2 June 2016 ID: 1620

Becky Marsay
Assets Engineer - Utilities
Nelson City Council
PO Box 645
Nelson
NEW ZEALAND

Dear Becky

INFLUENCE OF CHANGES OF MAITAI DAM OPERATIONS ON WATER QUALITY IN THE MAITAI RIVER AND RESERVOIR

This memo has been prepared at the request of Nelson City Council to clarify and predict the outcomes of modifying operations of the Maitai Dam (as proposed in Cawthron AEE: Kelly et al. 2016) and the effects that it may have on the water quality in the Reservoir and its downstream receiving environment. Specifically the following two questions have been raised for clarification:

1. How are present operations of the Maitai Dam affecting water quality in the Maitai Reservoir and downstream river relative to water standards cited in the Nelson Resource Management Plan (NRMP) for class C and B waters?

2. What improvements in water quality outcomes relative to the NRMP water standards could be made under the proposed mitigation outlined in the Maitai Municipal Water Supply AEE (Kelly et al. 2016)?

Water Management Zones

As outlined in the Maitai Municipal Supply AEE, the Upper Maitai River Catchment encompasses two water management classes in the NRMP, separated by the Conservation Zone of the Maitai Catchment (Map Bundle- Map 5). Upstream of the Maitai Reservoir and South Branch weir, all waters fall within the conservation zone and are designated Class A waters within the NRMP. All waters downstream (including) from the Maitai Reservoir and South Branch weir are considered Class C waters in the NRMP.

Water classifications within the NRMP are intended to reflect current state of water quality at the time the classification was reported in 2007 (Wilkinson 2007) and were not intended to comprise a planning objective or aspirational level of water quality. However, the NRMP also provides directions on the “priority for improvement”. In the case of the relevant reach the priority is “third” and to “upgrade to B where practicable” (Appendix 28.4 NRMP). The NRMP also contains district-wide policies (e.g. DO19.1.4 and DO19.1.6) that seek the improvements in water quality. As such, water quality standards for the Maitai Reservoir and downstream waters were evaluated under the proposed improvement options in terms of the likelihood of meeting water standards for Class B waters, considered to have “very good” water quality.

Water Quality under existing operations of the Maitai Dam

Water quality conditions in the Maitai River and Reservoir under existing operations were evaluated using consent monitoring data and detailed water quality investigation data collected over the past 15 years' dam operations, in the period 2000–2015 (Table 1). Most of these data, and their status relative to water standards cited in the NRMP, are contained in the AEE (Kelly et al. 2016) with sections denoted in footnotes within the table. However, a number of parameters cited in the NRMP have not been monitored as part of consent monitoring (or further investigations) and therefore expert knowledge was used to make predictions of the likelihood of these standards being met or breached. For some parameters there was limited monitoring data for portions of Maitai River, mostly for reaches downstream of the Forks. In cases where there was limited data on which to base these predictions, the table entry was qualified as being data deficient (DD).

Under existing operations of the Maitai Dam, NRMP Class C water standards were achieved for 9 of the 12 standards cited relative to the Maitai Reservoir, for 13 of the 16 standards relative to the Maitai South Branch, and for 14 of the 16 standards relative to the Maitai River downstream of the Forks (Table 1). Generally speaking, water standards were mostly achieved for waterborne disease (faecal contamination), toxic algae, turbidity, temperature, nutrients, periphyton, and objectionable materials (scums or grease). Water quality conditions under existing operations did not achieve the NRMP standards for dissolved oxygen, toxicants (trace metals), and potentially water colour due to inputs of humic materials from the reservoir.

It is worth noting that several of the criteria cited in the NRMP are likely to be inapplicable to the Upper and Middle Maitai River due to natural water quality conditions that render water qualities outside of the cited limits; nor are they mediated by the presence of the Maitai Dam. This included NRMP standards for dissolved oxygen in Class C waters, which appears overly restrictive: citing conditions within a range >90% saturation. This is not achieved in the Maitai South Branch or in the Maitai Reservoir, and is likely not achieved for many unmodified rivers in the Nelson region. The NRMP water clarity and colour standards are unlikely to be met because of natural humic materials (derived from beech-forest catchment drainage in the North Branch) that are stored in the Reservoir following flood events. While these diminish water clarity, this occurs in throughout beech-forest drainage areas in New Zealand and is not associated with degraded water quality conditions. Lastly NRMP standards for toxicants (in sediment) are not met throughout the Maitai Catchment due to the occurrence of high chromium and zinc content of the mineral-rich geology of the Dun Mountain mineral belt which surrounds the headwaters. This results in elevated sediment trace-metal concentrations over most of the Maitai River (Sneddon and Elvines 2012).

Should these factors be taken into account, we would suggest that NRMP water standards for C Class waters were achieved for 7 of the 9 standards relative to the Maitai Reservoir, and all 13 standards relative to the Maitai South Branch (below the weir) and main stem downstream of the Forks.

Table 1. Existing and predicted water quality outcomes for the operation of the Maitai Dam under proposed mitigation options outlined in the Maitai Municipal Supply AEE (Kelly et al. 2016) relative to water standards cited in the Nelson Resource Management Plan (NRMP). Note that cells are highlighted based on existing operations achieving NRMP standards of A & B Class(green) C class (orange) or D class (red). Also highlighted are probabilities of mitigation options (i.e., backfeed management, destratification aeration, hypolimnetic aeration) resulting in operations meeting the Class B NRMP standards being either low (pink), moderate (purple) or high (aqua) probability.

	South Branch				**Reservoir**				**Downstream of Forks**			
	Existing (water standard)	Backfeed Management (probability of meeting Class B)	Destratification aeration (probability of meeting Class B)	Hypolimnetic aeration (probability of meeting Class B)	Existing (water standard)	Backfeed Management (probability of meeting Class B)	Destratification aeration (probability of meeting Class B)	Hypolimnetic aeration (probability of meeting Class B)	Existing (water standard)	Backfeed Management (probability of meeting Class B)	Destratification aeration (probability of meeting Class B)	Hypolimnetic aeration (probability of meeting Class B)
Waterborne disease risk[0]	A^{DD}	H	H	H	A^{DD}	H	H	H	A^{DD}	H	H	H
Toxic algae[1]	A	NA	NA	NA	A^{DD}	NA	NA	NA	A	NA	NA	NA
Dissolved oxygen[2]	D	L	L	M	<D	L	H	H	C^{DD}	L	L	M
Turbidity[3]	B	H	H	H	NA	NA	NA	NA	B	H	H	H
Clarity[4]	C^{DD}	M	H	H	C	L	L	L	B^{DD}	H	H	H
Colour[5]	?^{DD}	?	?	?	NA	?	?	?	?^{DD}	?	?	?
Temperature[6]	B	L	H	H	NA	NA	NA	NA	C	L	H	M
pH[7]	A	H	H	H	A	H	H	H	A^{DD}	H	H	H
Periphyton[8]	C	L	M	M	NA	NA	NA	NA	C^{DD}	L	M	M
Nutrients[9]	B	H	H	H	C	L	M	M	B^{DD}	H	H	H
Toxicants (water)[10]	C	L	H	H	<D	L	H	H	B^{DD}	H	H	H
Toxicants (sediment) [11]	<D	L	L	L	<D	L	L	L	<D	L	L	L
Objectionable material [12]	A	H	H	H	A	H	H	H	A	H	H	H
Aesthetic[13]	C	M	H	H	A	H	H	H	A	H	H	H
Macroinvertebrates[14]	C	M	H	H	NA	NA	NA	NA	C^{DD}	M	H	H
Aquatic habitat[15]	C	M	M	M	C	L	H	H	C	M	M	M

DD= data deficiency reduces certainty around evaluating this standard, NA= Not applicable to the water class, ? = Unknown, L = low probability, M = moderate probability, H= high probability of meeting Class B water standards

Table references

[0] Not presently monitored, but based on low waterfowl numbers and limited human use it is expected these waters will meet NRMP standards

[1] AEE Sections 2.2.5 and 2.6.5; noting that the NRMP standards of no toxic algae detected in 100 ml of water poorly aligns with national standards for benthic cyanobacteria which cites that no more than 60% coverage of the riverbed by potentially toxic species (MfE 2009). Cyanobacteria toxicity risk is now commonly assessed using periphyton cover rather than water column samples, and therefore we have not been able to assess this standard. Based on periphyton cover data collected routinely at the site, there were no instances in which cyanobacteria mat cover in the South Branch or downstream of the Forks exceeded the MfE criteria, and therefore we assume a Class A standard is met for the Maitai River downstream of the dam. No toxic cyanobacteria have been found in the reservoir.

[2] AEE Sections 2.2.3, 2.5.3, Table 25; noting that Class C standards for minimum daytime DO of not less than 90%saturation is regularly breached during summer periods in the South Branch downstream of the backfeed. No data are available downstream of the spillway, but it is anticipated that Class C standards are also not met. It is worth noting that overall, the NRMP DO standards are very stringent and are frequently not met even in portions of the river upstream of the South Branch backfeed weir. The NRMP Class C standards for DO in reservoirs of between 90–110% saturation is not specified for depth or season, which would be expected to naturally cause fluctuations in DO in thermally stratified lakes (i.e., lakes > 10m depth) outside of these limits. Mitigation options of destratification or hypolimnetic aeration in the reservoir could result in NRMP standards for Class B (mean daily DO of 98–105%) being met over most portions of the water column, and lessen the more severe effects of reservoir deoxygenation that presently occur.

[3] AEE Section 2.5.5; noting that consented discharge conditions for the Maitai dam cite an allowable increase of 10NTU, which far exceeds the NRMP Class C standards for mean turbidity of 3 NTU. Presently conditions downstream of the backfeed and spillway discharges meet both the consented limits and the NRMP standards for Class B waters of 2 NTU (turbidity increased backfeed on average by 0.53 NTU below the backfeed to 1.10 NTU (mean 2000-2015 monthly data). It is expected that all the options could improve turbidity conditions in the South Branch to meet NRMP standards by reducing trace metal flocculent material discharged to the river via the backfeed.

[4] AEE Figure 11E; noting that water clarity as black disk measurement has not been conducted downstream of the Maitai Dam. Based on Secchi disk monitoring conducted in the Maitai Reservoir, due to natural humic materials derived from beech-forest catchment drainage, the aspirational Class B NRMP standard of 4 m Secchi may not be met, but the C class standard of 2.5 m is met. The discharge of these humic materials downstream affects river water clarity downstream, but assuming the mitigation options result in no iron flocculent material discharged via the backfeed, it is probable that the 4 m clarity standard would be met in the South Branch downstream of the backfeed. Downstream of Forks it is probable that the Class B standard of 4 m is presently met and would likely improve under any of the proposed mitigation options. No mitigation options proposed address water clarity changes caused by natural humic materials so therefore the only improvements in water clarity can be achieved through minimising trace metal discharges that flocculate in the oxic river environment downstream.

[5] No colour data have been collected as part of the Maitai Dam consent monitoring. Therefore it is unknown if colour NRMP standards of no more than a five Munsell points change are met downstream of the backfeed or spillway. As previously discussed, natural humic materials derived from

beech-forest catchment drainage affect colour within and downstream of the Maitai Reservoir. No mitigation options proposed address these changes related to humic materials, and it is uncertain if these standards could ever be met.

[6] AEE Section 2.5.2 and 3.1.1; noting that the NRMP C Class standards (daily mean 22 °C, daily maximum 27 °C) are met throughout the river downstream of the dam. The aspirational NRMP Class B daily maximum standard of 24 °C (downstream of Forks) is exceeded occasionally in late summer (due to the effect of the warm surface outflows from the Reservoir) can affect river temperatures during mid-summer when flows are sufficient to operate the spillway. Mitigation options will vary in regards to their influence on downstream river temperature ranges, discussed in detail in Section 3.1.1 and depend on how the backfeed is operated.

[7] pH is not monitored as part of consent conditions, but based on Maitai Reservoir water column profiles conducted between 2013–2015 it is expected NRMP standards for pH between 7.2–9 are met (Kelly unpublished data).

[8] AEE Section 2.6; noting that periphyton standards cited in the NRMP of <60% cover by medium-thickness mats and < 30% cover by long filaments (both South Branch downstream of the Forks) are exceeded on occasion, usually during summer. Mitigation measures proposed to reduce the discharge of toxicants (dissolved metals and nutrients) from the backfeed are anticipated to improve periphyton conditions downstream of the backfeed and spillway. It is anticipated that reservoir mixing or hypolimnetic aeration would cause more pronounced improvements.

[9] AEE Sections 2.2.3, 2.5.6; noting that nutrient concentrations in the South Branch presently meet NRMP Class B standards of 9 and 120 µg/l for dissolved reactive phosphorus (DRP) and dissolved inorganic nitrogen (DIN) respectively. Reservoir concentrations exceeded NMRP Class B standards for Total Nitrogen of 160 µg/l, but do not breach the Class C TN standard of 250 µg/l. Some possible improvements in reservoir nutrient concentrations could be achieved by the reservoir mixing or aeration mitigation options that would limit nutrient recycling from reservoir sediments, but these improvements are anticipated to be minor. This could further improve nutrient concentrations downstream.

[10] AEE Sections 2.2.3, 2.5.4; noting that iron and manganese concentrations in the Reservoir and backfeed waters are elevated in excess of NRMP Class D concentrations cited in ANZECC 2000 (ANZECC 90% protection level) and in other international standards during periods in which bottom waters become hypoxic (< 50% DO saturation). The options for reservoir mixing or aeration is expected to eliminate this problem and would improve concentrations in water and sediment downstream. It is expected that flocculation of trace metals results in the South Branch meet the Class C standards outside of the 100 m mixing zone. Downstream of the Spillway and Maitai Forks the NRMP Class B standards (ANZECC 95% protection level) are likely to be met, noting limited data availability.

[11] AEE Sections 2.2.4, 2.5.4; noting that concentrations of chromium and zinc in river and reservoir sediments exceed all NRMP standards set at the high trigger points cited in ANZECC 2000 guidelines. All other toxicants sampled met ANZECC criteria. These exceedances for chromium and zinc are not related to the Maitai Dam, and occur because of catchment drainage and erosion from the Dun Mountain mineral-rich areas. None of the mitigation options proposed would affect the issue of naturally high sediment trace metals, and it is not expected that these NRMP standards could be met in the Upper Maitai Catchment.

[12] Not addressed in Maitai Dam consent monitoring, but based on repeated site visits there have been no records of objectionable materials related to the Maitai Reservoir or downstream discharges.

[13] Aesthetics have not been specifically addressed in the AEE or through consent monitoring. Based on the occurrence of iron staining of the riverbed downstream of the backfeed beyond the mixing zone indicates aesthetics appear to be affected, suggesting that a NRMP Class B standard would not be met (objectionable odours or sights) but that a Class C standard (no impairment of water use or fish tainting) is met. Hydrogen sulphide odours that occur in late summer when the backfeed discharges anoxic water also impairs aesthetics over a period of around 1 month (April). Reservoir mixing or hypolimnetic aeration options are expected to completely eliminate these occurrences. Backfeed management to discharge from oxic layers of the reservoir could minimise these effects but may not be able to fully eliminate them, as there is sulphurous odours around reservoir mixing periods in autumn.

[14] AEE Section 2.7; noting that macroinvertebrate communities in the South Branch below the backfeed are continuing to trend lower and no longer meet the NRMP Class B standard of 100 MCI and 5 QMCI. The NRMP class C standard of 80 MCI and 4 QMCI is achieved presently, but could trend lower if operations were left as status-quo. Limited data have been collected in the immediate reaches downstream of spillway (below Forks) but the limited existing data suggest that conditions are around or slightly below the NRMP Class B standard of 100 MCI and 5 SQMCI in this portion of the river (Allen et al. 2014). Improvements in water quality and periphyton cover associated with the three mitigation options are expected to moderately improve macroinvertebrate community metric scores, and could potentially meet the cited NRMP Class B standards.

[15] AEE Section 2.8.2 relating to fish passage; noting in the NRMP that aquatic habitat functions are not impaired (pertains to both Class B and C waters). The presence of the spillway has impaired fish passage to the North Branch and the backfeed weir has been a partial passage barrier and at times provides chemical barrier. In the Maitai Reservoir, the combination of high water temperatures in surface layers and anoxic conditions at depth render the Reservoir poorly suited to sensitive aquatic life such as fish and potentially other aquatic invertebrate species. Improvements to water quality in both the Reservoir and its associated backfeed discharge, as well as fish passage improvements cited in the AEE could remediate these effects.

Improvements in Water Quality under proposed mitigation options

Under the NRMP, the intention of the plan was to maintain and improve water quality conditions relative to existing state. In this context, mitigation options proposed for the operation of the Maitai Dam were evaluated in terms of water quality conditions in the Maitai Reservoir and downstream river environment achieving standards cited for Class B waters (very good condition), or at a minimum, maintaining Class C grades.

Significant improvements in the Upper Maitai River, and to some extent the Middle Maitai River, are expected to occur under all of the proposed mitigation options identified in the Maitai Municipal Supply AEE (Kelly et al. 2016). The option around management of the backfeed to source waters only from oxic layers of the reservoir would improve conditions around clarity, aesthetics (iron staining), macroinvertebrates, and aquatic habitat, but there could be some minor adverse water temperature effects.

Based on predicted improvements in water quality conditions of backfeed water, we predict that in the South Branch there is a medium probability that 4 out of the 7 existing NRMP water standards that are currently Class C (or worse) will be improved to Class B. We also predict that in the Maitai River below the Forks there is a medium or high probability that 2 out of the 5 existing NRMP water standards that are currently Class C (or worse) will be improved to Class B. (These do not include the sediment trace metals which are naturally elevated.) With only management of the backfeed there will be no change in the 5 standards in the Reservoir that are currently Class C or lower.

For the aeration destratification and hypolimnetic aeration mitigation options which are aimed at reversing water quality issues associated with reservoir stratification and anoxia, these options would result in much wider improvements in water quality relative to the NRMP. Both options would significantly improve conditions for turbidity, clarity, temperature, toxicants in water (trace metals, nutrients), aesthetics, periphyton, macroinvertebrates, and aquatic habitat. Moreover, these improvements would be more widespread, by improving conditions in the river downstream of the backfeed as well as within the Reservoir.

Under these options we predict a moderate or high likelihood that 7 out of the 8 existing NRMP water standards in the South Branch that are currently Class C (or worse) will be improved to Class B. We also predict a moderate or high likelihood that 4 out of the 5 existing standards in the Maitai Reservoir that are currently Class C or less will be improved to meet Class B. And finally we predict a moderate to high likelihood that all 5 parameters that are currently Class C or less in the Maitai downstream of the Forks will be improved to Class B. (These do not include the sediment trace metals which are naturally elevated.)

Nelson City Council is presently in the process of developing their second generation water plan. Through this process it is expected that some of the water standards presently applied to the Upper Maitai Catchment will be more closely examined in terms of their applicability and achievability for these outcomes. It might be expected that some of the standards that are presently unable to be met because of natural factors (e.g., high sediment trace metals, humic colouration affecting water clarity) will be evaluated and improved upon in order to plan for more achievable outcomes. Newer generation water plans are also more inclined to set standards relative to percentiles (90^{th} percentile numbers) rather than absolute limits, recognising that extreme conditions associated with climate variation and disturbance events (e.g., floods and droughts) can result in atypical conditions that are likely to breach absolute standards. It is expected following this approach that NRMP standards for some of the parameters that presently are not met in the Maitai (e.g., water clarity, dissolved oxygen) could be established with better recognition of natural variability that might cause these standards to be breached.

It may also be that the community aspirations (expressed through the second generation water plan) for improvement in water quality may also have changed. This is already evidenced through

community groups such as Friends of the Maitai and community involvement in improvement projects overseen by Project Mahitahi.

Overall, the mitigation options proposed in the AEE for the Maitai Municipal Supply scheme are likely to achieve significant gains in terms of their water quality outcomes and be compatible with the goals of managing and improving aquatic habitats of the Upper Maitai Catchment as a high value freshwater system.

We trust the information provided in this letter provides a suitable level of detail required to address the questions identified. If you require further information to address any questions relating to our response, please feel free to contact us.

Yours sincerely

Scientist

Dr David Kelly
Senior Freshwater Scientist
Team Leader- Freshwater Ecosystems
Cawthron Institute, Nelson

Reviewed by

Roger Young
Group Manager Coastal & Freshwater
Cawthron Institute
Nelson

References

Allen C, Kelly D, Holmes R, Jiang W 2014. Longitudinal assessment of the health of the Maitai River: the influence of the Maitai reservoir. Prepared for Nelson City Council. Cawthron Report No. 2552. 40 p. plus appendices.

ANZECC 2000. Australian and New Zealand Guidelines for Fresh and marine water quality. Australia and New Zealand Environment and Conservation Council and Agriculture and Resource Management Council of Australia and New Zealand.

Kelly D, Hay J, Shearer K, Allen C, Holmes R 2016. Maitai River municipal supply aquatic ecology — summary of environmental effects. Prepared for Nelson City Council. Cawthron Report No. 2810. 182 p. plus appendices.

Ministry for the Environment 2009. New Zealand guidelines for cyanobacteria in recreational freshwater waters. Interim Guidelines. Ministry for the Environment and Ministry for Health, Wellington.

Sneddon R, Elvines D 2012. Sediment contaminant levels in the Nelson Area catchments: 2012. Prepared for Nelson City Council. Cawthron Institute. 46 p. plus appendices.

Wilkinson J 2007. Updated freshwater classifications for Nelson. Cawthron report 1349, 58p.