Technical Memorandum
Water Quantity

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Purpose

The purpose of this memorandum is to provide an overview of requirements the National Policy Statement for Freshwater Management 2020 (NPS-FM) regarding water quantity and specifically the requirements to set environmental flows and levels, and associated limits. The memorandum also provides information on the current state of water allocation across Taranaki and details the technical work done to help support the implementation of the NPS-FM requirements.

Overview of surface water quantity

Taranaki receives frequent and plentiful rainfall. The amount of rainfall is extremely variable however, increases significantly from the region's coastal fringes to areas of higher elevation across the eastern hill country and the slopes of Taranaki Maunga. Much of this rainfall rapidly flows to the sea via rivers or streams or enters groundwater through infiltration, causing considerable variation in river flows, particularly seasonally.

Taranaki has 217 parent catchments, made up of more than 500 named rivers and streams. More than 300 rivers flow from the flanks of Taranaki Maunga in a distinctive radial pattern across the ring plain. Typically, ring plain rivers are short, small and fast-flowing.

By contrast, eastern hill country rivers display a branch-like pattern of drainage. The rivers of the hill country are generally longer than ring plain rivers and are contained by narrow valleys that carry relatively high sediment loads as a result of erosion.

The taking, use, damming and diversion of surface water is an issue of major public and economic interest in Taranaki. Water is a fundamental need for of a wide range of agricultural and industrial activities, while providing drinking water for a large proportion of the Taranaki community. At the same time, there has been concern to ensure that sufficient water remains available to maintain healthy rivers and streams for aquatic life, provide for instream uses, such as fishing and swimming, and to recognise and provide for the cultural and spiritual values of tangata whenua with regard to freshwater.

Water quantity and the National Objectives Framework

The National Policy Statement for Freshwater Management 2020 (NPS-FM) requires the Taranaki Regional Council (TRC) to set environmental flow and levels for all of the region's waterways (Figure 1). Environmental flows and levels must be set as rules in plans. A flow can be considered the quantity, variability, flow, duration and timing of flows or water levels to give effect to Te Mana o te Wai, the long-term visions and outcomes set by the community and tangata whenua (MfE, 2023). When setting limits Council must prioritise the health and wellbeing of waterways over all other values, including economic needs.

NPS-FM

Clause 3.16: Setting environmental flows and levels

(1) Every regional council must include rules in its regional plan that set environmental flows and levels for each FMU, and may set different flows and levels for different parts of an FMU.

(2) Environmental flows and levels:

  (a) must be set at a level that achieves the environmental outcomes for the values relating to the FMU or relevant part of the FMU and all relevant long-term visions; but

  (b) may be set and adapted over time to take a phased approach to achieving those environmental outcomes and long-term visions.

(3) Environmental flows and levels must be expressed in terms of the water level and flow rate, and may include variability of flow (as appropriate to the water body) at which:

  (a) for flows and levels in rivers: any taking, damming, diversion, or discharge of water meets the environmental outcomes for the river, any connected water body, and receiving environments

  (b) for levels of lakes: any taking, damming, diversion or discharge of water meets the environmental outcomes for the lake, any connected water body, and receiving environments

  (c) for levels of groundwater: any taking, damming, or diversion of water meets the environmental outcomes for the groundwater, any connected water body, and receiving environments.

(4) When setting environmental flows and levels, every regional council must:

  (a) have regard to the foreseeable impacts of climate change; and

  (b) take into account results or information from freshwater accounting systems.

Figure 1: Clause 3.16 of the NPS-FM setting out the requirements for councils to set environmental flows and levels.

Water quantity is also of one of the five key biophysical components of the ecosystem health value in Appendix 1A of the NPS-FM. Unlike the other four components of the ecosystem health value, the NPS-FM does not prescribe attributes for environmental flows nor is it compulsory to develop any. It prescribes the overall design framework, including details of how the regime must be expressed in plans, but leaves flexibility for councils to use their own methods in determining what their regime is, and how the flows and levels will be set. Flows and levels also have a direct influence on outcomes for a wide range of other attributes. Hence, the setting of flows and levels requires a holistic consideration of the flows required to achieve target states for ecosystem health and a wide range of other compulsory and non-compulsory values and attributes. Figure

2 illustrates how the management of flows and levels through the NPS-FM and regional planning frameworks is intended to support the achievement of water quality outcomes. A similar framework can be applied in relation to other attributes impacted by flows and levels.

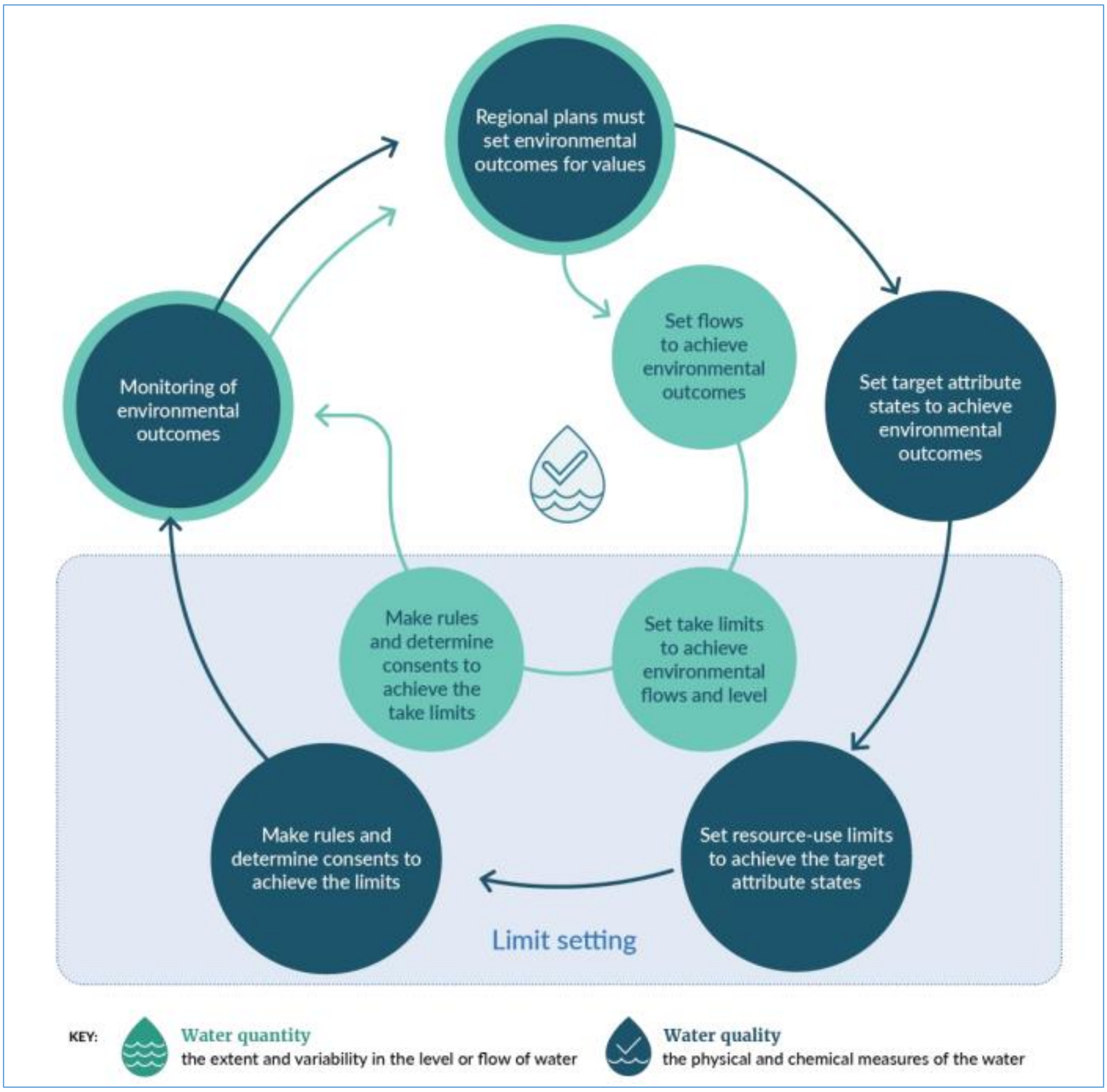

Figure 2: Process of setting and achieving limits on water takes and resource use as envisaged by MfE (Guidance on the National Objectives Framework for the NPS-FM, 2022).

Once the requirements for flows and levels have been developed, corresponding limits on water use, including take limits and minimum flows must be set as rules in regional plans and as conditions on resource consents to ensure the flows and levels are not breached by the taking, damming or diversion of water.

In summary, regional plans must:

- Set environmental flows and levels for all freshwater bodies (rivers/streams, lakes and groundwater) to achieve outcomes, and long-term visions and desired outcomes for each freshwater management unit (FMU). The environmental flow being a specified flow limit (in m^3/s) that must be maintained at all times;

- identify the maximum amount of water to be taken, dammed or diverted from the river expressed in m^3/s;
- identify water take rules and limits required to meet the environmental flows and levels set; and
- identify when controls on activities (when and where to take water) will be restricted or stopped in order to meet the flows and levels.

Measuring and assessing flows and levels

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 Council monitor's river flows and levels at 41 locations across the region, with an additional three sites monitored and maintained by NIWA. Data from our river flow monitoring network helps us understand how river flows change in response to natural stream processes, as well as changes in climate and water use. The size and variability of flow within a river influences in-stream values such as ecosystem health and habitat for key species, mahinga kai and water quality. It also dictates a river's suitability for recreational activities and the amount of water available to take and use.

For water management purposes we describe river flows using statistics known as the mean flow and the mean annual low flow (MALF). The mean flow is the average flow of the river from all recorded measurements, while the MALF is the average of the lowest flows recorded over a continuous 7-day period across all the recorded years. MALF is generally the minimum flow needed to maintain a catchment's natural character and ecosystem health however, as this measurement is an 'average', flows do naturally fall below MALF during prolonged periods of dry weather or drought.

Estimations of MALF are made using long term flow records but, if no records are available, it can also be estimated using records from hydrologically similar streams. When developing estimates of MALF, flow records are first 'naturalised'. Primarily this involves removing the influence of water takes from the flow so that they are more representative of the natural state of a waterbody (i.e. the state of that waterbody in the absence of any discharges or abstractions). By naturalising flows it is possible to undertake analysis to detect trends in flows over time and to produce more robust flow statistics. It is then also possible to determine whether any changes in river flows observed over time are due to natural variability (e.g. climate) or changes in the patterns and frequency of water takes.

Water use and allocation in the Taranaki region

Current regional policy setting

The Regional Freshwater Plan for Taranaki (RFWP) sets the current policies and limits on how much water can be taken from rivers, streams and lakes, and the rate at which it can be abstracted. The RFWP has been in place since 2001.

The RFWP permits the use of small amounts of freshwater for domestic purposes or stock or dairy farm use in Taranaki. In most catchments, a resource consent is not required if water is taken at a rate of less than 1.5L/s, is less than 25% of the total stream flow, and where the volume does not exceed 50 cubic metres a day. Where a proposed water take does not comply with the conditions for a permitted take, a resource consent is required. Current policies provide guidance on the amount of water that may be used in a given situation. In real terms, these policies set a minimum requirement of 66% of MALF to be retained as a minimum flow at the location of a proposed take. The minimum flow, is the point at which a consent must reduce or cease taking water to ensure that the ecosystem health is protected.

The basis of the minimum flow limits derived for the current RFWP was the protection of ecological health. This was assessed through a study of minimum flow requirements for the Taranaki region (Jowett, 1993). Jowett prepared a report for the Council outlining methods that could be used to determine minimum flow limits. The Council decided to use the habitat retention method which would set minimum flow limits to provide protection for in-stream food producing habitat and flow-sensitive instream species (brown trout). Through the subsequent policy development process, it was determined that one-third loss (i.e., retention of two-thirds) of food producing or brown trout habitat at MALF was acceptable. Jowett's work concluded that two-thirds of the trout and food producing habitat available at MALF is essentially two-thirds of MALF. Hence, a regional minimum flow limit was set at 66% of MALF.

The RFWP does not set limits on the total amount of water that can be allocated from a stream as a proportion of its MALF, other than for a small number of streams where specific protections are provided for however, a guideline allocation limit of 33% of MALF has generally been applied.

Appendix I provides an overview of other Council's limit setting rules.

Water use and allocation

There are 117 current consents to take, use or divert water in Taranaki, across 49 of the region's 217 parent catchments (Figure 3). Five of these catchments – the Waiwhakaiho, Waitara, Tangahoe, Pātea and Waitotara – account for 51% of all consented water allocation. Total allocation, including hydroelectric schemes is in excess of 11.6 million cubic metres per day. A breakdown of the number of consents and the total daily volume (including/excluding hydroelectric generation) that is allocated in each FMU is shown in Table 1. As can be seen the Volcanics FMU is the most heavily consented in terms of consents and allocated volume

Table 1: Number of consents and total daily volumes (m^3/day) for each FMU.

FMU	Number of consents	Consented daily volume allocated (m^3/day)	Consented allocation (excluding hydroelectric) (m^3/day)
Southern Hill Country	13	87,075	87,075
Coastal Terraces	12	54,032.4	54,032.4
Pātea	9	8,686,068.4	46,068.4
Volcanic Ring Plain	65	2,307,501	242,541.2
Waitara	12	499,705	50,425.3
Northern Hill Country	6	1,133.6	1,133.6

Approximately 96% of this is allocated for hydroelectric generation and is considered non-consumptive, as the water returns at or near the point of abstraction. When hydroelectric generation is excluded, the two most significant water uses by volume in Taranaki are pasture irrigation and public water supply, which account for 35% and 27% of the region's total consumptive allocation, respectively (Figure 4).

In addition to consented water use, a desktop assessment carried out by the Council estimated that up to 54,300 cubic metres per day is potentially used for permitted activities such as stock drinking water (TRC, 1998).

Overall, the amount of water allocated for consumptive purposes has not changed significantly in the past decade, increasing just 3% from 2013 (Figure 5). This increasing demand has mainly been for water from smaller catchments and predominantly for pasture irrigation.

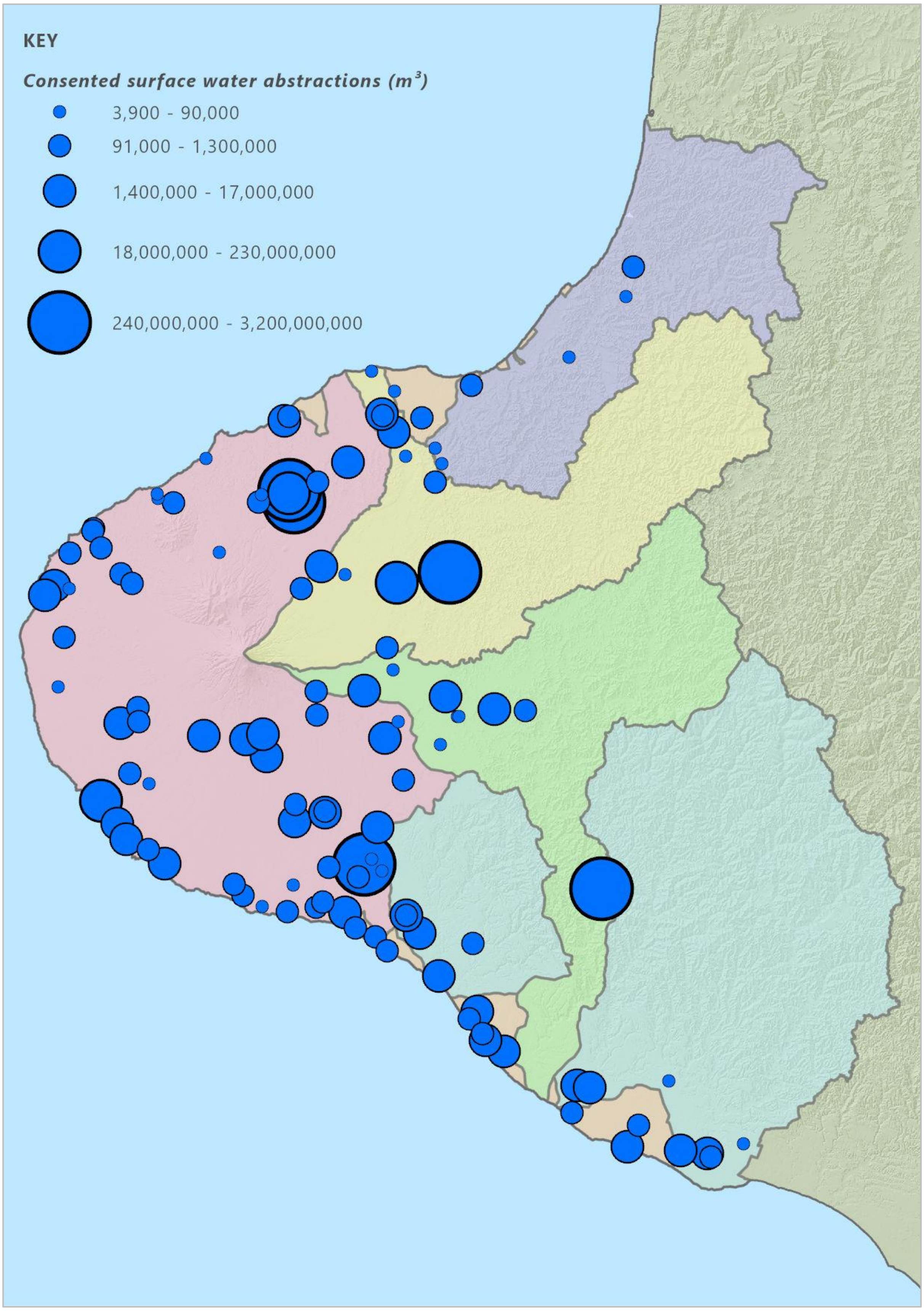

Figure 3: Locations of consented surface water abstractions (including hydroelectric generation) in each proposed FMU as of July 2023.

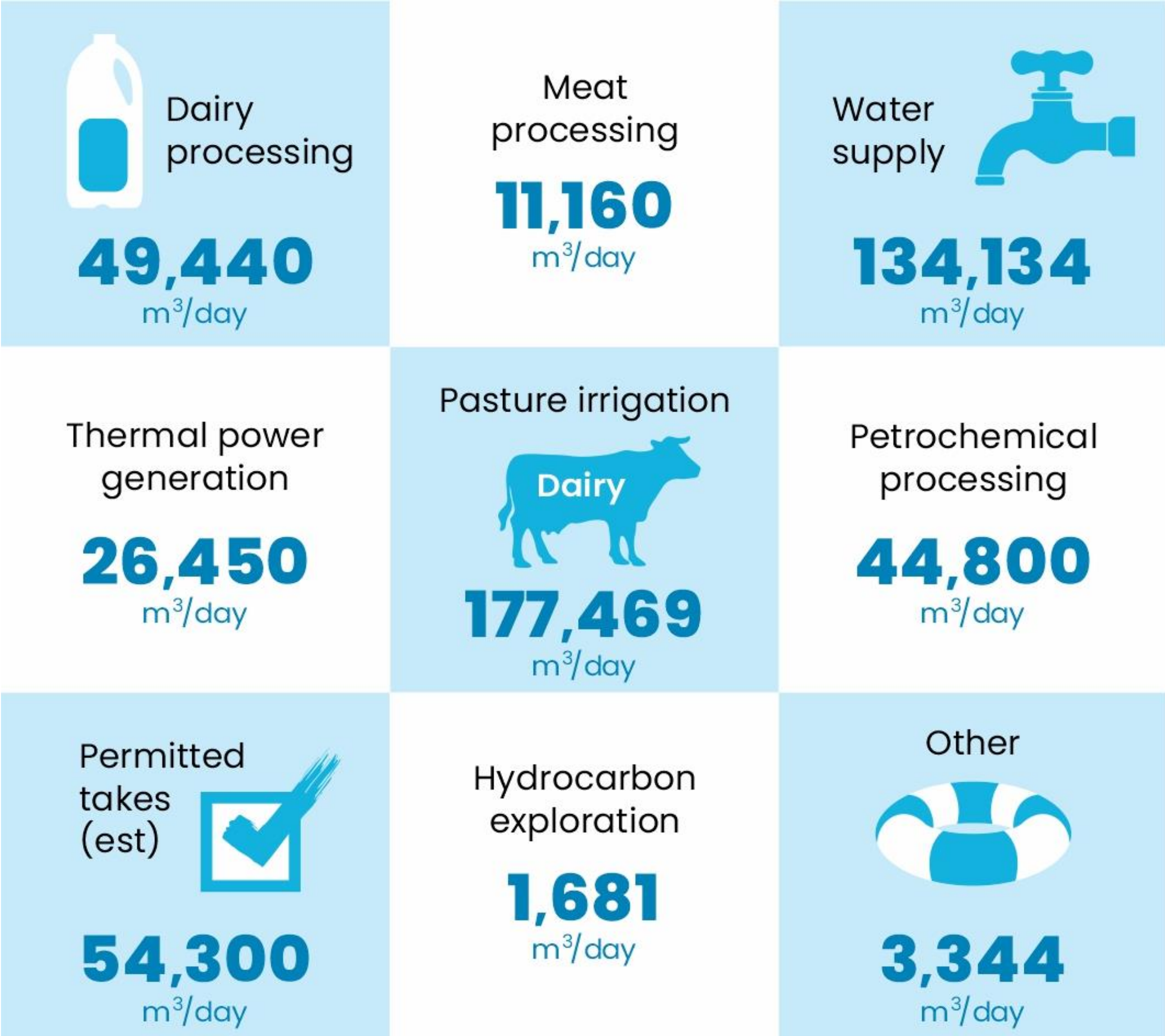

Figure 4: The amount of water allocated by consumptive use types in Taranaki as of 2020.

YEAR	1999	2003	2008	2013	2020
VOLUME ('000s)	321	442	474	489	502

Figure 5: The total amount of water allocated for consumptive uses in Taranaki by year.

Mean annual low flow (MALF)

Currently there are 35 tributaries within 33 catchments that have more than 33% of MALF allocated at a consented take location. Streams with higher levels of allocation generally spend more time at MALF, or any alternative minimum flow limit set. More time at low flows can impact on the ecology of rivers, and also restrict the ability of consent holders to exercise their takes at certain times of the year.

There are eight streams/rivers where MALF has not been calculated through site specific investigations, so the percent of the MALF allocated has been estimated using the NZ River Maps tool developed by NIWA. NZ River Maps has calculated the estimates of environmental conditions across the entire New Zealand river network, including flow statistics. The majority of resource consents to take, use or divert water have set limits on the volume or rate that water can be taken, or both. There are some exceptions to this, which generally relate to older consents, large industrial takes, or public water supplies. Some activities, like providing water for stock drinking purposes or for firefighting, have legal protection under the Resource Management Act (1991). Limits are designed to provide protection for the waterbody for which the water is taken. Similarly, not all consents have a minimum flow limit stipulated in their conditions, as at the time of the consent application it was not considered a requirement. Again, these are typically older consents, or consents for large industrial takes or public water supplies. Of the total 117 consents granted, 44 consents (38%) currently have no minimum flow limit set.

Appendix II summarises the current surface water allocation status and associated limits across Taranaki.

Minimum flows

The purpose of minimum flows is to ensure sufficient in-stream habitat is provided to sustain populations during periods of low flow, as well as support water quality requirements of in-stream life. Providing for flow variability at a variety of scales is required for maintenance of channel form, sediment and periphyton flushing, benthic invertebrate productivity, fish and bird feeding opportunities, and fishing opportunities. Flow variability can be managed by limiting allocation or by having consent conditions to maintain or release some floods and freshes for flushing, and ensure some degree of natural flow recessions, especially to avoid long periods of flat-lining of the minimum flow.

The hydrological effect of a run-of-river flow allocation is illustrated in Figure 6. By removing the allocated flow (yellow band) the blue sections of the hydrograph (above the allocation limit) drop down onto the blue section below the minimum flow. The result is that sections of the hydrograph show an extended period at or below minimum flow, known as 'flat-lining'. Increasing the allocation rate increases the frequency and duration of flat-lining at the minimum flow with potential adverse consequences on invertebrate production, including the food supply for fish and birds. (Cawthron, 2017).

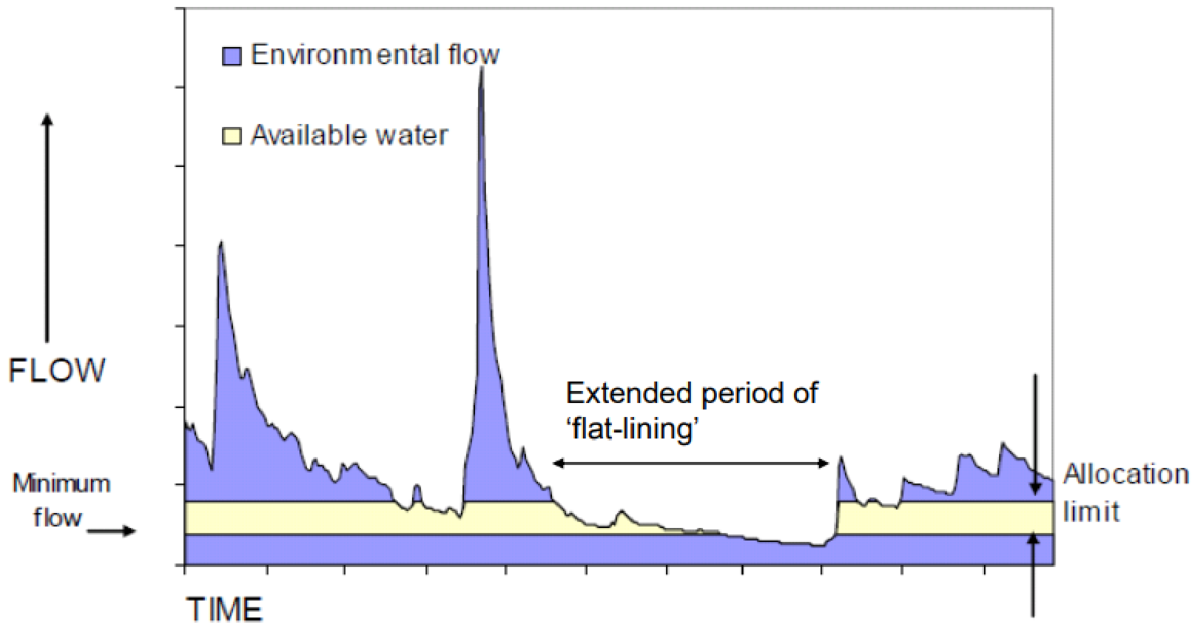

Figure 6: Illustration showing a minimum flow and the proportion taken by the allocation limit (Cawthron, 2017).

To give effect to the NPS-FM, limits on how much water can be taken and when will be required on all consents. Any new water take consents issued by the Council will be required to include limits, regardless of the activity. Plans will also need to be developed regarding how and when limits will be applied to any existing consents that don't currently have them. We'll also consider how we manage catchments where the amount of water currently allocated for use exceeds these revised limits and how we make sure water is being used in the most efficient manner possible. Figure 7 shows the tension when allocating water between:

- total amount that can be taken (allocation)
- how reliable it is for users (flow and level restrictions)
- how much we retain for waterbodies and freshwater ecosystems (minimum flow and level).

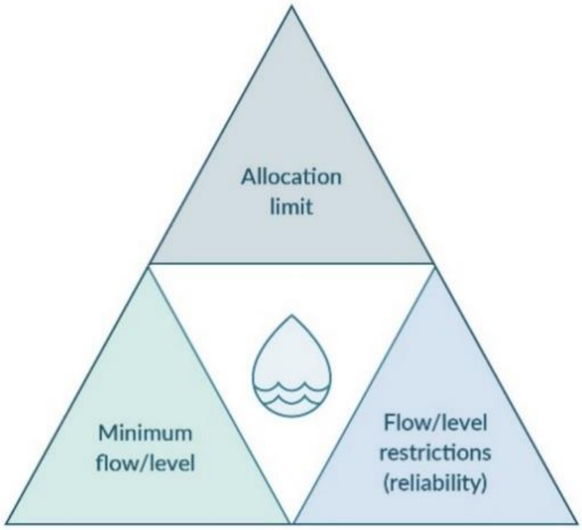

Figure 7: 'Iron triangle' of water allocation. Source:MfE 2023.

The Council must determine how Te Mana o te Wai will apply to waterbodies and freshwater ecosystems in Taranaki. Under the NPS-FM hierarchy of obligations, priority goes first to the health and well-being of water bodies, and then to people's health needs. Within the 'other well-being' matters, the community may choose its priorities, consistent with Te Mana o te Wai.

Through discussions with iwi/hapū, water users, stakeholders and the wider community, we will be working to design a new management approach that gives effect to Te Mana o te Wai and the hierarch of obligations, along with other requirements relating to the taking and use of freshwater.

Data collection, monitoring and reporting

Prior to August 2010, abstraction records were typically supplied manually to the Council as daily or monthly volumes. Water take consents had specific conditions on their abstraction rates and volumes, but many were not required to report on their activities.

The introduction of new Resource Management (Measurement and Reporting of Waters Takes) Amendment Regulations 2020, requires consent holders to record and report on their daily water usage and to ensure that their meter is installed and recording correctly. These regulations allow Council to enforce the correct installation of meters and to ensure that the meters are verified within +/- 5%. It allows for the gathering of 15-minute abstraction data, for those consents that take above 5 L/s, which is then fed into the Councils water quantity accounting system as required by NPS-FM.

Since the initial introduction of these regulations in 2010, the provision of abstraction records has improved greatly, allowing Council to assess the current allocation status based on actual usage and enabling better decision making when consents are renewed. Real time measurement of water use has helped to ensure that consents are granted for the appropriate amount of water for the activity and that water is not being 'locked up' and unavailable for potential other uses/users. It has also assisted in improving the quality of the naturalised flow records, as the flow is adjusted for the actual abstraction rate, not a derived constant rate based on daily volumes.

Water takes that are less than 1.5 L/s, are less than 25% of the total stream flow and do not exceed 50 m^3/day are generally permitted under the current Regional Freshwater Plan. The purpose of this rule is to allow small amounts of freshwater to be used for domestic purposes, stock or dairy farm use. When assessing these permitted take limits against other regional council's permitted rules (Appendix I), TRC's current limits are generous, and allow more water to be taken without consent than in other regions. Discussions with iwi/hapū, water users, stakeholders, and the wider community will be undertaken as part of the freshwater policy process to establish acceptable permitted take limits.

Maintaining accurate abstraction records and identifying permitted takes are critical to ensuring the council has a good understanding of permitted, consented and actual water use. This information also assists in establishing reliable naturalised flow records, and the subsequent statistics from those flow records. To further improve our knowledge of water takes it is recommended that any water takes that require a consent (i.e. water takes that are above the permitted take limit) will need to be metered and telemetered to Council, even if they are less than 5 L/s.

The Council has developed compliance programmes for all water take consents. These generally include regular inspections along with the collection of data to ensure compliance with consent conditions. Additional flow monitoring sites are installed, when required, to assess low flow consent conditions; such as those requiring consent holders to reduce or cease taking water. If a consent holder is found to be in breach of their consent conditions, enforcement action will likely occur and will generally require the consent holder to cease their activities until they can comply completely with all consent conditions. If they fail to do so, further enforcement action would follow. Fortunately, the need to pursue enforcement action relating to breaches of water take consents is rare. Over the 2020-2021 year, 97% of water users achieved either a 'high' or 'good' rating for consent compliance and environmental performance through their compliance monitoring programmes.

Modelling to support limit setting and decision making

To determine appropriateness of the current RFWP limits, the Council commissioned Dr Ian Jowett (Jowett Consulting Ltd.) to produce a technical report that investigated the following:

- The existing research on environmental flow requirements;
- The principles for setting minimum flow and allocation limits;
- Hydrological, water-quality and streambed invertebrate data relating to Taranaki rivers; and
- Recommendations or options for future environmental flow limits for Taranaki.

The report *Review of Minimum Flows and Water Allocation in Taranaki (2019)* used long-term monitoring data from nine Taranaki rivers to model the impacts of various combinations of minimum flow and allocation limits. The impacts were assessed both on the level of protection each combination of limits would offer for instream benthic invertebrates and fish populations, and the reliability of supply for water users under each scenario.

Jowett's analysis used a benthic invertebrate production model to assess the impact of a range of minimum flow and allocation limits on invertebrate communities. Benthic invertebrates are used in New Zealand (and internationally) as a primary measure of ecosystem health. They are also an important food source for native fish and trout. In New Zealand, the macroinvertebrate community index (MCI) has been included as an attribute under the NPS-FM and was also identified as a measure that is closely related to māori cultural values (Tipa and Tierney, 2003). The benthic production model applied in Jowett's analysis was used to predict an index of benthic invertebrate density for selected sensitive species with and without abstraction. The model is first run without any abstraction to give predictions of invertebrate density under 'natural' low flow conditions (MALF). The model is then re-run to simulate abstraction occurring at various combinations of minimum flow and allocation limits and the effect these have on reducing invertebrate densities. The reduction in invertebrate density under each scenario from the densities provided under 'natural' low flow conditions is used to calculate the level of protection provided to benthic invertebrates; i.e. a 20% reduction in invertebrate density from 'natural' low flow conditions is equivalent to an 80% level of protection.

In addition to benthic invertebrates, Jowett's analysis also included an assessment of the impacts of abstractions on trout and sensitive native fish species. Native fish and trout can be affected by low flows through a reduction in the amount of suitable habitat if the flows are low for a sufficiently long period. At low flows, the amount of habitat suitable for fish with high flow requirements, such as torrentfish, kōaro and adult trout is reduced. To maintain populations of these fish species with high flow requirements, extended periods at or below low flow (i.e. for more than 30 days) should be avoided.

Because trout, kōaro and torrentfish have the highest flow requirements of any freshwater fish species present in Taranaki, flows that maintain adequate habitat for them will be more than adequate for other species, such as tuna (eels) and inanga. Jowett's assessment of the impact of takes on these species was based upon the reduction in suitable habitat from that available under natural low flow conditions. Aligned with the assessment of impacts on benthic invertebrates, the impacts of various combination of limits on reducing fish habitat were also expressed as levels of protection provided for.

At the time it was drafted, Jowett's report was possibly the first New Zealand study to examine the combined ecological effects of minimum flows and allocation limits both on benthic invertebrates and fish populations (Jowett, 2019). For context, Jowett also assessed the impacts of a range of potential combinations of minimum flow and allocation limits on water users, based on the number of days restrictions to takes would occur under various scenarios.

The report and its findings were presented to a range of stakeholders, iwi and the regional Wai Māori Working Group through a series of workshops. Members of the Wai Māori Working Group raised concerns about the vulnerability of smaller streams to the impacts of water takes, and how well the modelling carried was able to quantify these impacts given the data was primarily collected from what they considered were large rivers.

Previous work reported nationally had already identified that the risk of adverse effects due to water takes depended on the size of the stream and the species present in it. This was recognised in the default recommendations in the proposed National Environmental Standard (NES) for ecological flows where a higher minimum flow was set for small streams than larger rivers (mean flow > 5 m^3/s). In response to the feedback however, it was agreed that more data collected locally in Taranaki to further investigate how impacts may differ based on stream size would be beneficial.

The Council commissioned Dr Jowett to undertake additional work and investigations to assess whether differing environmental flows and protection levels should be set for 'very small streams' or 'large' rivers (those much smaller or bigger than the Taranaki 'norm'). The work extended on the range of river sizes previously described by Jowett (1993, 2019) by including two very small streams and two of the largest rivers in Taranaki (Table 2). Comprehensive habitat surveys were carried out across the range of river and stream sizes and types at 17 sites in Taranaki over the course of the two studies.

Table 2: River size classes and details of the rivers surveyed in each class as part of Jowett's investigations

River size class	Mean (average) flow rate (m^3/s)	Rivers surveyed
Large	>30	Waitara*
Moderate	>5 to <30	Tangahoe, Waingongoro (2 x sites), Waiwhakaiho, Whenuakura*, Hangatahua (Stony)
Small	<5	Kapoaiaia, Kaupokonui, Manganui, Mangaoraka, Pātea (above confluence with the Mangaehu River), Waiongana, Kapuni
Very small	<1	Tawhiti, Mangatawa*, Waiokura*

* additional site surveyed in 2019

A second report by Dr Jowett *Considerations of Stream Size in Determining Minimum Flows and Water Allocation Limits in Taranaki Rivers* was completed in May 2020. The results of the habitat surveys were used to model and assess the effects of flow changes on the amount of suitable habitat for key indicator species in each surveyed river/stream. These models enabled the effects of various environmental flow limits to be tested and the amount of protection provided for benthic invertebrates and fish under each scenario to be estimated.

The results of the analysis showed that, in terms of their habitat, 'very small' streams are not significantly different from those classed as 'small'. It concluded that there was no technical basis to have different environmental flow limits for 'small' and 'very small' streams. Both types are the most vulnerable to effects from reduced flows, and the report confirmed the amount of water allocated for use would need to be lower than in larger rivers in order to achieve the same levels of ecological protection. It is estimated that up to 95% of Taranaki rivers would be classified as 'small'.

Similarly, the analysis also confirmed that large rivers can sustain higher levels of allocation and lower minimum flows, while maintaining levels of protection comparable to smaller streams.

The basis of the modelling and the associated allocation and minimum flow scenarios tested are based on achieving certain levels of protection for instream species (fish and macroinvertebrates). What an appropriate level protection is, will need to be determined by the Council working with tangata whenua, stakeholders and the wider Taranaki community.

Table 3 shows an example set of potential water allocation and minimum flow limits that would provide 90% protection levels. It is often considered that an effect of 10% is minimal or 'less than minor'. Any impacts on species at this level would be difficult to detect through monitoring. 100% protection can only be achieved if there is no abstraction of water from a stream/river. The current RFWP limits are also shown for comparison. The current limits are estimated to provide a protection level of approximately 77%.

A trade-off for increased protection levels is the reduction in the amount of water available for resource users and the reduced reliability of water supply when it is needed. Restrictions can either be total (no taking allowed) or partial (some reduction in take rates) to ensure compliance with minimum flows. Shown in Table 3 is the number of days per year it is estimated that some form of partial restriction would apply to water users when limits are set that provide for a 90% level of protection across the various stream size classes.

When compared to current limits, it shows the impact of more stringent limits required to achieve higher levels of protection will have on water users.

Table 3: Minimum flow and allocation limits required to achieve 90% protection levels across the range of stream size classes modelled and the corresponding days of partial restrictions expected for water users, with the exception of the current RFWP which provide a protection limit of 77-87%.

Stream size	Minimum flow as % MALF	Allocation volume as % MALF	Days per year of partial restrictions
Small	100	20	42 +/- 11
	90	10	18 +/- 7
Moderate	100	40	64 +/- 16
	90	30	42 +/- 11
	70	20	9 +/- 5
Large	100	50	74 +/- 19
	90	40	53 +/- 13
	70	30	30 +/- 9
Current RFWP*	66	33**	18

* provides 87% protection for benthic and 77% protection for fish

** guideline value only - no allocation limit specified in the existing RFWP

Examples of the differing minimum flows and allocation limits for each size stream are shown in Figures 8 to 10, showing the effect on taking at the maximum consented rate, but reducing and subsequent ceasing of the take when flows reach the minimum flow limit. Also provided on these graphs is the effect based on the current RFWP.

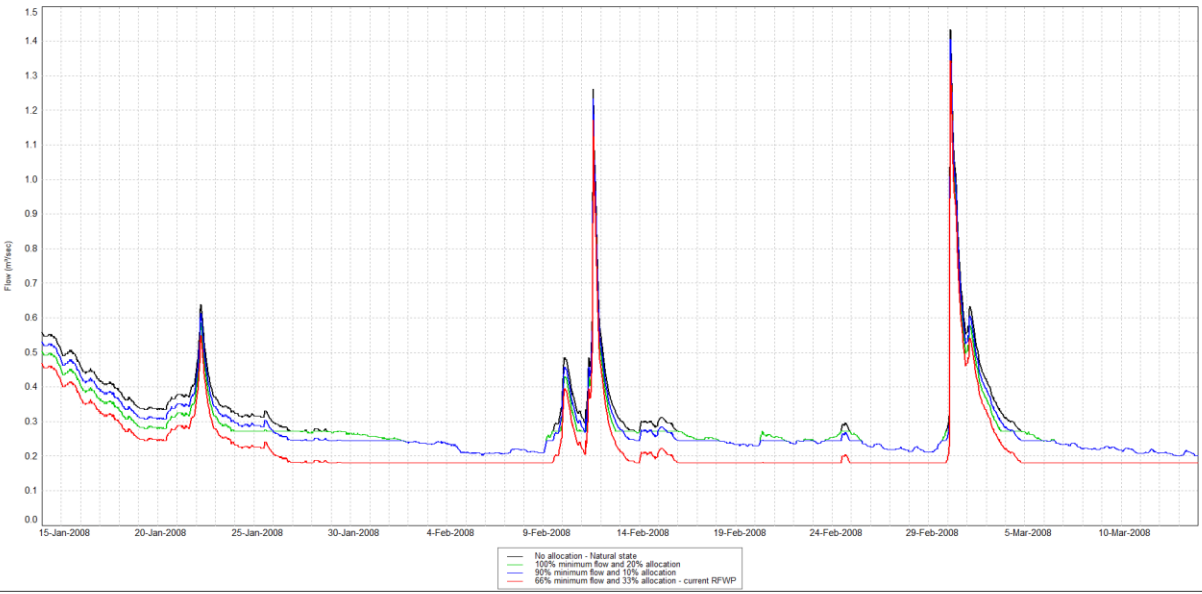

Figure 8: Example of a 'small stream' with no abstraction (natural state)(black), 100% minimum flow, with 20% allocation(green), 90% minimum flow, with 10% allocation(blue) and current RFWP rules of 66% minimum flow and 33% allocation(red).

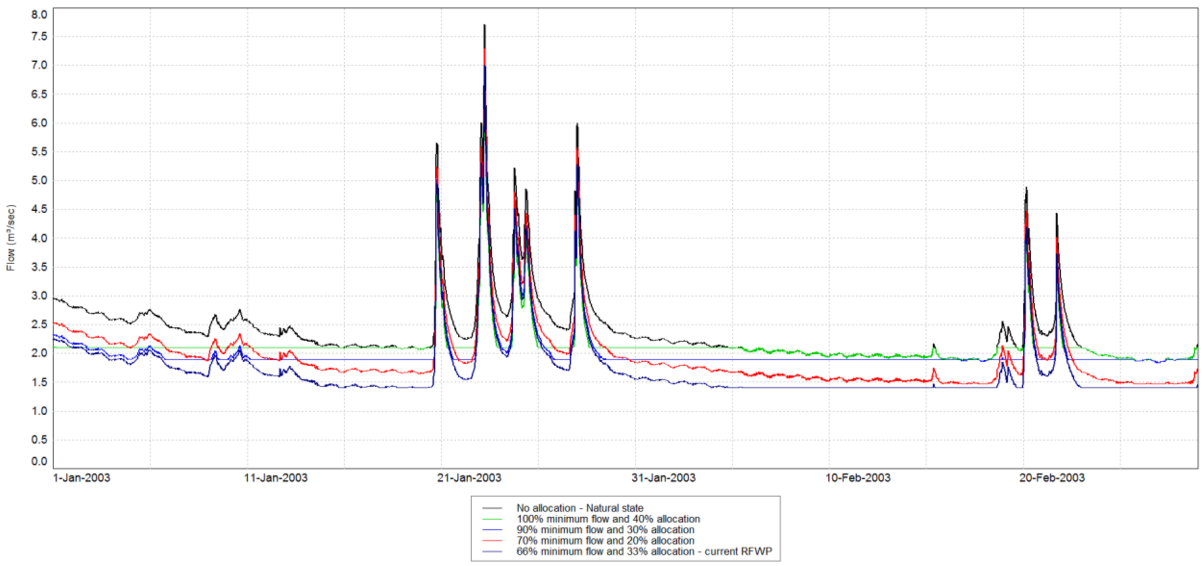

Figure 9: Example of a 'medium stream' with no abstraction (natural state)(black), 100% minimum flow, with 40% allocation(green), 90% minimum flow, with 30% allocation(blue), 70% minimum flow, with 20% allocation(red) and current RFWP rules of 66% minimum flow and 33% allocation(dark blue).

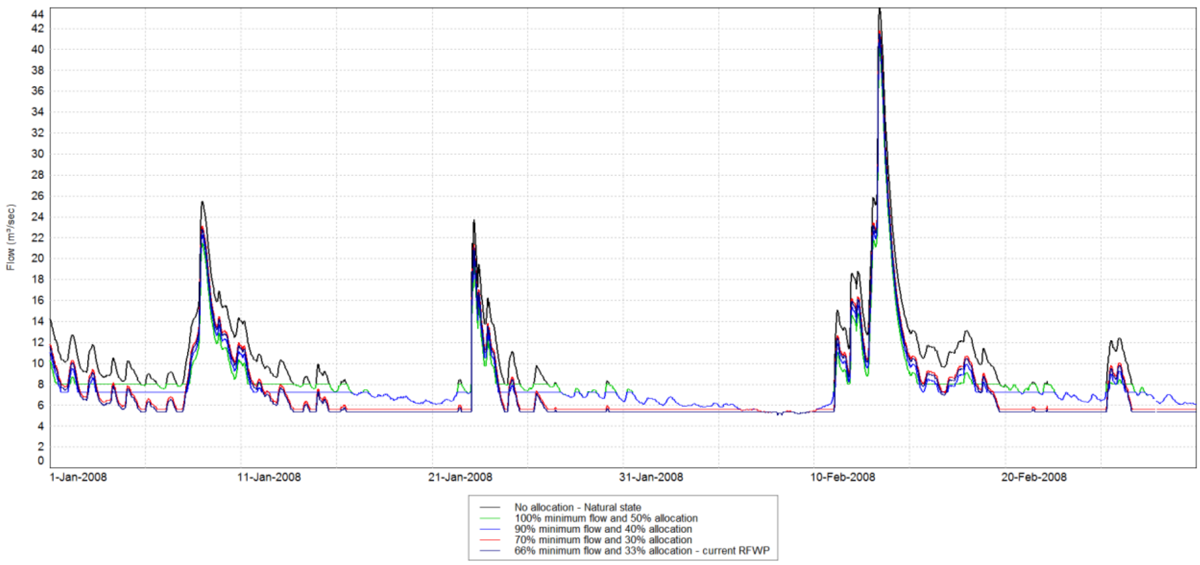

Figure 10: Example of a 'large stream' with no abstraction (natural state)(black), 100% minimum flow, with 50% allocation(green), 90% minimum flow, with 40% allocation(blue), 70% minimum flow, with 30% allocation(red) and current RFWP rules of 66% minimum flow and 33% allocation(dark blue).

Key points:

- by setting a higher minimum flow, more water is available for allocation but if full allocation is utilised streams will reach their base state (minimum flow) more quickly; this approach also results in a greater number of days with partial restrictions.
- setting lower minimum flows but permitting less allocation allows for flows to maintain more of their natural character, but the flows have the potential to flatline for longer; this approach results in fewer days of partial restrictions.
- all the examples show that any of the scenarios listed will provide greater levels of flow variability and protection, but generally more days of partial restrictions than currently provided for under the current RFWP.

The modelled impacts on the benthic invertebrate community are considered conservative, and can be considered worst-case. This is because it is assumed that the maximum allowable allocation was abstracted all through the year and this would rarely be the case. In reality, impacts are likely to occur during summer, and will generally be short-lived, with habitat and fish numbers recuperating during wetter seasons with less water demand. Riparian management can also positively affect benthic invertebrates and fish communities by increasing shade to reduce water temperatures and creating cover and habitat diversity for fish, and conversely can contribute to adverse effects where riparian vegetation is limited or absent.

There are a number of options available to the council in terms of setting limits and targets for the allocation and use of freshwater in Taranaki. The in-stream habitat assessment process discussed above will guide Council in setting appropriate limits.

Overview of groundwater quantity

Groundwater and shallow surface water systems are hydraulically connected however, the degree of connectively varies depending on the local hydrology and geology. In Taranaki, the connection between groundwater and surface waters is poorly understood.

Groundwater abstraction primarily occurs across a small number of the region's aquifers or water-bearing hydrogeological units, where overlying land use or development has necessitated a particular water supply need that cannot be adequately met by surface water abstraction.

The typically low yields associated with the region's shallow unconfined aquifers mean that abstraction from wells penetrating them is generally only suitable for low demand uses, such as stock water, general farm or domestic supply purposes. Given the low yields and typically low demand uses of groundwater, the majority of abstractions from the region's shallow unconfined aquifers meet the conditions of Rule 15 of the RFWP, in terms of abstraction rate and volume limits, and can therefore be undertaken as a permitted activity provided all other conditions of the rule are met.

The region's deeper confined aquifers located within Tertiary formations are generally higher yielding than those encountered in overlying Quaternary units, and are generally targeted for higher demand water use. These include industrial and agricultural use, as well as public water supply.

Groundwater use and allocation in the Taranaki region

For the purposes of groundwater accounting, the region has been subdivided into 12 groundwater aquifers that align with geological unit boundaries (Figure 11).

An estimate of sustainable yield has been calculated for each of the aquifers (Appendix III). These have been calculated by estimating the amount of rainfall likely to recharge each aquifer on an annual basis. The calculations are therefore based on conservative estimates of 'new' water entering each aquifer each year, not on water that is already in storage.

The total volume of rainfall potentially recharging each aquifer (rainfall recharge) was calculated by multiplying 30% of the average annual rainfall by the spatial area of each aquifer receiving direct recharge from rainfall (i.e. unconfined areas of an aquifer exposed at surface). Sustainable yields have been conservatively set at 35% of rainfall recharge for all aquifers. This equates to allocable volumes that are approximately 5-10% of the total annual rainfall, so is very conservative (Appendix III). In other words, it is assumed that the remaining 90-95% of rainfall either evaporates, is discharged as surface run-off or replenishes groundwater storage. Calculations are based on those proposed by Ministry for the Environment (MfE), 2008.

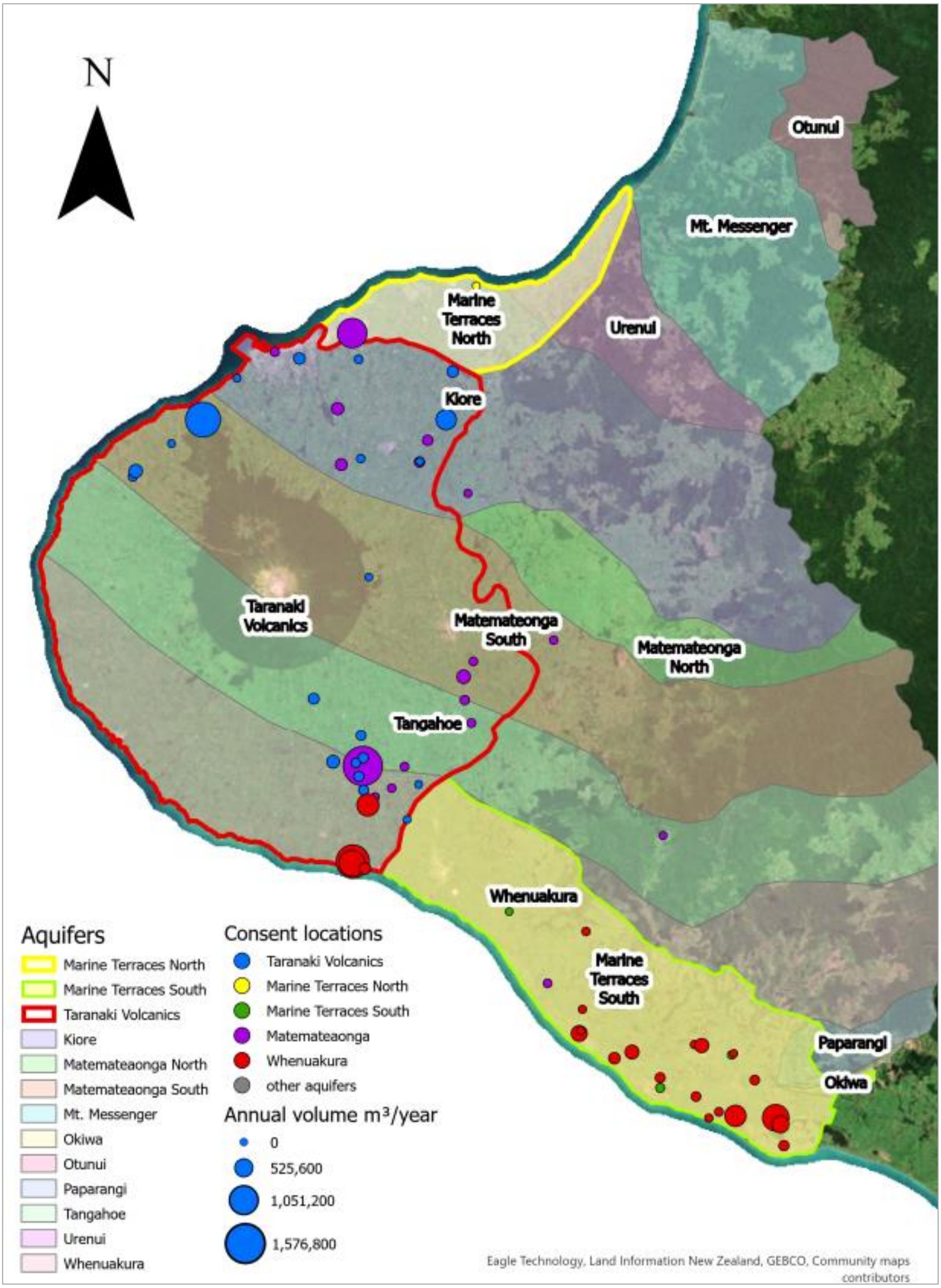

Figure 11: Groundwater aquifers across Taranaki and consented groundwater take locations by volume as of 30 June 2020.

The permitted groundwater take estimates were aggregated and apportioned by aquifer. This included an estimate of the volume of permitted groundwater takes sourced from both unconfined aquifers and areas of Tertiary aquifers confined by overlying Quaternary hydrogeological units.

A total of 73 consents authorise the taking of groundwater, 68 for water supply and five for dewatering purposes. The locations of all consented groundwater abstractions are shown above in Figure 11. The special conditions attached to each of these consents vary, as a result of standard consent conditions evolving over time. All current consents to abstract groundwater have either a take rate or volume restriction or, in some cases, a combination of both.

Where volume limits are specified in the conditions of a consent, this figure was used to calculate the volume of water that could potentially be taken under the consent on an annual basis. These calculated usage figures likely represent an overestimation of actual water use, as these figures assume the exercising of the consent for the full limit, 24 hours a day, 7 days a week.

Appendix III summarises the current levels of groundwater allocation against estimated sustainable yields for each aquifer.

Baseline state in the Taranaki region

The demand for groundwater has increased slightly over the last decade, but remains low with the total groundwater allocation equating to less than 2% of the regions estimated sustainable yield.

The highest level of allocation is currently seen in the Whenuakura aquifer, where a combined total of 10.6% of estimated sustainable yield is allocated across the aquifer. The Matemateaonga aquifer has approximately 2.7% allocated. All other aquifers have insignificant volumes of water allocated (<1% of estimated sustainable yield).

The relatively low demand placed on groundwater resources across Taranaki is likely due to several factors. Firstly, most areas of Taranaki receive regular and plentiful rainfall, with a steep rainfall gradient inward from coastal areas. The high rainfall experienced in Taranaki also means that, outside of coastal areas, soil moisture deficits are generally low and when there is a deficit, it is generally short lived. As a result Taranaki has not seen the rapid increase in water demand for pasture irrigation, as has been seen elsewhere in New Zealand. The rainfall characteristics and topography within Taranaki also means there is an abundance of surface water systems, which means rivers and streams are generally accessible when water supply is needed. Where available, surface water supplies are typically preferred to groundwater sources, given they can be obtained at a much lower capital cost. The low yields from Taranaki aquifers often mean that multiple bores are required to supply high demand uses, making the use of groundwater uneconomic. Surface water systems are generally able to sustain the majority of current water demand in Taranaki.

Notwithstanding the above, there is potential for growth in groundwater demand in the future. Any significant growth would likely be driven by a shift in current land use, development of new land uses or industrial activities that require greater higher water inputs than those activities that predominate currently. If more surface water systems across the region reach their allocation limit in coming years, or significantly tighter limits are applied to the taking of surface water, any future increases in regional water demand may necessitate the need for more groundwater sourced water supply. However, this is a matter that would require the development of further science and investigation, and would require a programme of work that would extend beyond the current freshwater policy programme timeframe.

Further Considerations

Climate Change

Under the NPS-FM, the Council must also consider the effects of climate change on freshwater, and ensure this is factored into our new policy and planning framework, including limit setting.

The Council commissioned NIWA to undertake a review of climate change projections and impacts for the Taranaki region. Key findings of this report were:

- Mean annual discharge across the region remains relatively stable to 2050, with a slight increase in mean annual discharge in some coastal areas (particularly north and west).
- By 2090, expected increase of 10-20% for some coastal areas, while the remainder of the region remains relatively stable.
- By 2050, MALF decreases for up to 95% of the river reaches across the region.
- BY 2090, decreases of up to 50% projected for the majority of the region, with the exceptions of southern parts of Taranaki, that have projections of small increases by 5-10%.
- It is currently projected that Taranaki will see little change in its annual rainfall volumes in the short to medium-term, and potentially a slight increase in rainfall by 2090, particularly over winter months, when the majority of groundwater recharge occurs.

Climate change has the potential to influence future rainfall patterns in Taranaki and, as a result, the volume of water recharging surface water and groundwater systems. This could impact both the regional water demand and the volume of water available for allocation.

For the purposes of surface water allocation, a conservative approach will be required to ensure that any future allocation does not exacerbate the extent of low flows in the waterways. This could be in the form of creating a policy framework to reduce the abstraction over-time and promoting of water harvesting. Also by having policies that will allow for the review of minimum flows to ensure that the desired in-stream habitat is being maintained.

For groundwater, if current predictions are realised, it's unlikely that the volumes available for allocation across the region will change significantly in the future. Predicted longer-term reductions in summer low flows in Taranaki rivers may result in further development of the regions groundwater resources.

Data limitations and uncertainty

When naturalising the flow record, some assumptions have been made in terms of the permitted takes occurring upstream of the point of interest. The permitted takes estimates have been calculated as a desktop exercise and have not been validated to assess the accuracy of the numbers. This will be addressed in the Council's new policy and planning framework as the NPS-FM requires Councils to record all permitted takes in its region. It should also be noted that minor discharges have not been included in the naturalising of the flow record, as there is a lack of available information to quantify the volumes and it is considered inherent in the hydrological record. For larger discharges, estimations of discharge volumes have been attempted and incorporated into the flow record.

As stated earlier, the confidence in the MALF statistics is dependent on any supporting information being accurate and sufficient to determine appropriate limits and levels. In some cases, further work to assess flow statistics is required before limits can be determined. This is the case for the sites where the MALF is "unknown".

There are ten streams with in-stream storage, and all of these streams appear to have more than 33% of MALF allocated. The method used to determine allocation volumes could be considered unsuitable for these situations. Canterbury Regional Council have an alternative method to assess allocation, which is undertaken by determining the streams mean annual discharge at the abstraction site and calculating the annual water demand by using the daily permitted volume from the consent x 212 (days). The % allocated is then determined by the consented annual demand divided by annual discharge. With this method only three of the ten streams have more than 33% allocated.

This report does not discuss the taking of supplementary flows (water harvesting), which are those flows that are taken during mid to high flows and stored for usage later, as currently there are no consents granted for this purpose in Taranaki. However, this could be explored further as a potential solution to helping address any over-allocation that might arise through changes to the current water allocation framework.

Recommendations

There are a number of steps that need to be taken before the Council can set appropriate limits and targets in relation to water use. This will include exploring options for setting environmental flows and levels to provide for the values and outcomes that the Council, tangata whenua and wider community are seeking for freshwater. Discussions around permitted take limits will be required, to determine what an appropriate limit is. Habitat suitability curves will assist in determining the appropriate level of protection, while the decision support tool provided by Jowett (2019) will assist in determining the flows required to achieve the relevant level of protection. Consideration will also need to be given to providing a sufficient buffer for any potential future changes in climate.

Under the new freshwater regulations, metering and reporting of all consented water takes (and to a lesser degree discharges) will be necessary, to enable the Council to fulfil its requirements to develop a water quantity accounting system. While all/many water takes of 5 L/s or greater already have water meters and telemetry installed, new water takes/some existing water takes still need to be upgraded to meet these requirements.

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APPENDIX I – Other Regional Councils approach to surface water allocation limits, minimum flow setting and permitted take limits

Authority	Allocation Limits	Minimum Flow Setting	Permitted Take Limits
Northland Regional Council *(proposed Regional Plan 2022)*	• Current consented allocation or % of MALF (10-50%) dependent on the Management Unit • Supplementary flows: 50% allocation for flows above median	• 80-100% of 7-day MALF depending on the Management Unit	• 10 m^3/day, or • 30 m^3/day for dairy shed and milk cooling existing at 1 September 2017, and • Rate of take is no more 30% of instantaneous flow
Auckland Council *(Auckland Unitary Operative Plan 2016)*	• Default limit of 30% of MALF, or • Site specific limit listed in plan	• Default minimum flow of 85% of MALF, or • Site specific limit listed in plan	• 20 m^3/day from a lake, or • 5 m^3/day from a river or spring
Waikato Regional Council *(Waikato Regional Plan – Operative 2022)*	• 5-30% of 5 year 7-day low flow • Supplementary flows: 10% allocation for flows above median	• Default limits of 90% of 5 year 7-day low flow for streams greater than 5 m^3/s, or • 95% of 5 year 7-day low flow for streams less than 5 m^3/s • Site specific limits listed in plan	• Default of 15 m^3/day, or • 30 m^3/day for site specific rivers • 150 m^3/day for temporary takes
Bay of Plenty Regional Council *(Regional Natural Resources Plan 2023)*	• 5 year 7-day low flow minus instream minimum flow requirement	• Default limit of 90% of 5 year 7-day low flow, or • For catchments with pressures, an in-depth instream flow assessment to be completed	• 15 m^3/day, and • Not exceed 2.5 L/s, or • no more than 10% of the estimated 5 year 7-day low flow (whichever is lesser)
Gisborne District Council *(Tairawhiti Plan – District Plan)*	• Default limit of 30% MALF, or • total allocation from that catchment at the date of Plan release	• 100% MALF for key specified water bodies • 90% MALF	• Not exceed 5 L/s, and • 10 m^3/day
Hawkes Bay Regional Council (Resource Management Plan 2006)	• 5 year low flow minus the minimum flow, or • Site specific limits listed in the plan	• For established sites, no more than 5% restrictions between November to April, • Site specific limits listed in the plan	• 20 m^3/day, and • Rate shall not exceed 10% of the instantaneous flow at the point of take
Horizons Regional Council *(One Plan 2022)*	• Site specific limits, or • 10% MALF, or • 5% of 7-day MALF • Supplementary flows: 10% allocation for flows above median	• Site specific limits, or • MALF, or • 7-day MALF	• For animal farming, not exceed 400 L/ha/day, and 30 m^3/day, or • 15 m^3/day, and • Not exceed 2 L/s

Authority	Allocation Limits	Minimum Flow Setting	Permitted Take Limits
Greater Wellington Regional Council *(Operative Natural Resources Plan)*	• Site specific limits, or • 50% of MALF for rivers with mean flows greater than 5 m^3/s, or • 30% of MALF for rivers with mean flows less than 5 m^3/s • Supplementary flows: 10-50% allocation for flows above median dependent on river.	• 90% MALF, or • Site specific limits	• 20 m^3/day for properties greater than 20 ha, or • 10 m^3/day for properties less than 20 ha, or • Farm dairy - 70 L/stock unit per property
Marlborough District Council *(proposed Marlborough Environment Plan)*	• Site specific limits, or • 50% of MALF for rivers with mean flows greater than 5 m^3/s, or • 30% of MALF for rivers with mean flows less than 5 m^3/s	• Site specific limits, or • 80% of MALF for rivers with mean flows greater than 5 m^3/s, or • 90% of MALF for rivers with mean flows less than 5 m^3/s	• Does not exceed 5% of instantaneous flow
Nelson City Council *(Draft Nelson Plan)*	• 10-20% of 7-day MALF, or • Consent specific limit	• 80-100% 7-day MALF dependent on site, or • Consent specific limit	• Not exceed 0.5 L/s, and • 1 m^3/day + 300 L per bedroom unit.
Tasman District Council *(Tasman Resource Management Plan)*	• Site specific limits	• Site specific limits	• 5-20 m3/day dependent on the Water Management zone
West Coast Regional Council *(operative Regional Land and Water Plan)*	• Consent specific conditions	• No minimum flow if abstraction if less than 20% of the MALF, or • 75% of MALF for all others	• 50 L/s and maximum 1500 m^3/day from main stem of listed rivers, or • 2 L/s and 25 m^3/day, if the waterbody is outside the ones listed in the plan, • 10 L/s and 150 m^3day for temporary use.
Environment Canterbury Regional Council *(Canterbury Land and Water Regional Plan)*	• Catchment specific limits and reductions as flows reduce	• Site specific limits, or • 70-90% 7-day MALF dependent on the location.	• 0.5-5 L/s and • 2–100 m^3/day dependent on the 7-day MALF of the stream, or • If MALF unknown no more than 5 L/s and 10 m^3/day.
Otago Regional Council *(operative Regional Plan 2022)*	• 50% of 7-day MALF, or • Site specific limit. • Supplementary allocation as per plan based on 7-day MALF	• Site specific limits, and • Supplementary allocation requires, no less than 50% of the natural flow to remain.	• Not exceed 0.5 L/s, and • 25 m^3/day, or • 100 L/s, and • 1000 m^3/day for the main stem of large rivers listed in the plan.

Authority	Allocation Limits	Minimum Flow Setting	Permitted Take Limits
Environment Southland Regional Council *(proposed Southland Water and Land Plan)*	• 30% of Q95 (flow that is exceeded 95% of the time), or • Consent specific limit	• Flow that is exceeded 95% of the time (Q95) • Also limits for secondary flows based on the time of year	• Not exceed 2 L/s, and • 40 m^3/day. • A water meter is required for all takes greater than 20 m^3/day.

Note: These limits and flow have been interpreted by Council staff from reviewing each of the Council's current plans or draft plans.

APPENDIX II – Surface Water Allocation Status and Limits

Northern Hill Country

Catchment	Stream/River	7-day MALF (L/s)	Total Allocation (L/s)	% of MALF allocated (annual flow for in-stream abstractions)	Minimum flow set (Y/N)
Mimitangiatua	Unnamed tributary	2.1	3	143	Y
	Mimitangiatua	194	12.5	6	N
Onaero	Mangahewa	13.8[1]	2	14	Y
	Onaero	321	19.4	6	N
Tongaporutu	Mangapepeke	15[1]	5	33	N

Northern Marine Terraces

Catchment	Stream/River	7-day MALF (L/s)	Total Allocation (L/s)	% of MALF allocated (annual flow for in-stream abstractions)	Minimum flow set (Y/N)
Waiau 1	Waiau 1	67	8.5	13	N
Waipapa 3	Waipapa 3	5.3	6	143[2] *(2%)*	Y

Pātea

Catchment	Stream/River	7-day MALF (L/s)	Total Allocation (L/s)	% of MALF allocated (annual flow for in-stream abstractions)	Minimum flow set (Y/N)
Pātea	Pātea – Cardiff Rd	176	44.8	26	N
	Konini	83	20.3	24	N
	Kahouri	109	5.6	5	Y
	Ngaere	33	28.5	87	N
	Makuri	314	34.8	11	Y
	Pātea – u/s confluence with Mangaehu	1346	374	25	Y

[1] MALF has been taken from the NIWA NZ River Maps tool. MALF will need to be calculated onsite prior to consent renewal.
[2] Consent has in-stream water storage, and minimum flows are generally set to MALF.

Southern Hill Country

Catchment	Stream/River	7-day MALF (L/s)	Total Allocation (L/s)	% of MALF **allocated** (annual flow for in-stream abstractions)	Minimum flow set (Y/N)
Manawapou	Unnamed tributary	6.3	6.1	97[2] *(8%)*	Y
Tangahoe	Tawhiti	329	211.4	64	N[3]
	Tangahoe	1232	457	37	Y
Waitotara	Waiau 2	146	40.7	28	Y
	Unnamed tributary	17[1]	4.4	26	N
	Waitotara	5401	594	11	Y
Whenuakura	Kokako	50	50.2	100[2] *(37)*	Y
	Mangatangi	5[1]	1.6	32	Y
	Whenuakura	2113	212	10	Y

Southern Marine Terraces

Catchment	Stream/River	7-day MALF (L/s)	Total Allocation (L/s)	% of MALF **allocated** (annual flow for in-stream abstractions)	Minimum flow set (Y/N)
Hauroto	Hauroto	4	41	1025[2] *(39%)*	Y
Kaikura	Kaikura	166	127.4	77[2] (24%)	Y
Mangaroa	Mangaroa	151	115.1	76	Y
Unnamed Catchment 5	Unnamed Stream 5	5.6[1]	7	125	N
Unnamed Catchment 8	Unnamed Stream 8	1.3[1]	7	538	N/A
Unnamed Catchment 10	Unnamed Stream 10	4.2[1]	7	167	N/A
Unnamed Catchment 22	Unnamed Stream 22	32	3	10	N
Waikaikai	Waikaikai	58	230	398[2] *(70%)*	Y
Wairoa	Wairoa	266	254	96[2] (33%)	Y

[3] 2 consents, and both have no minimum flow

Volcanics

Catchment	Stream/River	7-day MALF (L/s)	Total Allocation (L/s)	% of MALF allocated (annual flow for in-stream abstractions)	Minimum flow set (Y/N)
Heimama	Heimama	27	10	37	N
Inaha	Inaha	195	44	23	Y
Kaihihi	Mangatete	134	58.1	43	Y[4]
	Kaihihi	391	168	43	Y
Kapoaiaia	Kapoaiaia	256	11.1	4	Y
Kapuni	Kapuni	519	199	38	N[5]
Kaupokonui	Mangawhero-iti	131	121.6	93	Y
	Mangawhero - Bushline	235	70.8	30	N
	Kaupokonui	1522	333.1	22	Y
Motumate	Motumate	32	9	28	Y
Oakura	Kiri	76	1.9	3	Y
Oaonui	Unnamed tributary	9[2]	50	555 (25%)	N
	Oaonui	315	110	35	Y
Oeo	Oeo	126	48.4	38	Y
Otakeho	Otakeho	447	181.4	41	Y[2]
Ouri	Ouri	210	32	15	Y
Punehu	Punehu	298	54	18	Y
Pungaereere	Pungaereere	88	17.6	20	N
Taungatara	Cold Creek	295	79	27	N
	Taungatara	616	130.7	21	Y
Te Henui	Unnamed tributary	2.1	5	238	N
	Te Henui	245	11.7	5	N
Waiaua 2	Waiaua 2	1467	3928.2	268	Y[2]
Waihi 5	Waihi 5	49	42.4	86	Y
Waimoku	Waimoku	41	19.2	47	Y
Waingongoro	Waingongoro – Bushline	203	33.7	17	N
	Mangatoki - Bushline	71	30.3	42	N
	Waingongoro – Finnerty Rd	399	101.4	25	N

[4] Pasture Irrigation consent with minimum flow, but municipal water supply no limit
[5] 3 consents, and all have no minimum flow set.

Catchment	Stream/River	7-day MALF (L/s)	Total Allocation (L/s)	% of MALF allocated (annual flow for in-stream abstractions)	Minimum flow set (Y/N)
	Waingongoro – Eltham Rd	489	125.8	26	N
	Waingongoro – Skeet Rd	909	182	20	N
	Waingongoro	1529	247.8	16	Y
Waiokura	Waiokura	154	75	49	Y
Waiongana	Mangaoraka	87	24.6	28	Y
	Waiongana	1050	100	10	Y
Wairau	Wairau	96	15	16	N
Waireka 1	Waireka 1	10.5	15	143[2] *(3%)*	Y
Waiteika	Waiteika	18	4	22	Y
Waiweranui	Waiweranui	336	139	41	Y
Waiwhakaiho	Waiwhakaiho	3391	772.1	23	Y
Warea (Teikaparua)	Warea	338	73.3	22	Y
Werekino	Werekino	34	22.7	67	Y

Waitara

Catchment	Stream/River	7-day MALF	Total Allocation	% of MALF allocated (annual flow for in-stream abstractions)	Minimum flow set (Y/N)
Waitara	Te Popo	199	7.8	4	N
	Ngatoro	167	77.3	46	N
	Piakau 1	205	7.9	4	N
	Manganui	3945	5850.8	148[6]	Y
	Mangaone 4	118	37.6	32	N
	Waitara	6850	756[7]	11	Y

[6] Hydroelectric scheme. Water is diverted from the Manganui, but discharged into the Waitara.
[7] Hydroelectric in and out. Results in net 0 change, so consented abstraction removed.

APPENDIX III – Groundwater Allocation Status and Limits

Current levels of groundwater allocation across Taranaki in comparison to calculated sustainable yields for each groundwater aquifer

Geological age	Aquifer	(ML/yr)		
		Sustainable yield	Allocated	% allocated
Quaternary	Taranaki Volcanics	617,670,699	5,262,205	0.9
	Marine Terraces North	40,463,833	133,433	0.3
	Marine Terraces South	96,732,208	508,800	0.5
Tertiary	Kiore	154,171,531	149,600	0.1
	Matemateaonga	165,961,911	4,425,795	2.7
	Mt. Messenger	140,017,639	70,540	<0.1
	Okiwa	751,065	3,287	0.4
	Otunui	37,177,534	18,432	<0.1
	Paparangi	9,928,462	14,708	0.2
	Tangahoe	96,069,770	134,119	0.1
	Urenui	45,661,458	0	0
	Whenuakura	71,384,932	7,553,830	10.6