream allocation has no effect on downstream results), or cumulative (i.e. where upstream allocation affects the amount of water downstream of the reach).

Outputs

Reliability Plots – Show where, and how many streams are likely to encounter reliability problems.



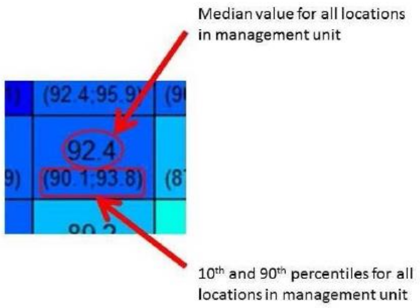
Species Specific Habitat Plots – Provide information about the extent of habitat change for a management scenario.

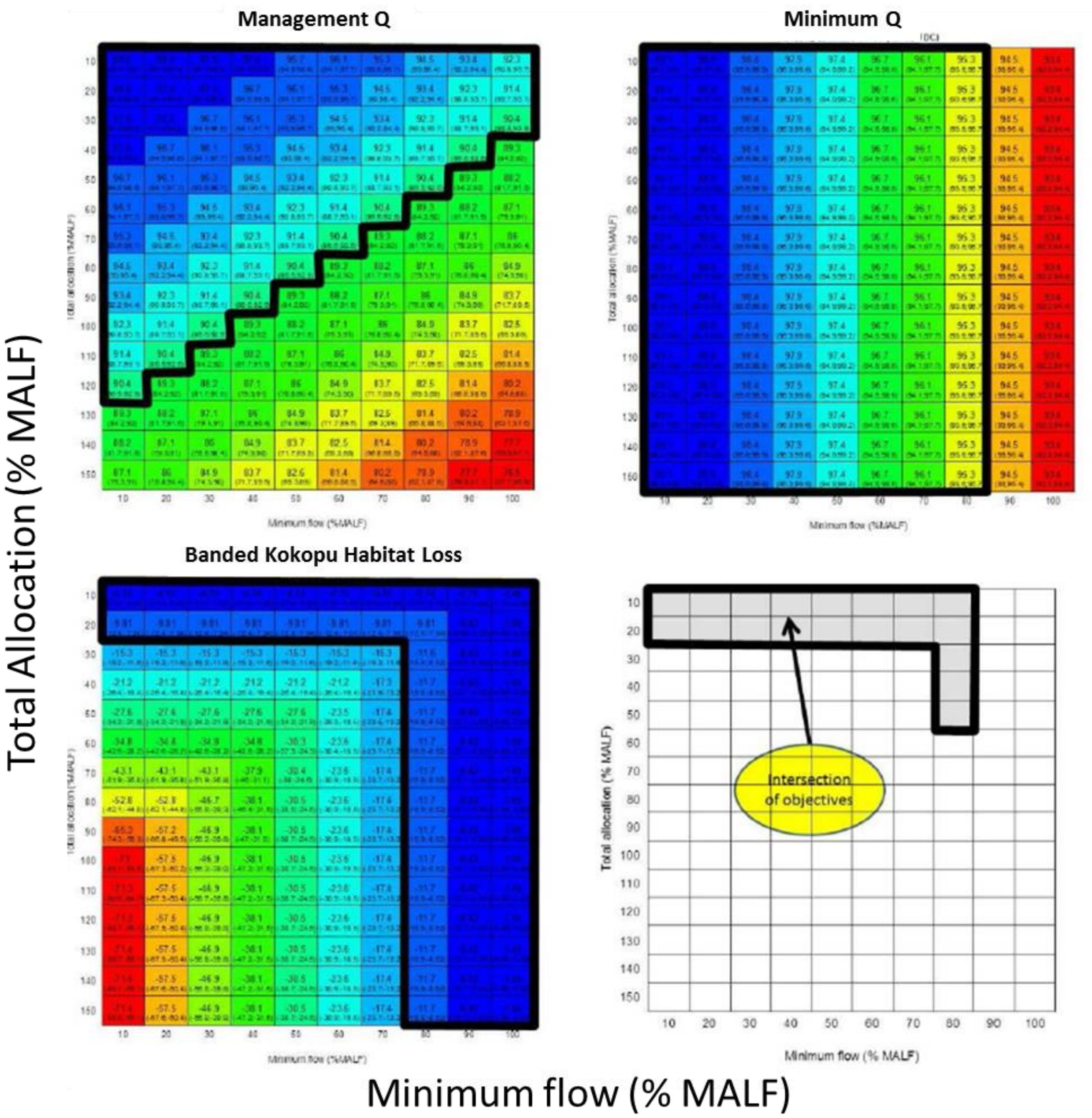

All time
February
Torrentfish
Shortjaw.Kokopu
Longfin.Eel.small
Brown.Trout.Adult
Change in Habitat (%)
-30 to -25
-25 to -20
-20 to -15
-15 to -10
-10 to -5
-5 to 0
0 to 5
5 to 10
10 to 15
15 to 20
20 to 25
25 to 30
30 to 35
35 to 40
40 to 45
45 to 50
50 to 55
55 to 60
60 to 600

Decision Space Diagrams – Can be used to determine which combination of limits satisfies a set of defined objectives. For example, if we set the arbitrary objectives of:

- median reliability at management flow ≥90%;
- median reliability at minimum flow of ≥95%;
- median loss of Banded Kokopu habitat ≤15%.

We could set Qmin and management flow according to the lower right pane.





How do we intend to use EFSAP?

Table 3: Inputs to the EFSAP model

	Range	**Reason**
Area	WMA specific	Environmental flows are being established within each WMA consecutively over time.
Stream classes	Small and large streams (≥ 10m³/s) in Volcanic Steep, Volcanic Gentle and Non-volcanic rivers	Biophysical classes recommended by Snelder et al (2016)[4] as reliability and habitat protection respond distinctly differently to allocation and minimum flow ranges.
Species	WMA specific	We decided to model the most common and "flow hungry" species within each WMA. This was decided upon by calculating the percentage of occurrence within each WMA (according to the NZFFDB) combined with probability of occurrence from FENZ predictive models, and applying a flow preference score based on work by Ian Jowett (2012)[5].
Stream Order	≥3	First and second order streams are omitted because many of these are unlikely to have flow for much of the year, and they are generally found in steep country where abstraction is unlikely to occur.
Habitat protection levels	100% down to 50%	Jowett (2012) suggested protection levels for a range of different species. While these ideally represent starting objectives for maintaining specified levels of ecosystem health, it would be useful for the EFSAP analyses to include decision diagrams showing what happens across a range of habitat protection levels (down to 50%). However, for species with DOC threat status, it is suggested that we use only the suggested protection levels is recommended by Jowett.
Reliability	100% down to 50%	EFSAP models are to be run with a reliability range between 50-100%. Then, if necessary in areas under abstraction pressure, communities could consider benefits of setting a "low reliability" allocation if other objectives were not met.
Minimum flow	100% MALF down to 50% MALF	This range provides simulation results for scenarios that are environmentally conservative as well as more resource-use enabling.
Allocation limits	10% MALF up to 80% MALF	
Timeframes	February (all years) and Annual	EFSAP analyses are to be run firstly using the February flow duration curves (FDCs), as this is when abstraction is usually highest, and flows usually the lowest. In this way, any models will be developed for times when maximum pressure is potentially being placed in the streams. The analyses will also be run for full year data.

[4] Snelder, T., Fraser, C., and Suren, A. (2016). Defining a biophysical framework for freshwater management units for the Bay of Plenty Region. Prepared by Land Water People for Bay of Plenty Regional Council. February 2016.
[5] Jowett, I. (2012). *Methods for setting ecological flow requirements in the Bay of Plenty Regional Water and Land Plan* (Rep. No. IJ1202).