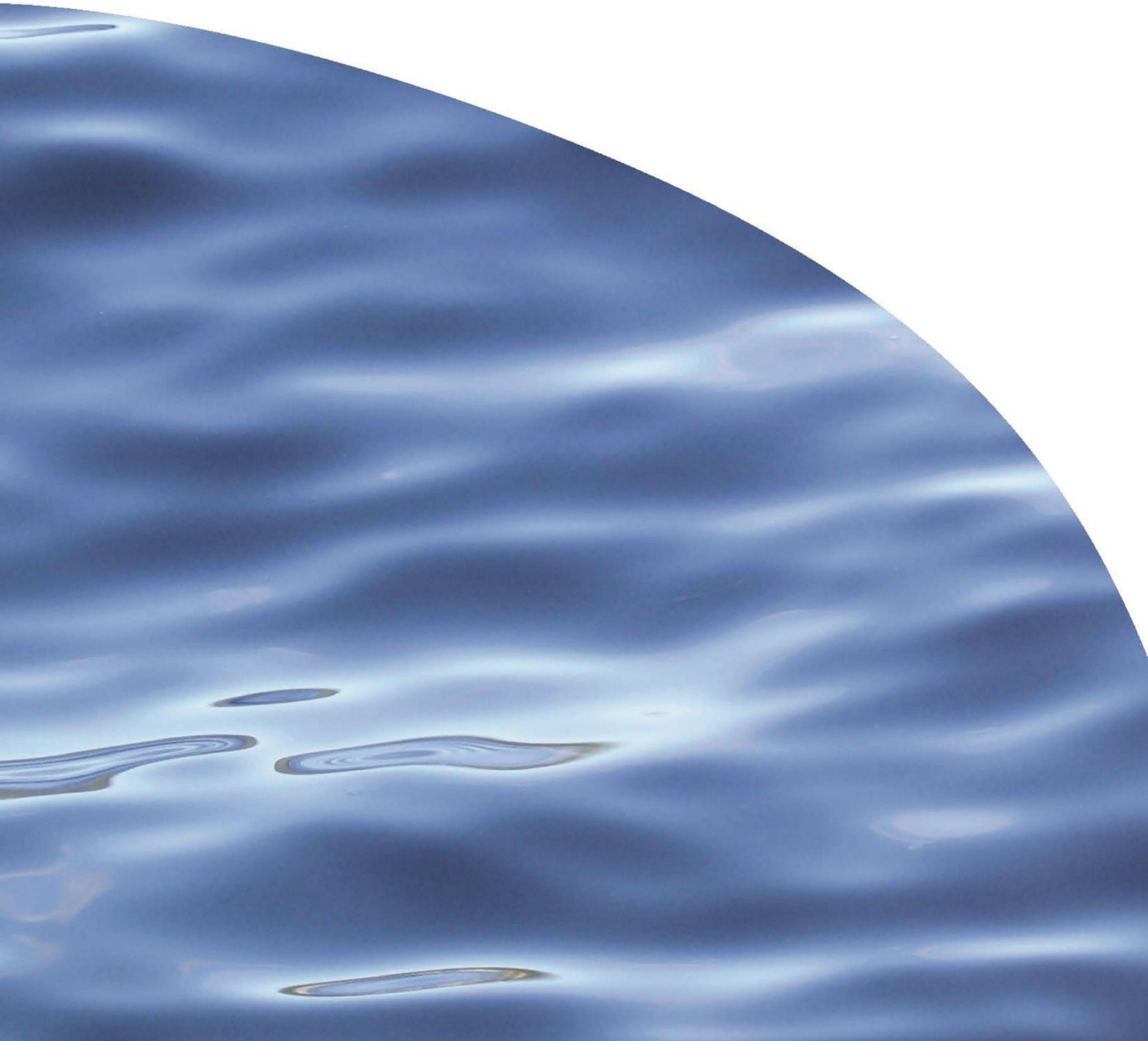
REPORT NO. 3581

REVIEW OF THE MONITORING PROGRAMME ASSOCIATED WITH WATER ALLOCATION IN THE UPPER MOTUEKA RIVER



REVIEW OF THE MONITORING PROGRAMME ASSOCIATED WITH WATER ALLOCATION IN THE UPPER MOTUEKA RIVER

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EXECUTIVE SUMMARY

Water management in the upper Motueka River is controlled by the Tasman District Council's (TDC) Tasman Resource Management Plan (TRMP). One of the conditions of this plan is that monitoring is undertaken to determine if there are any effects of the current water allocation regime on ecological values in the upper Motueka River between the Wangapeka confluence and the Kohatu Bridge (the segment of interest in the present report).

A variety of hydrological and ecological information is available from this segment of the river. Continuous measurements of water temperature and dissolved oxygen, along with low flow gauging have been implemented as part of the monitoring programme. Before additional data collection, it is important to review the existing monitoring programme (and information from past investigations) to ensure that it is fit for purpose. This report describes a review of the existing monitoring programme and available information, and provides recommendations and suggestions for additional information that may help support future plan improvements.

We recommend that the following elements are included in ongoing monitoring of the effects of the current water allocation regime:

- Continue continuous monitoring of water temperature at vulnerable sites and any site used for triggering water rationing through the river segment of interest.
- Continue continuous monitoring of dissolved oxygen at the upper and lower ends of the segment.
- Continue low flow gaugings to maintain and improve relationships between river flow in this segment and permanent flow recording sites.
- Continue the requirement for water take monitoring by all consent holders.
- Conduct a trial installation of fixed cameras to record the incidence of river drying in the lower Motupiko and lower Tadmor rivers.
- Build an updated river-aquifer model with improved representation of surface water and groundwater exchanges to improve understanding of the relationship between river flow, groundwater levels, water takes and river drying and to assist with water allocation planning and compliance. The model would use river drying information from the cameras along with information on river flows, groundwater levels, river cross-sections, rainfall recharge and groundwater abstraction to evaluate water table and river flow responses to changes in water takes. It could later be extended to evaluate nutrient transport from land uses to the aquifer and river(s) for water quality management purposes.
- Initiate annual monitoring in summer of water clarity, nutrients, faecal indicator bacteria, macroinvertebrate community and periphyton cover at the top (Motueka upstream of Motupiko confluence) and bottom (Motueka upstream of Wangapeka confluence) of the segment.

- Conduct a snapshot summer survey of surface water quality at multiple sites along the upper Motueka River during low flows at least once prior to the review of the TRMP in conjunction with a planned groundwater quality survey of the Tapawera Plains.

The following elements would be useful additions to the monitoring programme:

- Conduct physical habitat assessments along the segment to assess the presence of cool water refuges and the benefits of groyne placement on pool formation.
- Calculate ecosystem metabolism during low flow periods using the dissolved oxygen data collected at the upper and lower ends of the segment.
- Consider assisting with Fish & Game drift dives to assess trout abundance in the Glen Rae dive reach.

Other, lower priority, considerations for the monitoring regime (perhaps requiring central government funding) could include:

- Install a new permanent flow recording site within the segment.
- Monitor heavy metal concentration in riverbed sediments to add to existing data from the Integrated Catchment Management research programme, and identify any trends in nickel and chromium concentrations.
- Conduct surveys of native fish to build knowledge of their diversity and abundance in the segment.

All ecological data need to be complemented with flow and hydraulic geometry data and/or ecologically relevant flow statistics (e.g.7-day MALF) so they can be interpreted with respect to the flow regime. One-off surveys will have little value by themselves for detecting any effects of low flow.

We recommend that in 2024 a thorough analysis and review of the data from the monitoring programme, in addition to other relevant information, should be conducted to identify any effects of the water allocation regime in the upper Motueka River. The analysis and review should be completed by ecological/hydrological experts in conjunction with TDC water resource staff. The analysis and review will enable any effects to be identified prior to the review of the Tasman Resource Management Plan. It is difficult to estimate the cost of the review at this stage, but the cost of the external reviewer/s alone could be in the order of about $50-70K. There will also be staff/lab time and modelling costs for TDC associated with the monitoring programme.

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1. INTRODUCTION

Water management in the upper Motueka River is controlled by the Tasman District Council's (TDC) Tasman Resource Management Plan (TRMP). One of the conditions of this plan is that monitoring is undertaken to determine if there are any effects of the current water allocation regime on ecological values in the upper Motueka River between the Wangapeka confluence and the Kohatu Bridge (the segment of interest in the present report). There is significant stakeholder interest in water allocation in the upper Motueka and it is important to ensure that the water allocation regime in the upper Motueka River is sustainable and not affecting ecological values in this segment of the river or further downstream. Ecological monitoring within this part of the river needs to be fit for purpose to assure the public that the plan is providing for effective and sustainable water management.

Before additional data collection, it is important to review the existing monitoring programme (and information from past investigations) to ensure that it is fit for purpose. Cawthron Institute, in conjunction with Manaaki Whenua, have been contracted to conduct this review.

The review involved:

- a visit to key monitoring sites along the segment
- an initial assessment of the efficacy of the data that has been collected to date for identifying effects of the current water allocation regime
- recommendations on any additional information that is required to fill knowledge gaps
- suggestions on timing, scope and likely costs of data analyses that are required leading up to the TRMP review.

The review drew on data, models, knowledge and experience developed through the Integrated Catchment Management (ICM) research programme (https://icm.landcareresearch.co.nz/).

2. CURRENT WATER MANAGEMENT IN THE UPPER MOTUEKA

The upper Motueka Catchment is composed of three main river valleys: the Motupiko River (344 km^2), the Tadmor River (124 km^2) and the Motueka River (419 km^2) (Figure 1). The main morphological features of the upper Motueka River catchment are steep, narrow headwater channels and broad floodplains and terrace systems within hilly Moutere gravel terrain below the upper Motueka Gorge to the Wangapeka River confluence.

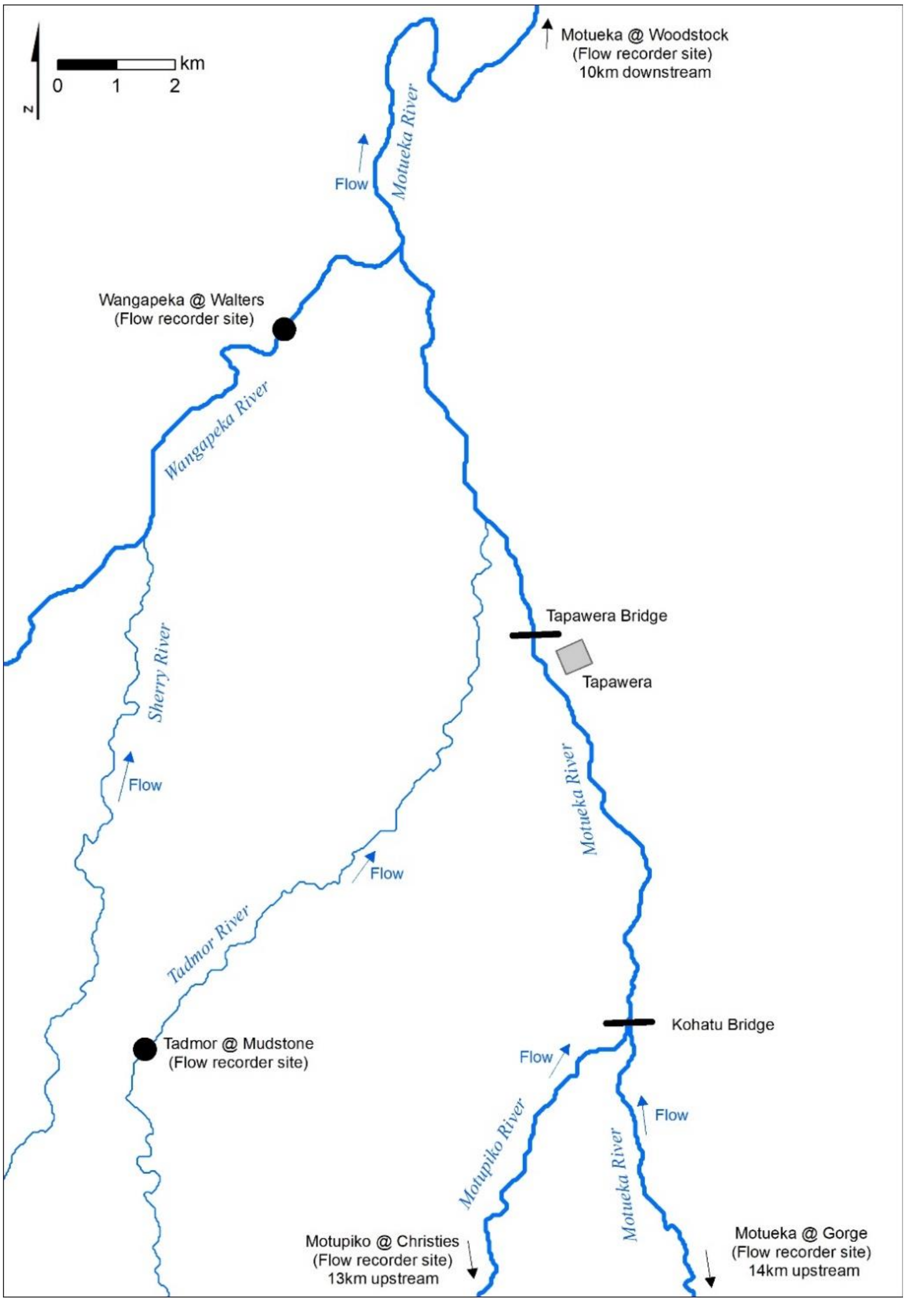

Figure 1. The upper segment of the Motueka River upstream of the Wangapeka River confluence.

Average annual rainfall is 1100–1250 mm, higher along the hills and lowest around Tapawera itself. In the summer months, evapotranspiration exceeds rainfall and irrigation is needed to ensure reliable crop production.

Groundwater is pumped from a shallow unconfined alluvial aquifer that occurs in the Quaternary river terrace formations and modern river deposits. The saturated thickness of these gravels ranges from 5 to 9.5 m compared with total thickness of water-bearing gravels of 9 m near Tapawera and 15 m near Norths Bridge. Depths to groundwater from ground level are typically 2–4 m (Fenemor & Thomas 2013).

The land upstream of the Wangapeka confluence with the Motueka River has a sizeable area of fertile alluvial river terrace and floodplain that is suitable for irrigated agriculture. Since the mid-1990s there has been an increasing demand for irrigation water, especially from groundwater in these flats.

Extraction of water is managed under policies and rules in Part V of the Tasman Resource Management Plan. Schedule 30 lists the water body uses and values which are relevant to the setting of minimum flows and water allocation limits. Of importance in the upper Motueka are values recognised as nationally significant in the Motueka Water Conservation Order, and recognition that upstream flows may be needed to sustain important downstream values such as fisheries and birdlife. Also recognised as important are water for irrigation, community supply, stock water, and recreational uses.

Within the upper Motueka area, allocation limits apply to various water management zones; Tapawera (314 L/s), Glen Rae (300 L/s), Tadmor (56 L/s), Motupiko (85 L/s) and Rainy (25 L/s) as shown in Figure 2. These zones are all fully allocated.

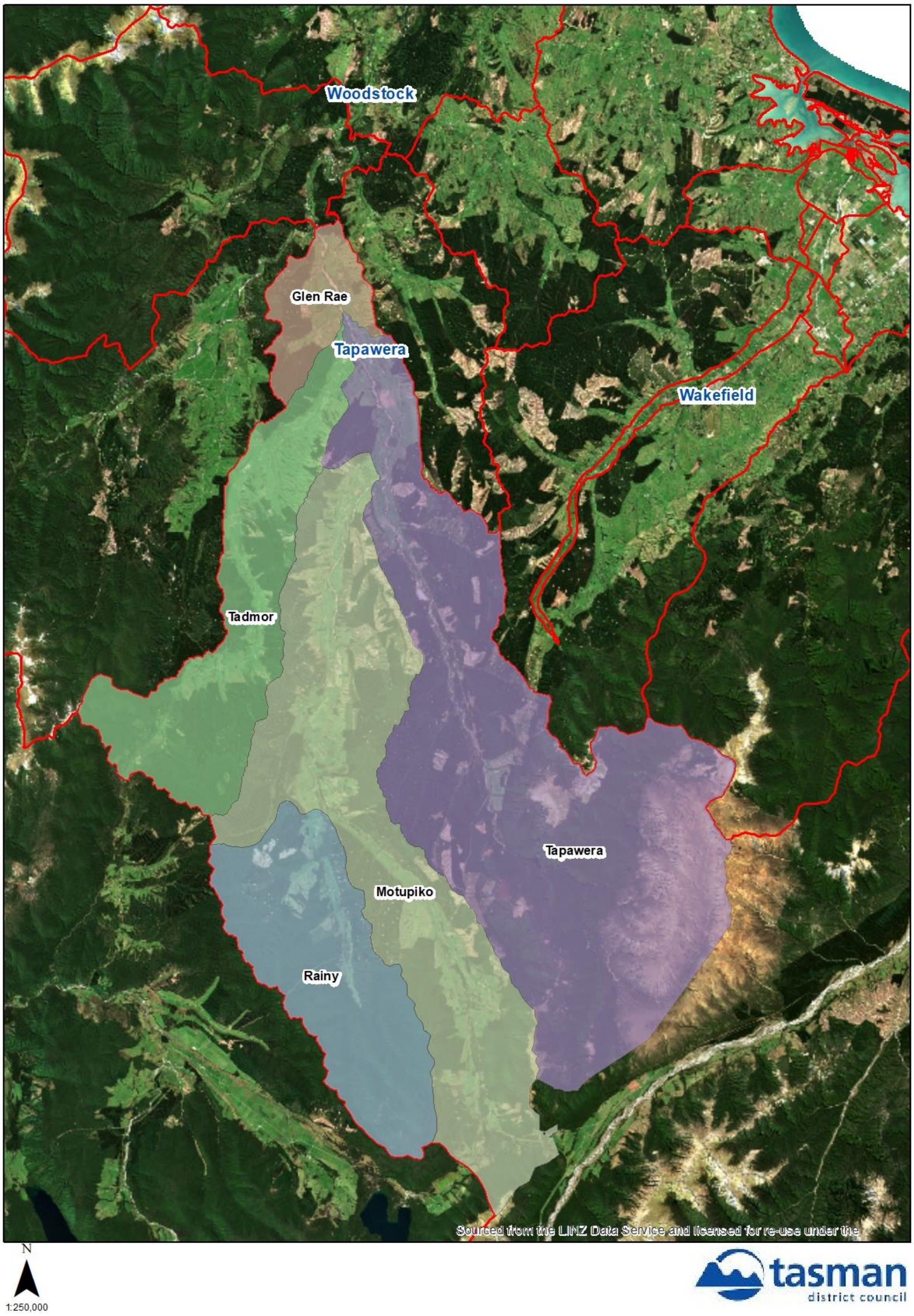

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Figure 2. Water allocation management zones in the upper Motueka Catchment.

3. EXISTING DATA

A variety of environmental data has been collected from the upper Motueka by TDC, scientists involved with the ICM research programme, Fish & Game and others.

3.1. Hydrological data

There are permanent flow recording sites of relevance to this segment of the river at the Motueka at Gorge, Motupiko at Christies, Tadmor at Mudstone, Wangapeka at Walter Peak, and Motueka at Woodstock sites (Figure 1). Flow gaugings have been carried out to develop relationships between permanent flow recorder sites and sites within the segment of interest. Mean annual low flow statistics calculated from either Motueka at Gorge flows or Motueka at Woodstock flows are shown in Table 1.

Table 1. Mean annual low flow (MALF) statistics for locations down the length of the upper Motueka River updated to 2020 (Data provided by Joseph Thomas, Tasman District Council, 21 October 2020). ‘u/s’ = ‘upstream’.

Site	1-day MALF (L/s)	7-day MALF (L/s)
Motueka at Gorge (1965+)	1404	1483
Norths Bridge (from Motueka Gorge correlation)	1506	1621
Hyatts (from Woodstock recorder correlation)	1580	1708
Hyatts (from Motueka Gorge correlation)	1510	1668
Motueka at Gorge, Motupiko, Tadmor combined	1854	1978
Motueka u/s Wangapeka (from Woodstock) (1969+)	2120	2369

Current allocation limits (total 780 L/s all from groundwater) represent around 35% of the 7-day MALF calculated for the Motueka upstream of the Wangapeka confluence. It is important to note that the 7-day MALF is based on actual flows (i.e. affected by water takes). The naturalised 7-day MALF would be higher, but difficult to quantify.

Low flow gauging runs for eleven sites along the segment indicate a consistent increase in flow in the section between the Glen Rae confluence and the Wangapeka confluence (Figure 3). This results from the underlying geology constricting groundwater as it approaches the gorge near the Wangapeka confluence, raising groundwater levels relative to river levels and from groundwater recharging river surface flows (Fenemor & Thomas 2013). Flows are relatively consistent in the upper reaches of the segment downstream of the Motupiko confluence, although during particularly low flows (i.e. below MALF) there is evidence of surface flow losses to groundwater, particularly in the reach between the Tapawera Bridge and the Glen Rae Confluence (Figure 3).

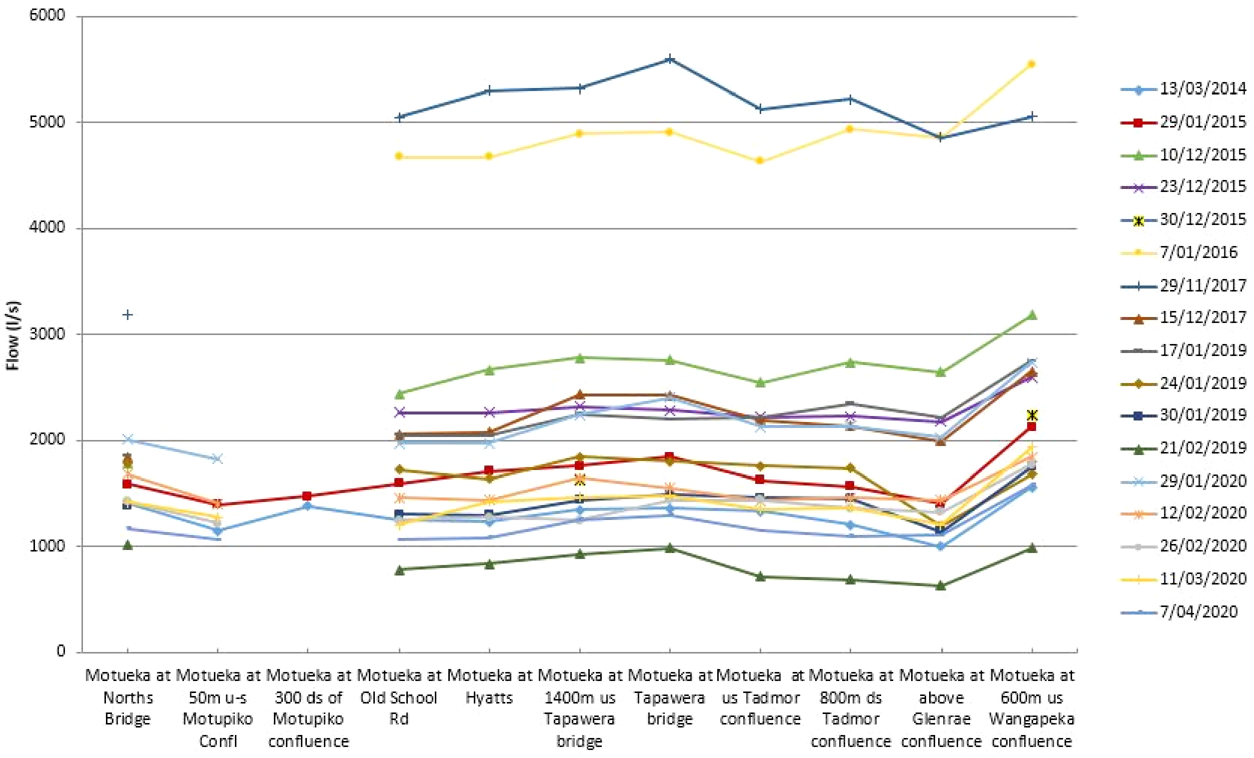

Figure 3. Low flow gauging results at 11 sites along the upper Motueka River from 2014-2020. Flows at Norths Bridge are upstream of, and not affected by, any water takes.

An upper Motueka groundwater-river interaction model has been developed from information on groundwater levels, river levels, surveyed river cross-sections, river flows, rainfall-recharge and groundwater abstractions (Gusyev et al. 2012; Hong et al 2010; Davie et al 2008: Ekanayake et al 2016). It has been used to compare the effects of different allocation scenarios on river flows and security of allocation for existing users (Fenemor & Thomas 2013). It should be noted that the model is not able to recalculate river water levels down-river as flow is lost to, or gained from, connected groundwater, since the model produces only an approximate fit based on measured flow losses and gains (Fenemor & Thomas 2013).

3.2. Water temperature

Council monitoring of summer water temperature at 6 sites along the river indicate that consistently high temperatures occur during summer, regularly exceeding 22 °C and reaching 25 °C for short periods in 2018 and 2019 (Figure 4). This is concerning as these warm temperatures are high enough to stress fish like brown trout, which prefer cool waters. Once temperatures are above 22 °C trout will experience stress and are expected to stop feeding. Trout will die relatively quickly once temperatures reach 25 °C. Laboratory studies indicate that native fish are somewhat more tolerant of warm temperatures than trout, with stress expected in the range 25–35 °C (Olsen et al. 2012). However, relatively large numbers of dead eels have been seen in the middle reaches of the Motueka during particularly warm periods (R Young pers. obs.) indicating that they may be more susceptible to high temperatures than the laboratory studies indicate.

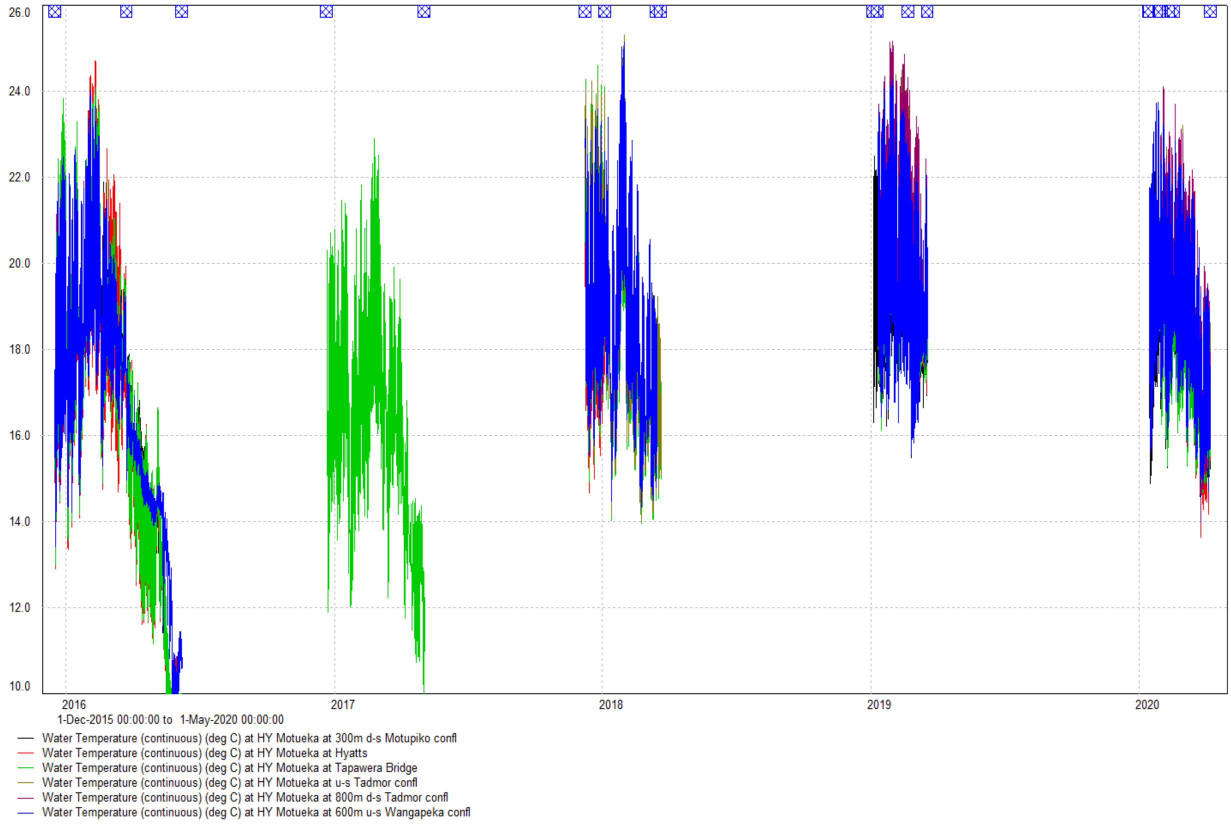

Figure 4. Summer and autumn water temperatures from 2016-2020 at 6 sites along the length of the upper Motueka River.

The high temperatures are relatively consistent downstream through the segment, although the highest temperatures seen during 2018 and 2019 were at the Hyatts site, 1–2 km upstream of the Tapawera bridge. Daily peaks in water temperatures upstream of the Wangapeka confluence are dampened to some extent by inputs of cool groundwater in this reach (Olsen & Young 2009).

Highest water temperatures are typically experienced during late afternoon in summer from December to March.

The high temperatures experienced in the upper Motueka River reflect the wide, open channel and general lack of shading. Daily mean water temperature is relatively insensitive to flow; it is more affected by climate. For example, the highest temperatures in January 2020 coincided with relatively high flows (Figure 5). Lower flows in February and March did not have equally high or higher water temperatures. As a river flows downstream, the water reaches an equilibrium temperature where cooling equals heating. Reductions in flow when the river is at equilibrium temperature have little effect on mean water temperature. Flow change has more effect on the amplitude of daily temperature fluctuations. As a result of diurnal heating and nocturnal cooling, daily fluctuations in water temperature increase as the flow reduces, but perhaps by less than 1.5 °C for a halving of flow (Theurer et al. 1984).

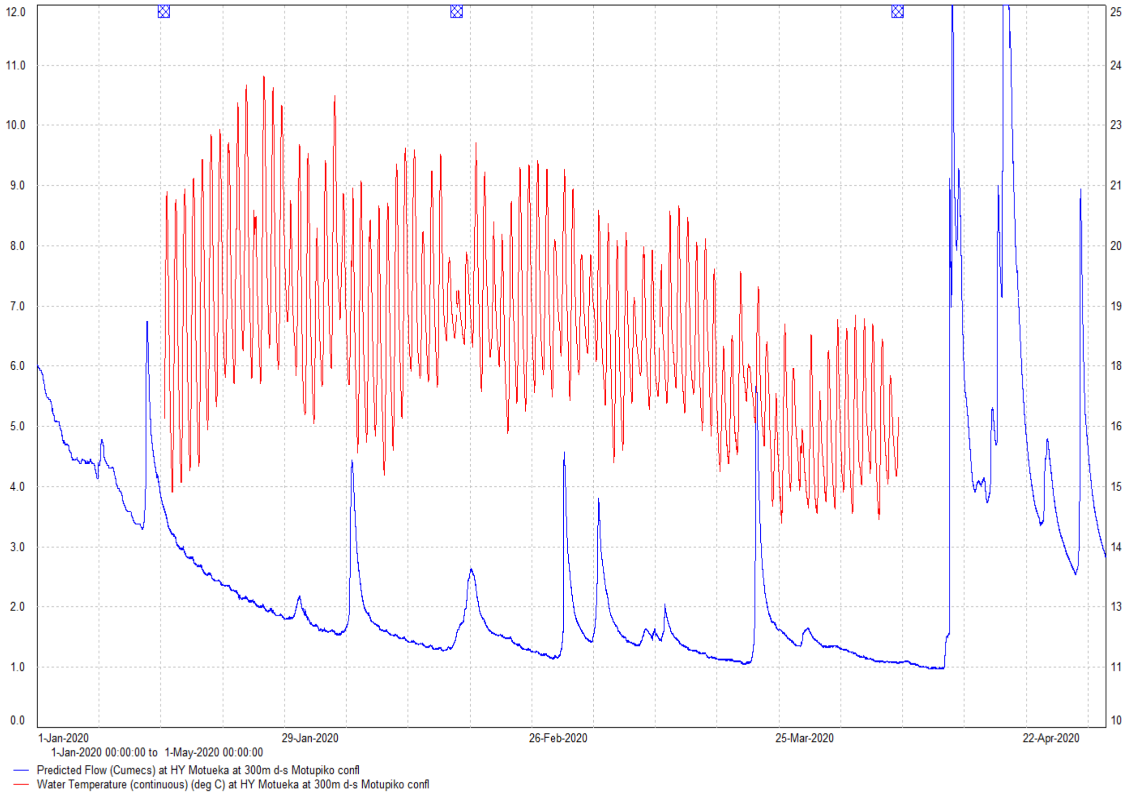

Figure 5. Water temperature and river flow in the Motueka River 300 m downstream of the Motupiko confluence during summer and autumn 2020.

Deep pools are likely to act as 'cold water refuges' for fish to retreat to during the warm conditions, especially in areas where cool groundwater may be recharging surface water (Olsen & Young 2009). Deep pools are abundant in the upper part of the segment and often associated with rock groynes (Figure 6). Further downstream, pools become rare and smaller. If the groundwater table falls to the extent that groundwater is no longer recharging surface water, then water temperatures in these refuges would be warmer. In the absence of effective refuges, shading and groundwater inflows, fish populations will be stressed by the peak temperatures shown in Figure 4.

Figure 6. Sampling downstream of Kohatu during the segment survey on 17 February 2020. Note the deep pool downstream of the rock groyne.

Council monitoring of water temperatures through this segment of the river has shown similar patterns to those seen earlier by Olsen and Young (2009) and more recently by Fish & Game summer monitoring during 2018–2019 (Figure 7), although the temperatures recorded by Fish & Game at the Glen Rae site (up to 27 °C) appear to be slightly warmer than those recorded by TDC at a broadly similar location over the same year (up to 25 °C).

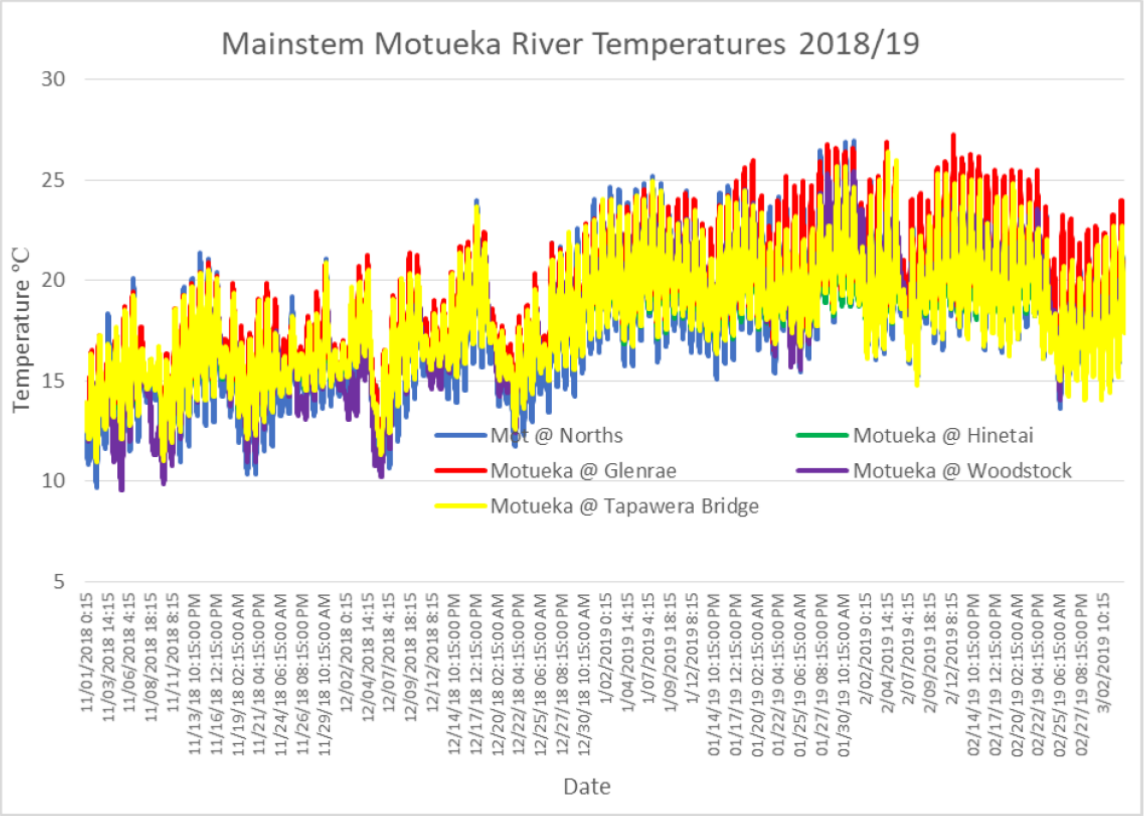

Figure 7. Water temperature data collected by Fish & Game in the upper and middle reaches of the Motueka River (November 2018–February 2019; From Nelson Marlborough Fish & Game – Fisheries Report 2018/19).

3.3. Dissolved oxygen

Council has been monitoring dissolved oxygen continuously at two sites through the segment—one 300 m downstream of the Motupiko confluence and one 600 m upstream of the Wangapeka confluence.

Dissolved oxygen concentrations have been relatively consistent for each site monitored, with levels ranging from approximately 98% down to 83% for the upper site and approximately 135% down to 85% at the lower site near the Wangapeka confluence (Figure 8). Peak daily dissolved oxygen levels were consistently much higher in the downstream site than the upstream site in February-March 2020, likely reflecting higher levels of periphyton growth in this section of the river.

Fortunately, minimum daily oxygen levels are relatively high (> 80% saturation) and unlikely to be low enough to stress aquatic life.

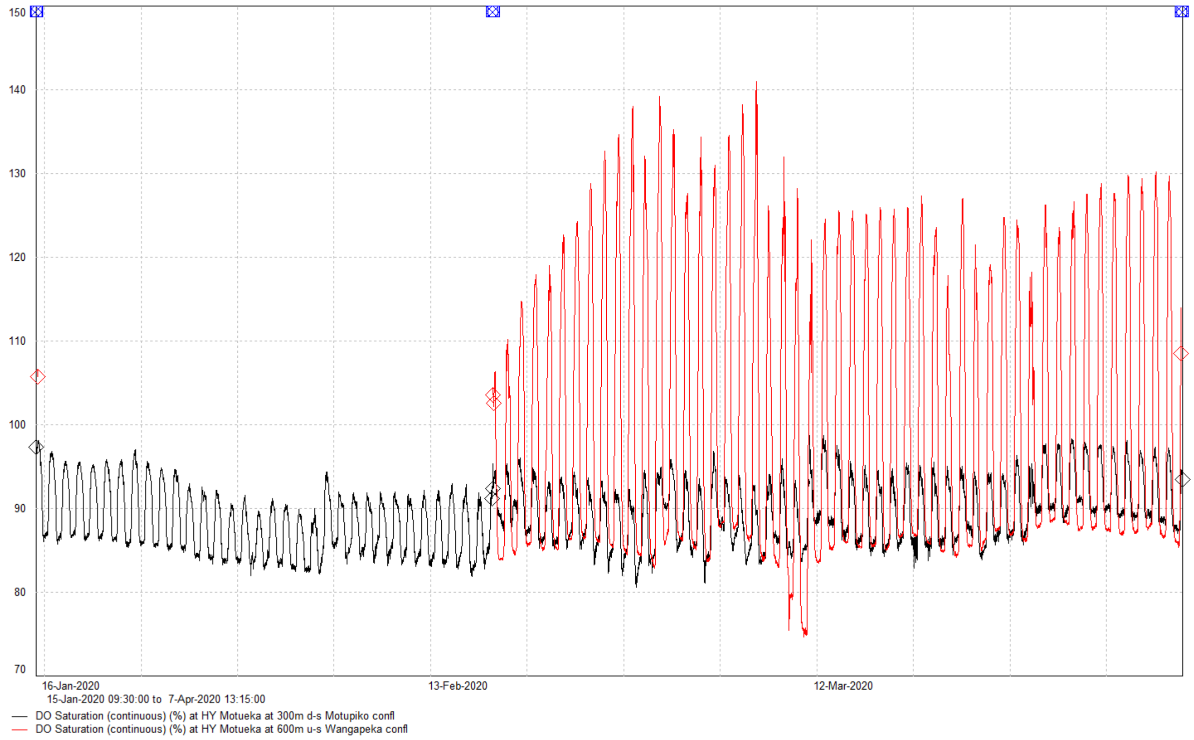

Figure 8. Dissolved oxygen (% saturation) at two sites in the upper Motueka River over summer and autumn 2020.

3.4. Water quality

There are 7 water quality monitoring sites in the wider Motueka that have been monitored monthly since July 2016 as part of the TDC's State of the Environment monitoring programme. The Motupiko River is sampled about 250 m upstream of the confluence with the Motueka River, along with the Motueka at Gorge site. The other current monitoring sites are not specifically relevant to water quality within the upper Motueka. Earlier monitoring included a site on the Motueka upstream of the Wangapeka confluence, and a site on the Motupiko River at Christies, which were sampled monthly from 1999/2000, respectively, through to October 2001 and then quarterly through until October 2015.

As part of this review we recommended that spot sampling of water quality be conducted at 5 sites along the river segment, comprising a site on the Motueka River upstream of the Motupiko confluence, a site downstream of the Motupiko confluence, a site at the Tapawera bridge, a site downstream of the Tadmor confluence and a site upstream of the Wangapeka confluence. Sampling was conducted on 11 March 2020.

This sampling indicated that there was a constant gradual increase in nitrate (NO_3-N) and *E. coli* levels down the river from upstream of the Motupiko confluence to the Motueka upstream of the Wangapeka confluence (Figure 9). Water clarity declined gradually down the segment, although there was no longitudinal pattern for dissolved reactive phosphorus (DRP) during this snapshot water quality sampling (Figure 9).

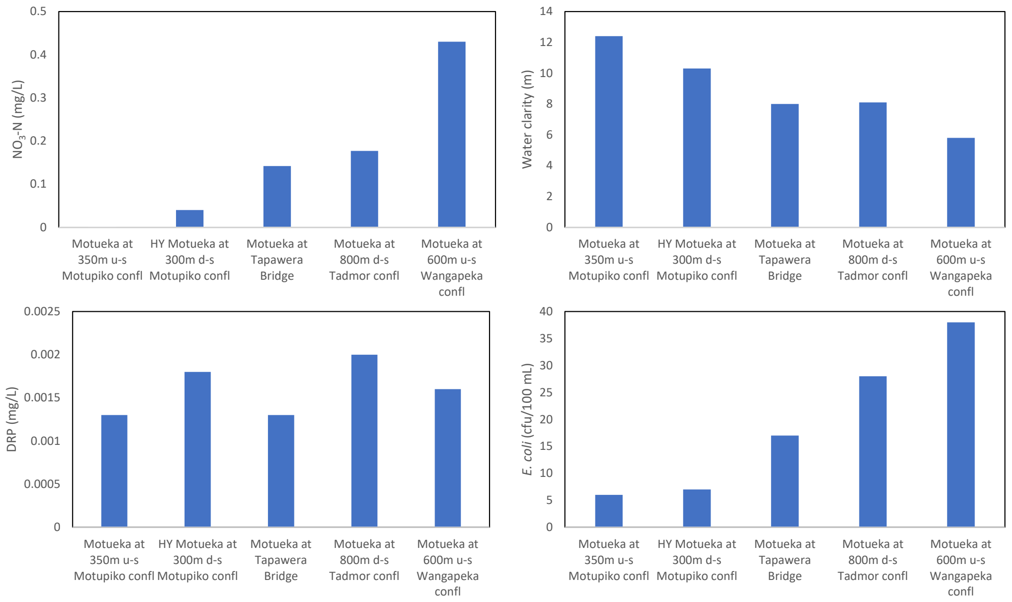

Figure 9. Water quality patterns along the upper Motueka River on 11 March 2020.

The increase in nitrate concentrations down the length of the segment is probably the cause of the increase in periphyton cover that was observed during a survey of the whole segment on 17 February 2020. The riverbed was largely free of green periphyton in the reach upstream of Tapawera. However, further downstream filamentous green algae covered much of the riverbed, with patches of benthic cyanobacteria in places (Figure 10).

Figure 10. Motueka River upstream from the Wangapeka confluence. Note the patches of filamentous green algae covering much of the riverbed.

It is likely that the increase in nitrate concentrations is caused by upwelling groundwater in the lower part of the study segment affected by pastoral and horticultural land uses along the Tapawera Plain and also possibly the Tapawera wastewater discharge to groundwater. There might also be small inputs from tributaries such as the Tadmor River; however, surface flows in the lower Tadmor are typically low, or zero, during summer periods.

This 11 March snapshot of water quality is broadly consistent with the longer-term water quality results from relevant sites (Figure 11; James & McCallum 2015; Young et al. 2010, Young et al. 2005). The concentrations of nitrate nitrogen observed in March 2020 at the Motueka upstream of Wangapeka site are within the range observed at this site over 2000–2015 (Figure 11).

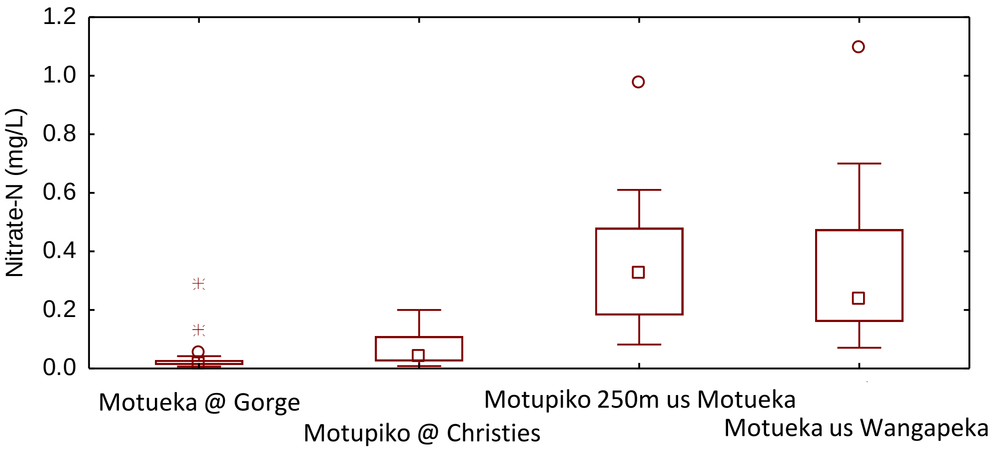

Figure 11. Box plots of nitrate nitrogen concentration from sites relevant to the upper Motueka where longer-term records are available. Median values are shown by the square in the middle of the box. The lower and upper bounds of the box represent the 25th and 75th percentiles of the data. The whiskers represent the 5th and 95th percentiles. Outliers are represented by stars/circles.

3.5. Invertebrates

Macroinvertebrate communities can provide an indication of water quality and are the food for higher trophic levels. As part of the ICM research programme and TDC State of the Environment Monitoring, macroinvertebrate samples have been collected from the Motueka River upstream of the Motupiko confluence, the Motueka upstream of the Wangapeka confluence, the Motupiko upstream of the Motueka confluence and also the Motueka at Gorge.

Macroinvertebrate community index scores at all these sites indicate that the community is dominated by species that are sensitive to pollution and therefore are indicative of clean water based on the Stark assessment criteria (Stark & Maxted 2007). According to the National Policy Statement for Freshwater Management (NPS-FM) attribute banding system for the Macroinvertebrate Community Index (MCI) (MfE 2020) the Motueka at Gorge would be an A-band site (>130) while the other sites would be in the B-band (>110 and < 130).

Table 2. Macroinvertebrate community index (MCI) and Semi-Quantitative Macroinvertebrate Community Index (SQMCI) scores for sites in the upper Motueka (from Young et al. 2010 and LAWA www.lawa.org.nz). 'u/s' = 'upstream'. * Five year average from 2015-2019.

Site	MCI	SQMCI
Motueka u/s Motupiko	121	5.6
Motueka u/s Wangapeka	123	6.5
Motupiko u/s Motueka	125*	
Motueka at Gorge	133	7.2

3.6. Fish community

The New Zealand Freshwater Fish Database holds records of freshwater fish observations from throughout New Zealand. Records in the vicinity of the upper Motueka include the following species, although upland bully, brown trout and longfin eels dominate the fish community:

- lamprey
- longfin eel
- shortfin eel
- dwarf galaxias
- brown trout
- torrentfish
- upland bully
- common bully.

Fish & Game conducts drift dive surveys of brown trout abundance at various locations throughout the Motueka Catchment. A reach near the Glen Rae confluence has been the only one dived relatively regularly in the upper Motueka reach. Trout numbers in this reach have varied considerably over time with changes possibly associated with juvenile recruitment success in previous years, presence of good physical habitat in the dive reach, water temperature and flows (Figure 12).

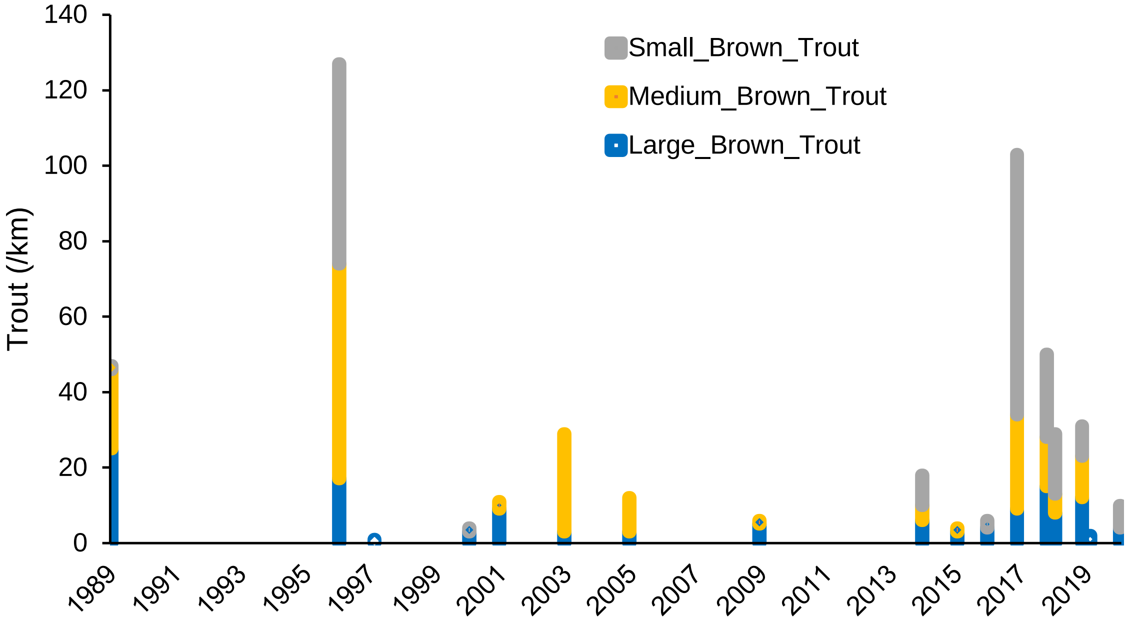

Figure 12. The abundance of large (> 40 cm), medium (20–40 cm) and small (< 20 cm) brown trout observed in the Glen Rae drift diving reach of the upper Motueka River over 1989–2020 (data from Nelson Marlborough Fish & Game).

3.7. Hydraulic-habitat modelling

One-dimensional (1-D) and two-dimensional (2-D) hydraulic-habitat models have been constructed for a 400 m reach in the Motueka River upstream of Tapawera with the aim of providing guidance on minimum flow requirements for this segment of the river (Hay & Young 2007). Flow management decisions need to consider the critical values of the segment of interest and provide flows capable of retaining a percentage of the habitat for the critical value that would be available at the mean annual low flow (MALF). The concept of critical values is based on the premise that if sufficient flow is provided to sustain the most flow sensitive, important instream value, then the other significant instream values will also be sustained. An argument can be made for adult brown trout being a critical value in the upper Motueka River because they are highly valued, common, and have the highest flow requirements of all fish known to occur there, apart perhaps from the native torrent fish, which are uncommon. Predicted habitat suitability for adult trout in the Motueka upstream of Tapawera peaks at flows just above 2 m^3/s and declines almost linearly with lower flows (Figure 13).

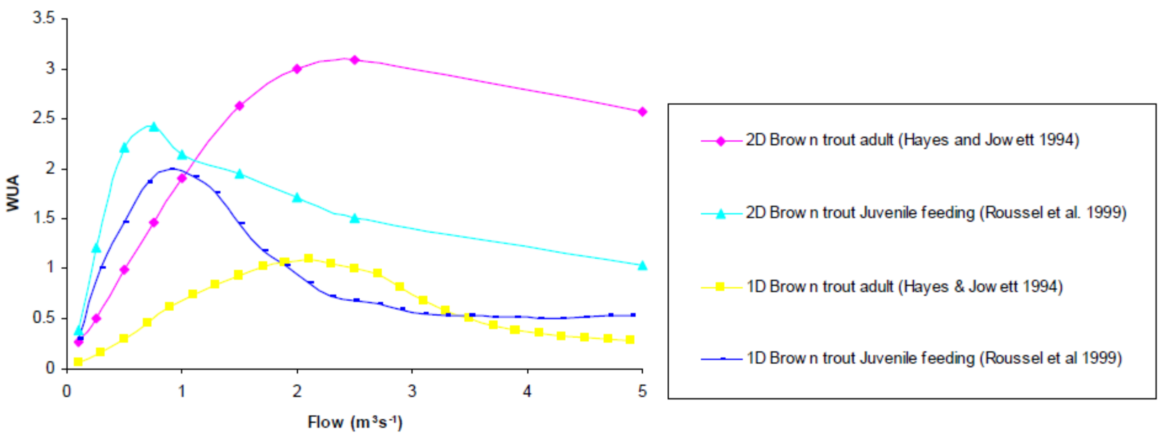

Figure 13. Predicted changes in habitat suitability (WUA) for adult brown trout and juvenile feeding, as calculated using 1-D and 2-D hydraulic-habitat models (from Hay & Young 2007).

Minimum flows can be based on the level of habitat retained at a flow relative to habitat maintained at the MALF. Research in New Zealand supports the MALF being considered an ecologically relevant flow statistic for trout and native fish species (Jowett 1992; Jowett et al. 2008), and hence an appropriate reference flow for estimating habitat retention (Figure 14). The level of habitat retention relative to habitat maintained at the MALF is somewhat arbitrary, since scientific knowledge of the response of river ecosystems, and fish populations in particular, is insufficient to identify levels of habitat below which ecological impacts will occur. A carefully designed and well-funded monitoring programme might detect effects of a 50% reduction in habitat on fish populations but is unlikely to detect effects of a 10% reduction in habitat—due mainly to the large natural spatial and temporal variability typical of fish populations. It is uncertain whether any effects of a 20% reduction in habitat on fish populations would be detectable.

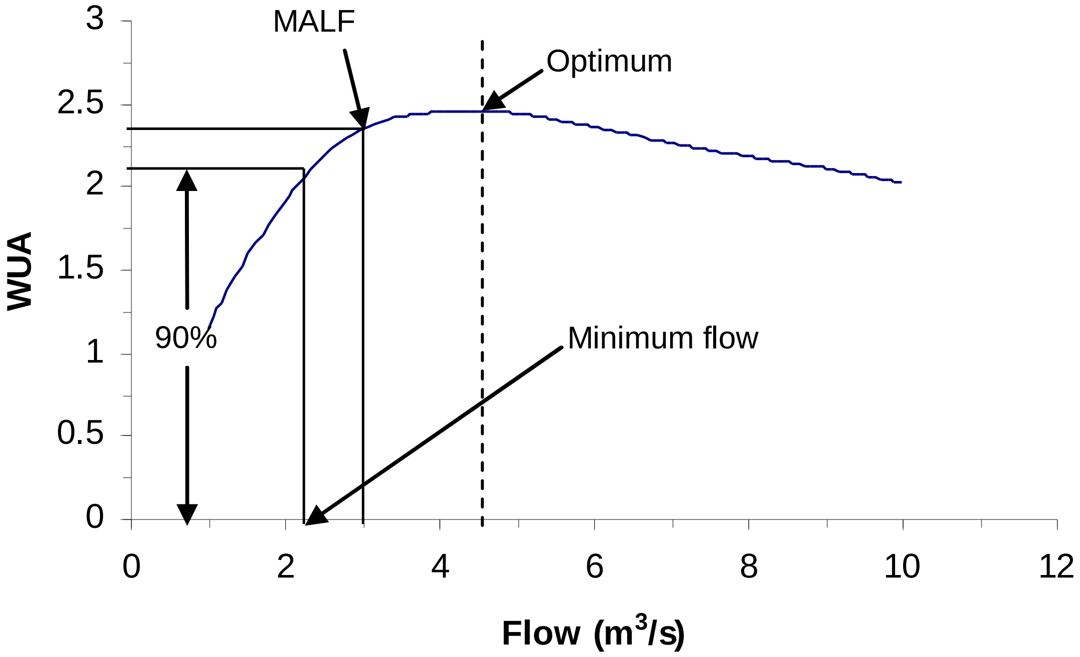

Figure 14. Derivation of a minimum flow based on retention of a proportion (90% in this case) of available habitat (WUA) that it retains relative to the habitat available at the MALF as recommended by Jowett and Hayes (2004).

The risk of ecological impact increases as habitat is reduced. When instream resource values are factored into the decision-making process, then the greater the resource value the less risk is acceptable. This concept has been adopted by several regional councils in identification of flow-critical instream values and setting minimum flow and allocation limits (e.g. Environment Southland, Greater Wellington Regional Council, Hawke's Bay Regional Council and Horizons). Applying these criteria to the Motueka River, with its highly valued trout fishery resource, would suggest a minimum flow that retains 90% of the predicted habitat available for adult brown trout at the MALF. This would give a minimum flow of 1.2 m^3/s for the segment of the Motueka River upstream of Tapawera. However, this segment, where the modelled reach was located, does not support as highly valued a fishery as downstream (e.g. around Woodstock). Consequently, a lower level of habitat retention in the Motueka River upstream of the Wangapeka confluence could be argued. For example, retention of 80% of the predicted adult trout habitat available at the MALF in this segment would require a minimum flow of 0.9 m^3/s. Natural low flows can occur during droughts regardless of water abstraction. Figure 3 shows that the only period of gauged low flows when flows less than 0.9 m^3/s have occurred was during the drought of February 2019, when the Motueka River flow at Norths Bridge was close to 0.9 m^3/s

prior to any groundwater depletion downstream. Management of water abstraction should aim to ensure that the severity and duration of effects of drought are not exacerbated by water abstraction.

The TDC updated provisions for the upper Motueka area are contained in the TRMP and came into effect in July 2017. The TRMP introduced a specific Step One rationing trigger (20% cut) for the Glen Rae and Tapawera zones based on a flow trigger of 1.4 m^3/s at the site upstream of the Wangapeka confluence. This was to better manage this segment as the previous Woodstock flow trigger can get masked by higher inputs from the Wangapeka River. Subsequent restrictions would be based on river flow recession and metered water take data from the zones and implemented through the TDC Dry Weather Task Force using the s329 water shortage direction provisions of the Resource Management Act 1991. Whilst not detailed in the TRMP, TDC staff have indicated subsequent triggers to Stage 2 (35% cut) and 3 (50% cut) are normally considered at flows of 1.2 m^3/s and 1.0 m^3/s at the site upstream of the Wangapeka confluence based on consumptive take, river flow and aquifer levels. TDC can consider further reductions including cease take beyond Stage 3 based on actual consumptive take and further river flow and aquifer level declines. The TRMP update also provided more specific (Step 1 to 3) rationing steps for the Motupiko and Rainy zones.

4. RECOMMENDATIONS ON MONITORING

In making recommendations on the monitoring programme relating to the water allocation regime in the upper Motueka River it is important to consider the likely effects of water abstraction. These effects will include reductions in river flow affecting flow velocities, depths and wetted area. As flow reduces the physical habitat available for invertebrates and fish dries up in river margins and other shallowest parts of riffles, and water quality can begin to deteriorate, with an increased risk of warmer water temperature, and larger periphyton blooms which can adversely influence daily cycles of dissolved oxygen and pH. Long periods of stable low flow can be extended with water abstraction, potentially exacerbating stress on aquatic organisms. It is important to note that all water abstraction in the upper Motueka River between the Wangapeka and Motupiko confluences is from connected groundwater rather than direct river pumping. Therefore, any effects are buffered compared to what they might be if they were direct river takes.

It is important that any monitoring data collected can be placed in the context of flow conditions and water takes up to and at the time of sampling, so meaningful comparisons of results can be made when/if the monitoring is replicated in the future. A one-off survey will have little value by itself for detecting effects of low flow, unless flow is low enough to cause catastrophic direct effects on survival via low dissolved oxygen and high water temperature. Ecological data ideally need to be complemented with flow and hydraulic geometry data[1] and ecologically relevant flow statistics (e.g. 7-day MALF) so survey data can be interpreted. To detect subtle indirect effects on density and/or population abundance, temporal, as well as spatial, variability in flows and ecological responses needs to be accounted for in study design. Monitoring and data analysis of also need to consider cumulative effects. For example, it is possible that prolonged and unrestricted abstraction of groundwater will lower groundwater levels during dry summers to such an extent that the water table would become detached from the river, turning ‘gaining’ reaches being recharged with groundwater into ‘losing’ reaches where surface water is lost to the groundwater system.

In terms of recommended ecological monitoring, linked to flow regime, an obvious starting point for choosing parameters for ecological monitoring is the Freshwater Biophysical Ecosystem Health Framework designed to meet reporting/monitoring requirements of the NPS-FM (MfE 2020; Clapcott et al. 2018). The framework highlights the five core components of ecosystem health, i.e. water quality, water quantity, physical habitat, aquatic life and ecological processes (see Clapcott et al. 2018). The report provides a template for assessing the ecosystem health of freshwater systems and is a mandatory concept underpinning monitoring and implementation of the NPS-FM 2020.

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[1] e.g. at least wetted width versus flow and mean depth versus flow.

4.1. Water quality

The current monitoring programme in the upper Motueka River between the Wangapeka and Motupiko confluences includes continuous water temperature measurements at 6 sites and continuous dissolved oxygen measurements at two sites (Figures 4, 5 and 8). Given the relatively low cost of running dataloggers for these parameters, we recommend that continuous monitoring continues, especially given that water temperatures in this segment of the river can reach levels expected to stress aquatic life. Temperature monitoring could focus on sites where highest temperatures have been previously recorded (Hyatts, Tapawera Bridge, above Tadmor confluence) and at any site used as a trigger for water rationing (above Wangapeka confluence). Correlations between water temperature and synthesised flow at each monitoring site would be useful to assess the frequency and duration of exceedances of threshold values affecting ecosystem health. This information might incentivise improvements to habitat/shading and/or reviewing minimum flow and low frequency provisions.

The March 2020 spot sampling of nutrients, water clarity and faecal indicator bacteria raised some concerns with water quality deterioration through this segment of the river (Figure 9). Additional monitoring of these parameters would be useful to determine if changes in land use within the valley that are associated with water takes and fertiliser regimes are influencing nitrate concentrations, faecal bacteria and water clarity. We recommend that at least one snapshot water quality survey along the upper Motueka segment is completed before the TRMP review. This should be done in conjunction with a proposed groundwater quality survey also due for completion before the review.

4.2. Water quantity

Water quantity monitoring in the segment of upper Motueka River between the Motupiko and Wangapeka confluences has been focussed primarily on gaugings to determine patterns of groundwater gain and loss and enable flow records and flow statistics for different parts of the segment to be estimated using the flow records from the Motueka River at Woodstock and/or the Motueka River at Gorge. These gaugings have also been critical for calibrating the groundwater-surface water model to understand how groundwater abstractions may be influencing river flows.

Ideally, it would be useful to set up a flow recording site within the segment—perhaps at Tapawera bridge—so actual flow measurements within the segment are available and accessible online, rather than relying solely on low flow gaugings used to develop synthetic flow records. This would provide a more transparent flow management regime for water rationing, providing a stable flow recording site is available.

We understand that one of the queries from Fish & Game relates to the drying zone at the lower end of the Motupiko River. This reach of the Motupiko River will dry naturally, but it is currently unclear if/how takes are contributing to the drying. Are the lengths and frequency of drying incidents extended as a result of existing takes? TDC staff have observed drying during visits to the river (Figure 15), but better information on when drying occurs would be very helpful. This could be obtained through a trial of a permanent camera set up in the lower Motupiko, and if possible also in the lower Tadmor, over the summer period (October-April). This information could be used to determine relationships between river flows at the Motupiko at Christies recorder (and Tadmor at Mudstone), water abstraction information and drying events. This information would also be useful to calibrate an updated river-aquifer model with improved representation of down-river flows (like the Waimea and Motueka Plains models) for water allocation planning and compliance purposes.

Figure 15. Photos of the lower Motupiko River close to drying (upper image 12 February 2020) and completely dry (lower image 26 February 2020).

4.3. Physical habitat

Some form of habitat assessment through the segment of interest would be advised (see Harding et al. 2009; Clapcott 2015). This would allow assessment of stream reaches to determine the extent of cold water refuges for fish during periods of high water temperatures. Critically, residual pool depth estimates for reaches should be obtained as these may give a relative indication of where aquatic life would be most vulnerable to elevated temperatures (Harding et al. 2009). Mesohabitat mapping of reaches with simple estimates of percentage cover of pools, riffles and runs would also be advised. Groynes and artificial habitat structures may also provide refuges for fish so the presence of these should be mapped out and coupled with the river surveys. This may give an indication of where new structures could be usefully deployed to protect and enhance fish populations. The effectiveness of groynes versus willow layering for maintaining habitat diversity could be considered with this physical habitat information.

There would also be some value in monitoring substrate heavy metal concentrations through the segment. There is strong evidence for high heavy metal concentrations being related to the natural sediment source in the Red Hills (Gillespie et al. 2011). However, water abstraction is unlikely to affect this.

4.4. Aquatic life

During our February 2020 survey, it was clear that periphyton changed along the segment of interest from thin mats dominated by diatoms in the upper reaches through to thicker periphyton in the lower reaches dominated by filamentous green algae and cyanobacteria. Quantification of periphyton cover at a series of sites along the segment of interest and relating this to water quality (e.g. nutrients) would be a useful addition to the monitoring.

We also recommend that routine macroinvertebrate monitoring is carried out at the top and bottom of the segment. Macroinvertebrates are robust indicators of ecosystem health and can reflect long-term water quality and physical habitat conditions that might be affected by prolonged periods of low flows, low dissolved oxygen and high temperatures. Only the most physico-chemically tolerant macroinvertebrate taxa may persist under poor water quality conditions, while more sensitive taxa will be lost.

Fish & Game has one drift dive reach within this segment of the river. Brown trout abundance seems to vary widely from year to year (Figure 12), perhaps related to recruitment success, changes in physical habitat, low flows, flooding, high temperatures or other factors. The diversity of native fish declines inland and therefore is naturally relatively low in this segment. Additional native fish monitoring would have some value, although quantitative measurements of native fish abundance would be very resource hungry given the relatively large size of the river. It is worth noting that the native fish Index of Biotic Integrity (IBI) is one of the new attributes in the NPS-FM 2020 (MfE 2020). Technological advances such as eDNA may help make fish diversity monitoring more feasible in systems like the upper Motueka.

4.5. Ecological processes

Functional indicators of ecological processes within watercourses can readily respond to changes in the river's physicochemical regime in ways that contrast with more 'static' indicators of stream structure such as water quality measurements (Young et al. 2008). A major advantage of including functional indicators in any monitoring programme is that they provide an integrated measure of ecosystem health, as they are affected by a range of biotic and abiotic variables, they can integrate environmental conditions over a significant period and they integrate responses over a diverse array of habitat types (Clapcott et al. 2018).

Ecosystem metabolism is a fundamental ecological process including gross primary productivity (GPP) and ecosystem respiration (ER) and can be used to describe how energy is created (GPP) and used (ER). Ecosystem metabolism can be calculated using continuous monitoring of dissolved oxygen, which is already being done as part of the current monitoring programme. Ecosystem metabolism is a newly proposed attribute for the NPS-FM 2020 and would be a particularly useful measure in the upper Motueka as it may well explain differences in the dissolved oxygen regime caused by changes in algal growth rates. However, further research is required to confirm rates of metabolism that are indicative of ecosystem health concerns.

4.6. Summary of monitoring recommendations

We recommend that the following elements are included in ongoing monitoring of the effects of the current water allocation regime in the upper Motueka River between the Wangapeka and Motupiko confluences:

- Continue continuous monitoring of water temperature at vulnerable sites and any site used for triggering water rationing through the segment of interest.
- Continue continuous monitoring of dissolved oxygen at the upper and lower ends of the segment.
- Continue low flow gaugings to maintain and improve relationships between river flow in this segment and permanent flow recording sites.
- Continue the requirement for water take monitoring by all consent holders.
- Conduct a trial installation of fixed cameras to record the incidence of river drying in the lower Motupiko and lower Tadmor rivers.

- Build an updated river-aquifer model with improved representation of surface water and groundwater exchanges to improve understanding of the relationship between river flow, groundwater levels, water takes and river drying and to assist with water allocation planning and compliance. The model would use river drying information from the cameras along with information on river flows, groundwater levels, river cross-sections, rainfall recharge and groundwater abstraction to evaluate water table and river flow responses to changes in water takes. It could later be extended to evaluate nutrient transport from land uses to the aquifer and river(s) for water quality management purposes.
- Initiate annual monitoring in summer of water clarity, nutrients, faecal indicator bacteria, macroinvertebrate community and periphyton cover at the top (Motueka upstream of Motupiko confluence) and bottom (Motueka upstream of Wangapeka confluence) of the segment.
- Conduct a snapshot summer survey of surface water quality at multiple sites along the upper Motueka River during low flows at least once prior to the review of the TRMP in conjunction with a planned groundwater quality survey of the Tapawera Plains.

The following elements would be useful additions to the monitoring programme:

- Conduct physical habitat assessments along the segment to assess the presence of cool water refuges and the benefits of groyne placement on pool formation.
- Calculate ecosystem metabolism during low flow periods using the dissolved oxygen data collected at the upper and lower ends of the segment.
- Consider assisting with Fish & Game drift dives to assess trout abundance in the Glen Rae dive reach.

Other, lower priority, considerations for the monitoring programme (perhaps requiring central government funding) could include:

- Install a new permanent flow recording site within the segment
- Monitor heavy metal concentration in riverbed sediments to add to existing data from ICM research, and identify any trends in nickel and chromium concentrations
- Conduct surveys of native fish to build knowledge of their diversity and abundance in the segment.

To date water temperature has been monitored over 5 summers at up to 6 sites through the upper Motueka River. Dissolved oxygen concentrations have been monitored only over one summer.

We recommend that an additional three years of data collection is completed so a range of dry, wet and ‘average’ years are covered by the monitoring programme prior to the review of the TRMP. This will enable an updated river aquifer model to be built to provide better information to guide water allocation planning and compliance.

In 2024, all data gathered as part of the monitoring programme, in addition to other relevant information, should be thoroughly analysed to identify any instream effects of the water allocation regime in the upper Motueka River.

It is difficult to estimate the cost of the review at this stage, but the cost of the external reviewer/s alone could be in the order of about $50–70K. There will also be staff/lab time and modelling costs for TDC associated with the monitoring programme.

5. REFERENCES

Clapcott J 2015. National rapid habitat assessment protocol development for streams and rivers. Prepared for Northland Regional Council. Cawthron Report No. 2649. 29 p. plus appendices.

Clapcott J, Young R, Sinner J, Wilcox M, Storey R, Quinn J, Daughney C, Canning A 2018. Freshwater biophysical ecosystem health framework. Prepared for Ministry for the Environment. Cawthron Institute Report No. 3194

Davie T, Young R, Hong T, Olsen D, Stewart M, Fenemor A 2008. Conceptual model linking instream ecology to numerical groundwater-surface water interaction model. Motueka Integrated Catchment Programme Report Series. June 2008.

Ekanayake J, Fenemor A, Payne J 2016. A tool to estimate ground water recharge from hillslopes to shallow foothill aquifers. Landcare Research contract report LC2478 for Envirolink. 41p.

Fenemor A, Thomas J 2013. Water Allocation Limits for the Upper Motueka Catchment. Prepared for Tasman District Council. Landcare Research Contract Report: LC 1631. 22 p.

Gillespie PA, Forrest RW, Peake BM, Basher LR, Clement DM, Dunmore RA, Hicks DM 2011. Spatial delineation of the depositional footprint of the Motueka River outwelling plume in Tasman Bay, New Zealand. New Zealand Journal of Marine and Freshwater Research 45: 455-475.

Gusyev M, Toews M, Daughney C, Hong YS, Minni G, Fenemor A, Ekanayake J, Davie T, Basher L, Thomas J 2012. Modelling groundwater abstraction scenarios using a groundwater-river interaction model of the Upper Motueka River catchment. Journal of Hydrology New Zealand 51: 85-110.

Harding J, Clapcott J, Quinn J, Hayes J, Joy M, Storey R, Greig H, Hay J, James T, Beech M, Ozane R, Meredith A, Boothroyd I 2009. Stream habitat assessment protocols for wadeable rivers and streams of New Zealand. University of Canterbury. 133 p.

Hay J, Young R 2007: Instream flow modelling and its application in the Motueka catchment. Prepared for Motueka Integrated Catchment Management Programme. Cawthron Report No. 1073. 34 p. plus Appendices.

Hong T, Minni G, Ekanayake J, Davie T, Thomas J, Daughney C, Gusyev M, Fenemor A; Basher L 2010. Three-dimensional finite-element transient groundwater-river interaction model in a narrow valley aquifer system of the upper Motueka catchment. GNS Science Report 2010/211, August 2010. 77 p.

James T, McCallum J 2015. State of the Environment Report; River Water Quality in Tasman District 2015. Prepared for Tasman District Council. 397 p.

Jowett IG 1992. Models of the abundance of large brown trout in New Zealand rivers. North American Journal of Fisheries Management 12: 417-432.

Jowett IG, Hayes JW 2004. Review of methods for setting water quantity conditions in the Environment Southland draft Regional Water Plan. NIWA Client Report HAM2004-018, Prepared for Environment Southland. 81 p.

Jowett IG, Hayes JW, Duncan MJ 2008. A guide to instream habitat survey methods and analysis. NIWA Science and Technology Series 54, NIWA Wellington. 121 p.

Ministry for the Environment 2020. National Policy Statement for Freshwater Management.

Olsen DA, Young RG 2009. Significance of river-aquifer interactions for reach-scale thermal patterns and trout growth potential in the Motueka River, New Zealand. Hydrogeology Journal 17: 175-183.

Olsen DA, Tremblay L, Clapcott J, Holmes R 2012. Water temperature criteria for native aquatic biota. Prepared for Auckland Council, Waikato Regional Council and Hawke’s Bay Regional Council. Auckland Council Technical Report 2012/036.

Stark JD, Maxted JR 2007b. A user guide for the Macroinvertebrate Community Index. Prepared for the Ministry for the Environment. Cawthron Report 1166. 58 p.

Theurer FD, Voos KA, Miller WJ 1984. Instream water temperature model. Instream flow information paper 16. United States Fish & Wildlife Service, Fort Collins, Colorado, USA.

Young RG, James T, Hay J 2005. State of surface water quality in the Tasman District. Tasman District Council State of the Environment Report. Cawthron Report No. 933. 69 p. plus appendices.

Young RG, Matthaei CD, Townsend CR 2008. Organic matter breakdown and ecosystem metabolism: functional indicators for assessing river ecosystem health. Journal of the North American Benthological Society 27: 605-625.

Young RG, Doehring KAM, James T 2010. State of the environment report; River water quality in Tasman District 2010. Prepared for Tasman District Council. Cawthron Report No. 1893. 165 p. plus appendices.