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Te Whatu Ao

Managing nuisance periphyton in the Lower Waiau River

Management and monitoring 2025–26

Prepared for Meridian Energy Limited

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Executive summary

Flows in the Lower Waiau River are managed by Meridian Energy Limited (Meridian) as part of the Manapōuri Power Scheme (MPS). Since 2013, Meridian's consent for the Manapōuri Tailrace Amended Discharge (MTAD; Water Permit 206156, Condition 7) has required periphyton monitoring and management to be undertaken in accordance with a protocol for controlled releases of voluntary supplementary flows from the Manapōuri Lake Control (MLC) structure (Appendix A). Supplementary flows of sufficient magnitude can reduce periphyton standing crop in the Lower Waiau River downstream of the MLC, although these effects are generally temporary.

The protocol outlines the monitoring and decision-making processes used to guide supplementary flow releases when periphyton cover approaches predefined nuisance levels during the spring, summer, and autumn monitoring period (1 November to 31 May). These nuisance levels are represented by amber and red river status, in contrast to green status when periphyton cover is low. The protocol specifies monitoring at three sites in the Lower Waiau River (Excelsior, Monowai, and Clifden) and a control site in the Mararoa River (Station Bridge). Surveys comprise visual assessments of periphyton cover, from which a periphyton standing crop index (SCI) is calculated for each site and sampling date. Water clarity is also measured.

The fortnightly monitoring programme is linked to flow assessments, with flow conditions and results from previous surveys determining whether a survey is required. Following each survey, SCI values are used to assign the river to one of three status categories: green (low SCI and acceptable conditions), amber (increasing SCI and consideration of a supplementary flow), or red (unacceptable SCI and release of a supplementary flow if conditions allow). The protocol also sets out the procedures and conditions under which supplementary flows may be released.

This report fulfils a consent requirement that the results of all monitoring undertaken in accordance with the protocol be forwarded to Environment Southland annually. The report covers the season from November 2025 to May 2026, which was the 20th season of regular monitoring, and the 14th since the protocol was first implemented.

The protocol (Appendix A) specifies that Meridian considers releasing four supplementary flows in each season (with a fifth considered in May) if the SCI conditions require and if the lake levels and electricity supply circumstances allow. In practice, achieving four releases has been uncommon, largely because lake levels are often too low to enable a supplementary flow when periphyton reaches red status. The protocol defines a typical supplementary flow release as a flow event that peaks between 160 and 230 m^3/s and achieves a mean flow of 120 m^3/s over a 24-hour period. The protocol also provides for variable supplementary flow releases, which do not meet these criteria but may still be beneficial for periphyton management.

In the previous (2024–25) monitoring season, a proactive approach to supplementary flow management was trialled. Under this approach, supplementary flow releases were considered at pre-scheduled times, subject to suitable lake levels, including periods when the river remained at green status. The anticipated benefits were that releases could occur when periphyton cover and SCI values were still relatively low, potentially

slowing subsequent periphyton growth, extending green status, and increasing the number of supplementary flows within a season. Two of the four supplementary flows in 2024–25 were implemented before red status developed, and these releases may have contributed to maintaining green status for longer. Based on this outcome, it was agreed that the proactive approach to supplementary flow management would be continued during the 2025–26 season.

An additional monitoring site was trialled at Excelsior during the 2025–26 season. The site, located ~70 m downstream of the established Excelsior monitoring site, was added to investigate whether channel changes observed at the existing site may have altered its response to flow disturbances over time making it less susceptible to the effects of high flows than in the past and therefore potentially less representative of responses to supplementary flow releases. Monitoring at both locations allowed for a comparison of periphyton development and responses to flow events, with particular emphasis on whether the new site showed development of nuisance periphyton communities characteristic of the reach and better periphyton removal during high flows.

During the 2025–26 monitoring season, mean flow at MLC (140 m^3/s) was more than double the long-term average (67 m^3/s), while the percentage of time under high flows (>3 × median flow) was also substantially higher than average (39% compared with 20%). From 18 February 2026, as part of the Manapōuri Lake Control Improvement Project (MLC:IP), flows at MLC were managed to vary with Mararoa River flows plus 5 m^3/s to meet consent requirements. This requirement was in place for the remainder of the 2025–26 monitoring season. The season was classed as a high-flow season based on flows at MLC. Mean flow in the Mararoa River was slightly above average, whereas mean flow in the Lower Waiau River at Sunnyside was the second-highest recorded since monitoring began. Elevated flows in the Lower Waiau River reflected contributions from both Lake Manapōuri and the Mararoa River, together with above-average inflows from tributaries downstream of the MLC.

Twelve periphyton surveys were carried out during the monitoring season, between 9 January and 28 May 2026. Overall, SCI in the Lower Waiau River was at green status for an estimated 61% of the time (above average), amber status for 19% of the time (about average), and red status for 20% of the time (below average). Two supplementary flow releases were undertaken, together with one augmented natural flow event. Proactive supplementary flow releases were considered at times but did not occur for different reasons. The season unfolded as follows:

- Following a prolonged lake spill from late September 2025 to early January 2026 and a second spill during January (which delayed the commencement of monitoring), the first five surveys (9 January, 23 January, 5 February, 17 February and 3 March) returned green status. Periphyton development was unusually slow at all sites, with the field team noting very little growth through January and early February. By the survey on 3 March, SCI had increased substantially at Excelsior and Monowai but the river remained at green status.

- Based on increasing SCI and suitable lake levels, planning proceeded for a supplementary flow release. A pre–release survey on 17 March returned red status, with substantial increases in SCI across the Lower Waiau River. A supplementary flow release was undertaken on 19–20 March using a variable hydrograph (peak flow of 109 m^3/s, maximum 24–h mean flow of 104 m^3/s, 3.46 GWh water), followed by a recreational flow release on 22 March. The post–release survey on 25 March returned amber status. SCI declined significantly at both Excelsior sites and at Clifden but increased at Monowai.
- Amber status persisted through the survey on 9 April. A second supplementary flow release was undertaken on 9–10 April using a larger variable hydrograph (peak flow of 159 m^3/s, maximum 24–h mean flow of 132 m^3/s, 4.39 GWh water). The post–release survey on 14 April also returned amber status. SCI declined at both Excelsior sites and at Monowai, but increased at Clifden where thick didymo mats continued to develop.
- Following the 14 April survey, Meridian augmented a natural fresh in the Mararoa River by releasing additional flow from the MLC between 17 and 22 April. The combined event peaked at 103 m^3/s and used 2.42 GWh of storage water. The next survey, undertaken on 30 April, returned red status. SCI increased at both Excelsior sites and at Clifden, but declined at Monowai.
- Red status persisted through the final two surveys (14 and 28 May). Lake levels remained too low to enable a supplementary flow release of sufficient magnitude to meaningfully affect periphyton, and no further releases were undertaken. SCI continued to increase at Monowai and Clifden through to the end of the monitoring season.

Periphyton development during 2025–26 differed markedly from recent years. Didymo establishment was delayed at all sites, particularly at Clifden, which remained unusually bare through much of summer. From March onwards, didymo cover increased steadily and persisted through to the end of the season. Monowai and Clifden were characterised by extensive thick didymo mats later in the season, whereas the Excelsior sites supported a greater proportion of sludge, mixed mats and *Microcoleus*. High cover of nuisance *Microcoleus* did not develop at any site during 2025–26.

The supplementary flow releases were most effective at removing loosely attached sludge and some *Microcoleus*, particularly at the Excelsior sites. Established thick didymo mats were comparatively resistant to removal, especially at Monowai and Clifden. Despite being smaller than typical protocol–sized releases, the supplementary flow releases contributed to maintaining or improving river status and likely prevented further deterioration in periphyton conditions.

Comparison of the existing Excelsior site and the downstream trial site (Excelsior_New) showed that both locations supported similar nuisance periphyton communities and followed comparable seasonal development patterns. The principal difference was the much higher cover of sludge at the existing site, consistent with field observations that it

is a lower–velocity habitat. Although the trial site supported healthy didymo and *Microcoleus* growth and may better be better suited to meet the objectives of the programme, there was insufficient evidence that nuisance periphyton removal during high–flow events was better at the downstream location due to the size of the supplementary flow releases monitored this season. Consequently, relocation of the Excelsior monitoring site is not recommended at this stage.

Water clarity is included in the monitoring programme under the protocol because it is an easily measured general indicator of water quality. Water clarity was generally high throughout the season and achieved the relevant proposed Southland Water and Land Plan (pSWLP) guideline values on all but one occasion. The single non–achievement occurred at Excelsior in January following the return to minimum flows at MLC after the January lake spill. There was no evidence of persistent water clarity issues at any site during the monitoring period.

The monitoring programme will continue in its current format for the 2026–27 season, as required under Condition 7 of the MTAD consent (Water Permit 206156). Five recommendations arise from the programme in 2025–26, including three related to the hydrographs of supplementary flows and the timing or pre–release and post–release surveys that are carried forward from previous reports:

- where feasible, continue to release supplementary flows with variable hydrographs as well as typical hydrographs so that the comparative effectiveness of different release shapes can continue to be evaluated;
- continue to make all reasonable efforts to carry out pre–release and post–release surveys as close as practicable to the commencement and completion, respectively, of supplementary flow releases to reduce variability in SCI caused by different accrual times (recognising that the delays are often unavoidable);
- continue to report on supplementary flow outcomes using additional indicators alongside SCI and river status, including the types of periphyton removed and observations of sloughing, sediment mobilisation and mat condition;
- continue, when possible, to take a proactive approach to releasing supplementary flows to potentially delay periphyton growth and extend green status; and
- continue the trial of the downstream Excelsior site for at least one further monitoring season before any decision is made regarding relocation of the long–term monitoring site. Additional monitoring under a wider range of flow conditions, including one or more typical protocol–sized supplementary flow releases, if possible, would provide a stronger basis for comparison between the two locations.

1 Introduction

1.1 Purpose of report

This report is an annual requirement of consents granted to Meridian Energy Ltd. (Meridian) for operation of the Manapōuri Power Scheme (MPS). Specifically, this report relates to condition 7 of Resource Consent 206156 which addresses management of nuisance periphyton growth in the Lower Waiau River, Southland. Condition 7 required Meridian to develop a protocol for the release of "voluntary supplementary flows" (i.e., flushing flows to supplement naturally occurring floods) to the Lower Waiau River, to assist in periphyton management. Throughout the rest of this report, such flushing flows are referred to as "supplementary flows" or "supplementary flow releases".

The most recent version of the protocol (last amended in November 2018) is reproduced in full in Appendix A. The protocol also includes the full text of Condition 7 of Resource Consent 206156. The protocol sets out steps for monitoring periphyton and decision-making around the release of supplementary flows when periphyton cover approaches pre-defined nuisance levels (termed amber or red river status, as opposed to green status) during spring, summer and autumn (November to May). Background information on nuisance periphyton in the Lower Waiau River in relation to the MPS and development of the protocol is provided in Appendix B.

Clause 9 of the current version of the protocol states that "the results of all monitoring undertaken in terms of this protocol will be forwarded to Environment Southland annually". This report documents the monitoring and management carried out under the protocol during the monitoring season that ran from 1 November 2025 to 31 May 2026. The 2025–26 season was the 20th season since regular monitoring began, and the 14th since the protocol was implemented.

In the 2025–26 season, additional transects were trialled approximately 70 m downstream of the current Excelsior site to assess the suitability of moving the site for long-term monitoring and to achieve programme objectives, as recommended by Kilroy and Hogsden (2025). The additional transects were used for a comparative analysis of periphyton and the effects of flow on periphyton at the two Excelsior locations over the monitoring season. Results of the trial are presented in this report along with recommendations for future monitoring at Excelsior.

In early 2026, construction commenced on the Manapōuri Lake Control Improvement Project (MLC:IP), an environmental initiative undertaken by Meridian to improve the conveyance and reliability of flow delivery from Lake Manapōuri into the Lower Waiau River. As part of consent requirements, flows at the Manapōuri Lake Control structure (MLC) were managed from 18 February 2026 to vary with those in the Mararoa River (+ 5 m^3/s). This flow requirement was in place for the remainder of the 2025–26 monitoring season (and beyond) and differed from flow management in previous monitoring seasons.

1.2 Approach to release of supplementary flows in 2025–26

Clause 8 of the protocol specifies that:

> "… four controlled releases of supplementary flows will be provided during 1 December to 1 May … if the SCI conditions fall within the amber or red indices … if lake levels and electricity supply security circumstances allow",

And

> "A fifth flow in May will be considered ….". In addition, Clause 5.1 states that: "Meridian will provide a maximum of 15 GWh of storage water releases (i.e., water that otherwise would be retained for optimal energy generation) for all supplementary flows between December and the end of May".

In the 2024–25 season, Meridian trialled a more proactive approach to supplementary flow releases for nuisance periphyton management. Under this approach, opportunities for supplementary flow releases were considered at pre-scheduled times earlier in the season, provided Lake Manapōuri water levels were suitable, rather than waiting for river conditions to reach amber or red status. Two of the four supplementary flow releases implemented in 2024–25 occurred before red status developed (11–12 December 2024 and 15–17 January 2025) and may have contributed to maintaining green status for longer periods (Kilroy and Hogsden 2025).

Kilroy and Hogsden (2025) recommended continuing this proactive approach in future seasons to help delay periphyton growth, extend periods of green status, and improve alignment with the supplementary flow protocol. Historically, implementation of supplementary flow releases has often been constrained by low water levels in Lake Manapōuri during summer, when nuisance periphyton cover is most likely to reach amber or red status. A review of monitoring seasons since implementation of the supplementary flow protocol (from 2012–13 onward) showed that three supplementary flow releases were achieved in only three seasons, while the maximum annual allocation of 15 GWh has never been fully utilised, although energy usage approached this limit in 2023–24 (13.82 GWh).

The proactive approach was continued in 2025–26, with supplementary flow releases considered when lake levels and operational conditions allowed, to maximise opportunities for nuisance periphyton management.

1.3 Report structure

The report is structured as follows.

Section 2 provides monitoring site information and a summary of monitoring methods, with further details in Appendix C.

Section 3 provides results and discussion on the 2025–26 monitoring season, including a review of hydrological conditions in 2025–26 compared to previous seasons, an overview of monitoring results, details of supplementary flow releases during the season,

comparative analysis of periphyton and effects of flow on periphyton at the two Excelsior sites, and a summary of water clarity readings compared to those made in previous seasons.

Section 4 provides a synthesis of the results, with conclusions and recommendations.

2 Methods

The site details and summary of methods are provided below, with further details provided in Appendix C.

2.1 Monitoring sites

Periphyton was monitored at three sites on the Lower Waiau River and one comparison site (control site) on the Mararoa River (Table 2.1, Figure 2.1). Additional transects were surveyed 100 m downstream of the existing Excelsior site for comparative purposes this season, and to assess the suitability of moving the site for long-term monitoring and to achieve programme objectives. For the purposes of this report, the existing site is referred to as Excelsior and the additional transects as Excelsior_New.

Table 2.1 Sites monitored in the Mararoa and Lower Waiau Rivers in 2025–26 (listed upstream to downstream). Sites coordinates are the NZTM projection. Station Bridge is on the Mararoa River, the other three sites are on the Lower Waiau River. n/a = coordinates not available.

Site	E, N	Access directions	Notes	Closest flow recorder
Station Bridge	1207545, 4948864	Turn off SH94 2 km east of Princhester Creek. Turn left after 3.5 km, site is 150–180 m downstream of the bridge.	Monitored since 2011, except in 2014–15. Site location change in 2022–23 to more suitable uniform run downstream. Site moved ~ 10m u/s due to minor gradient change for 2025–26 season.	Mararoa @ Cliffs (~35 km downstream) (site 79737, Meridian site managed by Earth Sciences New Zealand (Earth Sciences)).
Excelsior	1185690, 4933530	True left, 1.5 km downstream of MLC and d/s of Excelsior Creek. About 200 m downstream of angler access.	Monitored since 2006. Most susceptible to effects of supplementary and other flow releases from MLC.	Waiau @ MLC Tailwater (1.5 km upstream) (site 79719, Meridian site managed by Earth Sciences).
Excelsior_New	n/a	True left, ~1.57 km downstream of MLC and d/s of Excelsior Creek. About 70 m downstream of existing Excelsior site.	Monitored in 2025–26 season for comparative purposes with existing Excelsior site.	Waiau @ MLC Tailwater (1.57 km upstream) (site 79719, Meridian site managed by Earth Sciences).
Monowai	1182610, 4915090	On true right upstream of Monowai Bridge and 3 km downstream of Monowai River	Monitored since Jan 2009. Stable site (large substrate). Site location change in 2022–23 as water depth and flow had reduced at original site since 2019 so	Waiau @ Sunnyside (500 m downstream) (site 79735, ES site).

Site	E, N	Access directions	Notes	Closest flow recorder
		confluence. Follow track to river through paddock on west side of bridge, ~300 m.	that surveys became impractical.	
Clifden	1190475, 4888870	True left, upstream of SH99 Bridge and suspension bridge. Access through gravel extraction area.	Monitored since 2006. Unstable site (small, mobile substrate). Site location change in 2022–23 to upstream location with suitable substrate (representative of the wider reach) and better access. Notable change to active river channel and immediate floodway adjacent to and upstream of existing survey site noted in January 2026. Site moved ~70 m downstream for 2025–26 season.	Waiau @ Tuatapere (12 km downstream) (site 79701, Earth Sciences site).

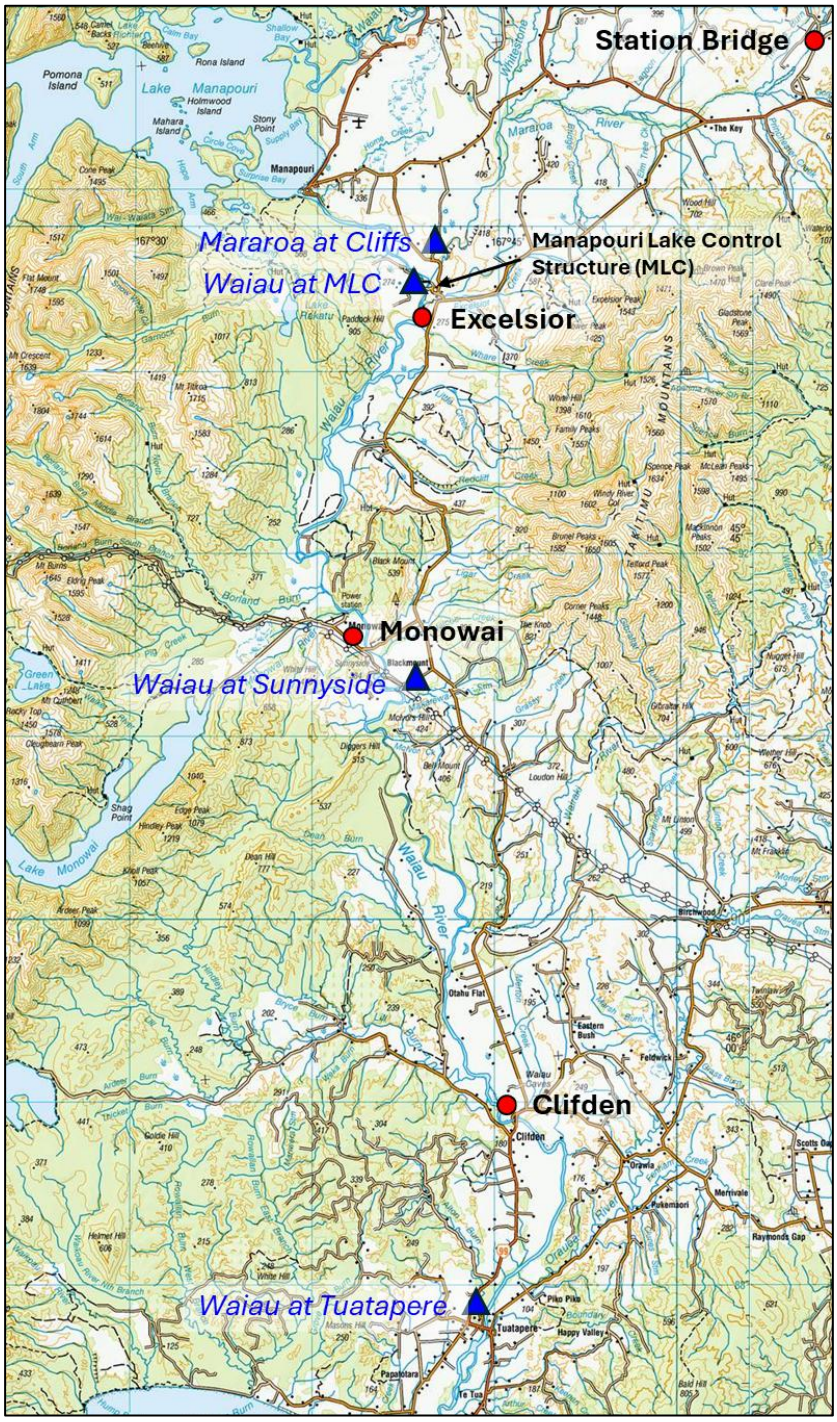


Figure 2.1 Location of the four established monitoring sites (red circles), and the nearest hydrological recording sites (blue triangles). The trial site (Excelsior_New) in 2025–26 is located ~70 m downstream of the established Excelsior site shown on the map.

2.2 Field monitoring procedures

Fortnightly monitoring commenced at the five sites on 9 January 2026 and continued until 28 May 2026. Surveys were preceded by checks on flow conditions, following the flow chart in Appendix 1 of the protocol (see Appendix A in this report). For further

details about timing of monitoring in relation to flows, refer to the methods in Appendix C.

All surveys in the Lower Waiau were carried out at times of minimum flow (i.e., 12–16 m^3/s measured at the MLC), to ensure that surveyed areas were always in the permanently wetted area of the river channel. Minimum flows are generally safe for wading at Excelsior. The Mararoa River is safe for wading when flows are less than ~20 m^3/s, and the two downstream sites in the Lower Waiau are safe when flows at the Lower Waiau at Sunnyside are less than ~38 m^3/s.

Surveys were conducted by staff from Tohu Environmental. Each survey comprised visual assessments of periphyton cover at each site and a water clarity measurement. Details of the visual assessment methods are set out in Appendix C. Briefly, at each site, periphyton cover was assessed in 20 areas of the riverbed using an underwater viewer and percentage cover of periphyton was estimated visually in 10 categories based on texture and colour (Table C.1).

Water clarity was measured at each site during each survey using the black disk method (Davies–Colley 1988). The mean of two readings was reported as water clarity.

2.3 Data and reporting

2.3.1 Periphyton percentage cover, standing crop index (SCI), and river status

Data from the 20 views were used to calculate mean percentage cover of each periphyton category at each site. Cover by medium and thick mats and cover by sludge were combined into a standing crop index (SCI), which is the product of percentage cover and vertical thickness of periphyton in millimetres. Refer to Appendix C for background to the metric.

SCI data from the three Lower Waiau sites were combined to determine river status, as follows:

i. Green – all is well: mean SCI at each of the three sites < 220; OR overall mean SCI < 200;

ii. Amber – alert: at least one site with SCI > 220 AND overall mean SCI greater than 200 but less than 300; OR overall mean SCI between 200 and 600;

iii. Red – response required: at least two sites with SCI > 220 AND mean SCI > 300; OR mean SCI > 600.

The alternative criteria (i.e., OR; using mean SCI) were used only when the primary criteria were not exactly met. For example, scores from three sites of 95, 210 and 655 have a mean SCI of 320, and one site exceeds 220. The combination does not fit the primary criteria for amber or red status. The alternative criterion places the river at amber status because mean SCI is in the range 200–600.

2.3.2 Post monitoring reporting and responses

The results of each survey were reported via email to Meridian, normally within 48 hours of completion of the survey. Amber or red status trigger "consideration of the release of a supplementary flow", following the procedure and conditions set out in the protocol. In the 2025–26 season, supplementary flow releases were also considered when SCI had increased since the previous survey, but the river was still at green status (see Section 1.2). This follows the proactive approach to releasing supplementary flows that was trialled in the previous season (2024–25).

Decision-making prior to supplementary flows included a review by the Meridian hydrologist of current lake levels and the forecast over the next few days for lake levels and river flows. If a supplementary flow was deemed feasible, a decision was also made on whether the release should have a "typical" hydrograph (i.e., meeting the original definition in the protocol) or a "variable" hydrograph (i.e., usually a release with a longer recession). "Variable" supplementary flow releases were introduced as an option in the 2018–19 season, for a trial period of 10 years. Refer to Clause 4.5 in the protocol (Appendix A) for details. To assist in deciding whether an upcoming flow release (e.g., in response to amber or red status) should be a "typical" release or a "variable" release, criteria for releasing a trial variable supplementary flow have been developed since their introduction in 2018–19. The criteria include: (a) sufficient water availability, because variable releases generally require slightly more water than a typical release, and have a longer recession; (b) high likelihood that they will not be augmented by tributary flows (i.e., they occur as isolated releases), (c) suitable previous typical supplementary flows to enable a comparison of effects.

Condition (a) is practical and requires advice from Meridian's hydrologist. Conditions (b) and (c) reflect the fact that variable supplementary flow releases are under trial. A trial implies that we should be able to compare the effects of the variable flow releases with those of typical releases. Realistic comparisons are possible only if the flow releases are isolated events, and a comparable typical flow release is available. "Comparable" here means that pre-flow-release SCI at the three monitoring sites is similar. At the end of the 10-year trial, the comparisons will assist in making a decision on whether the variable flow releases should be continued.

2.3.3 Annual reporting: hydrological data and comparison with periphyton

The closest hydrological recording sites to each monitoring site are shown in Table 2.1 and Figure 2.1 in Section 2.1. Flow records were accessed from these sites. All references to flows in the results are daily mean flows unless stated otherwise. The flow data were used to calculate flow metrics (e.g., proportion of time in different flow bands, number of high flows) in all monitoring seasons from 2008–09. The flow metrics were compared across seasons (in table format). Periphyton cover, SCI and river status in 2025–26 were reviewed qualitatively in the context of flow conditions in previous seasons. Refer to Appendix C for more details.

2.3.4 Annual reporting: supplementary flow releases

The circumstances leading up to each supplementary flow release were described and the flow release hydrographs were plotted. The outcomes of the releases were summarised as pre– and post–periphyton cover and SCI results.

2.3.5 Comparative analysis of periphyton, Excelsior sites in 2025–26

Comparison at the two Excelsior sites (existing, Excelsior; trial, Excelsior_New) focused on periphyton cover, development of typical nuisance periphyton at this location (i.e., *Microcoleus*, didymo), and the extent of periphyton removal during high flow events (including supplementary flow releases and natural floods). Evidence that Excelsior_New supported the development of typical nuisance periphyton communities and showed better periphyton removal during high flow events would provide support for relocating the monitoring site downstream to better meet the objectives of the monitoring programme.

2.3.6 Annual reporting: water clarity

Measurements of water clarity have been included in the monitoring since the 2010–11 season and were included in the initial version of the protocol. Box plots were used to compare water clarity measurements made in 2025–26 with those made in previous seasons and in relation to the limits set out in the proposed Southland Water and Land Plan (pSWLP[1], Court Version May 2024). Refer to Appendix C for further details.

[1] Most of the pSWLP became operative from 27 May 2024. See Southland Water and Land Plan to be made operative – Environment Southland

3 Results and discussion

3.1 River flows at MLC and in tributaries, 2025–26

Monitoring in 2025–26 was preceded by a lake spill that began in late September 2025 and continued until early January 2026. Mean flow at the Waiau at MLC during October (648 m^3/s, Table 3.1) was the highest since monitoring began for this programme. Flows at MLC returned to minimum flow on 4 January and remained there until 10 January, when a second lake spill event commenced. Following this event, flows returned to minimum flow on 22 January. Flows at MLC were managed to vary with those in the Mararoa River (+ 5 m^3/s) from 18 February 2026 as part of consent requirements for the MLC:IP. This requirement was in place for the remainder of the 2025–26 monitoring season.

Over the monitoring season (1 November 2025 to 31 May 2026), mean flow at Waiau at MLC was 140 m^3/s, substantially higher than the long-term mean of 67 m^3/s. The river exceeded three times the median flow for 39% of the monitoring period (83 days), compared with a long-term mean of 20% (42 days). Based on comparison with previous monitoring seasons, flows at MLC during 2025–26 were classified as "high" (Table 3.1). Consistent with this classification, the river was at minimum flow for only 30% of the monitoring period, well below the long-term mean of 63%.

The flows assessed during the season included two supplementary flow releases and augmentation of a natural event. The supplementary flow releases contributed an additional four days (2% of the monitoring season) during which flow at MLC exceeded three times the median flow, and they also increased the seasonal mean flow (see Section 3.3).

Between 1 November 2025 and 31 May 2026, mean flow in the Mararoa River at Cliffs was slightly higher than the average flow across all previous monitoring seasons (Table 3.1). Mean flow in the Waiau River at Sunnyside was also above the long-term mean and higher than all previous monitoring seasons except 2019–20. Mean inflows from tributaries downstream of MLC[2] were similarly above average (Table 3.1). Together, these patterns indicate that the elevated flows observed in the Lower Waiau River during 2025–26 were driven by high inflows from both Lake Manapōuri and the Mararoa River, with additional contributions from tributaries downstream of MLC.

As in all previous seasons, high inflows from tributaries downstream of MLC affected the timing of monitoring surveys. These inflows can create unsafe conditions at the Monowai and Clifden sites, even when the flow at MLC is at or near minimum levels.

[2] As approximated by Waiau at Tuatapere minus Waiau at MLC (not accounting for time of travel down the river).

Table 3.1 Summary of flow statistics in the Lower Waiau and Mararoa Rivers from the start of fortnightly monitoring in 2008–09 to 2025–26. Flows are mean daily flows. Seasons are 1 November to 31 May. Numbers in blue are flows, black are percentages. Percentages (rounded to the nearest whole number) were calculated based on median flow from 2008 to 2026, shown in parentheses in the headings. In the flow distribution columns flows min. to 3 × median are small freshes; 3–7 × median are small floods up to a typical supplementary flow release; 7–15 × median are larger lake or Mararoa floods; 15–20 × median are mostly large lake spills; >20 × median are very large lake spills. Flow category for the season was defined from the mean flow and >3 × median flow duration at MLC using the criteria defined in Section 3.1, footnote 2. Orange shading indicates the two driest years.

Season	Waiau at MLC (median flow 16.8 m³/s)									Mararoa at Cliffs (med. 22.3 m³/s)		Waiau at Sunnyside (med. 45.5 m³/s)		Trib. flows (Tuatapere minus MLC)		Flow category
	Mean flow (m³/s)		Flow distribution (% time in flow bands, November to May)							Mean flow (m³/s)	% time	Mean flow (m³/s)	% time	Mean flow (m³/s)	% time	
	October	Nov to May	min. flow	min.–3 × med	3–7 × med	7–15 × med	15–20 × med	>20 × med	>3 × med	Nov–May	>3 × med	Nov–May	>3 × med	Nov–May	>3 × med	
0809	162	82	63	13	6	6	4	8	24	28	7	104	20	67	8	high
0910	17	133	49	12	9	13	5	12	40	34	6	165	32	61	4	high
1011	52	38	58	25	12	4	2	0	18	20	1	59	9	37	0	low
1112	37	19	79	19	2	0	0	0	2	18	0	41	0	44	0	low
1213	329	81	49	30	6	3	2	10	21	24	6	104	17	48	2	high
1314	304	79	65	8	8	9	1	8	27	25	8	107	21	60	5	high
1415	47	101	58	15	7	3	2	15	27	29	8	125	21	68	7	high
1516	26	81	68	11	6	5	2	8	21	24	7	109	16	58	3	high
1617	42	42	73	14	5	4	1	3	14	19	0	65	10	46	0	low
1718	16	31	70	19	6	4	1	0	11	21	4	62	8	58	7	low
1819	33	48	52	23	18	4	0	2	25	32	7	86	13	65	4	intermediate
1920	39	182	25	33	8	5	5	24	42	39	15	227	36	69	10	high
2021	286	22	86	8	5	1	0	0	6	20	0	50	4	55	4	low
2122	84	18	80	18	0	1	0	0	1	15	0	37	0	43	1	low
2223	17	36	70	13	11	6	0	0	17	25	8	58	10	59	6	low
2324	298	58	66	11	8	9	4	2	23	22	1	79	15	52	2	intermediate
2425	393	46	72	12	6	4	3	3	16	18	0	67	10	47	1	low
2526	648	140	30	31	7	4	6	22	39	28	5	169	35	58	2	high
All yrs	157	67	63	17	7	5	2	6	20	24	4	93	15	55	4	

3.2 Periphyton SCI and flows, Lower Waiau River

3.2.1 2025–26 season compared with previous years

Twelve periphyton surveys were carried out during the monitoring period, between 9 January 2025 and 28 May 2026. The survey results are shown in the context of all previous surveys in Appendix D and observations (additional to the cover estimates) made by the survey team are summarised in Appendix E. The complete log of all flow checks and surveys maintained through the season and used to report results to Meridian is provided in Appendix F.

Mean SCI across the three Lower Waiau sites and all surveys between November and May was in the same general range as most of the previous eight years (200–400, Table 3.2). Maximum SCI (607; mean of three sites) was lower than that recorded over the past four seasons. Estimates of the percentage of time the river was at red, amber and green status in each season indicated that 2025–26 was below average for red, about average for amber, and above average for green, based on all seasons from 2008–09 to the present (Table 3.2). The highest mean SCI in 2025–26 was reported at Monowai (mean SCI of 408).

3.2.2 Green status, 9 January to 3 March

Two lake spills from 17 September to 4 January and 11 January to 21 January set up the Lower Waiau River for green status on the first five surveys of the season (9 January, 23 January, 5 February, 17 February, and 3 March) and into early March (Figure 3-1). According to the protocol, the four surveys up to 17 February were not required because the 30-day mean flow predicted green status (see Appendix F). The surveys were conducted with agreement between Meridian and Earth Sciences NZ.

Observations from the field team indicated there was little periphyton growth to record on 9 January and only initial establishment of mats at Excelsior and Monowai sites by 23 January (Appendix E). During the 5 February survey, periphyton growth was still minimal across the sites, with very clean substrate noted at Clifden, minimal cover of *Micrcoleus* at both Excelsior sites and some sludge present (Excelsior, Monowai). The field team noted on the 17 February survey that it 'has been a significantly different season' due to the extreme lack of algal growth.

The flow check on 1 March indicated that a survey was required (Appendix F). At the survey carried out on 3 March 2026, SCI had significantly increased at sites in the Lower Waiau, with SCI more than doubling at Excelsior and Monowai (Figure 3-1), but green status was maintained. Didymo cover and thickness had increased at all sites, except Clifden where only small individual colonies were established, in contrast to usual conditions at this site at this stage of the monitoring season (e.g., close to 100% didymo cover). Significant cover of sludge was noted at the existing Excelsior site and cover of *Microcoleus* had increased at the trial site (Excelsior_New) site (Appendix E).

Based on this outcome and existing lake levels, Meridian and Earth Sciences NZ discussed the options of potentially releasing a pre-emptive supplementary flow to assist with maintaining green status. These discussions considered lake levels,

forecasted and actual rainfall, as well as the potential effectiveness of smaller (than typical) supplementary flow releases for different types of periphyton (e.g., *Microcoleus* and loosely–attached sludge vs. didymo).

3.2.3 Red status, 17 March

The survey conducted on 17 March returned red status, with a substantial increase in SCI across the Lower Waiau River sites (Figure 3–1). This increase coincided with flows at MLC remaining at minimum levels since the previous survey. At the time of the survey, Lake Manapōuri was approaching the lower limit of its main operating range and was below the level required to release a typical supplementary flow as specified in the protocol (Figure 3.2).

Building on from discussions initiated in early March, a pre–planned supplementary flow was released on 19–20 March (see Section 3.3.1). This was followed by a recreational flow release on 22 March, which provided a mean flow of 36 m^3/s, over 24 h.

The survey undertaken on 25 March, following the supplementary flow release and recreational flow release, returned amber status. SCI decreased at the two Excelsior and Clifden sites, but increased at Monowai (Figure 3–1, Appendix F). Following the survey, discussions and planning commenced for a further supplementary flow release. However, lake levels remained close to the lower limit of the main operating range into early April, constraining release options.

3.2.4 Amber and red status, 25 March to 26 May

Amber status persisted until the survey on 9 April, which was undertaken immediately prior to a supplementary flow release on 9–10 April (see Section 3.3.2 for details). As with the March supplementary release, water levels in Lake Manapōuri were insufficient to enable a typical protocol–sized supplementary flow (Figure 3.2).

The post–release survey on 14 April also returned amber status[3]. SCI reduced at both Excelsior sites and Monowai, but more than doubled at Clifden (Figure 3–1). A concurrent hydrology review forecast rainfall in the Mararoa River catchment and predicted a natural fresh event down the Mararoa River in coming days. Meridian and Earth Sciences NZ subsequently discussed the potential benefits of augmenting this event for nuisance periphyton management in the Lower Waiau River. Meridian advised that flows at MLC during the fresh would be approximately 20 m^3/s greater than flows in the Mararoa River. The flow augmentation event occurred between 17–22 April (see Section 3.3.3 for details).

The next survey, undertaken on 30 April, returned red status. This survey was conducted just over a week after the augmentation event concluded and once flows had subsided sufficiently to allow safe access for surveying at downstream sites. SCI increased at Excelsior and Clifden but decreased at Monowai (Figure 3–1). A subsequent hydrology review indicated that, due to low lake levels, it was not possible to release a

[3] The average SCI across the three Lower Waiau sites was close to red status, but using the existing Excelsior site, status remained at amber.

flow of sufficient magnitude to have a measurable effect on periphyton at any site, and no further action was taken.

Red status persisted at the next survey on 14 May, when an increase in SCI was reported at all sites in the Lower Waiau River. SCI also increased at Station Bridge in the Mararoa River during this period. Given the ongoing red status, supplementary flow options were actively considered. However, lake levels remained too low to enable a typical supplementary flow release and discussions between Meridian and Earth Sciences NZ concluded that any smaller release was unlikely to achieve a meaningful reduction in periphyton given the current conditions.

The final survey of the monitoring season was conducted on 28 May and again returned red status. SCI decreased at Excelsior but increased at Monowai and Clifden. SCI at Station Bridge had also increased relative to the previous survey. As lake levels remained unsuitable for an effective supplementary flow release, no release was undertaken.

Table 3.2 Summary statistics for SCI and river status in the Lower Waiau River by season. Max. for survey is the highest mean value across the three sites. Numbers in parentheses for 2026 include data from the new site at Excelsior (Excelsior_New). Season type defined as in footnote 2 in Section 3.1. †Low survey N in 2019–20 caused by Covid-19 national lockdown and high flows early in the season (two surveys carried out in June 2020 to compensate for earlier surveys missed). SFR = no. of supplementary flow releases in the season; * = at least one SFR combined with natural high flow. Orange shading indicates the two driest years.

		Mean SCI		Mean SCI by site			% time under river status			Season type (flow)	SFR
Season	N	Overall mean	Max. for survey	Excelsior	Monowai	Clifden	RED	AMBER	GREEN		
2008–09	12	265	755	260	385	152	30	9	61	High	2
2009 – 10	10	278	739	175	407	250	27	7	66	High	1*
2010–11	13	508	1564	423	618	475	42	21	37	Low	4*
2011–12	14	483	792	210	621	618	58	42	0	Low	
2012–13	11	330	893	231	598	160	20	23	57	High	1*
2013–14	9	510	1181	406	935	188	36	6	58	High	1*
2014–15	8	501	1413	371	694	437	33	6	61	High	
2015–16	12	383	668	236	518	395	45	16	38	High	3*
2016–17	11	280	981	244	360	235	45	7	48	Low	2*
2017–18	6	234	626	38	433	232	25	2	73	Low	
2018–19	9	370	695	131	478	502	28	11	61	Inter–mediate	2
2019–20	2†	222	354	119	331	216	24	9	67	High	
2020–21	12	218	403	152	288	213	39	5	57	Low	1

Season	N	Mean SCI		Mean SCI by site			% time under river status			Season type (flow)	SFR
		Overall mean	Max. for survey	Excelsior	Monowai	Clifden	RED	AMBER	GREEN		
2021–22	13	341	853	89	340	594	50	16	34	Low	2
2022–23	11	275	716	247	402	175	29	22	49	Low	3*
2023–24	12	250	744	181	389	193	28	20	52	Inter-mediate	3*
2024–25	12	288	1049	103	307	455	40	10	50	Low	4*
2025–26	12	276 (235)	607	144 (111)	408	276	20	19	61	High	2
Means, all seasons		346		214	493	330	36	14	50		1.5

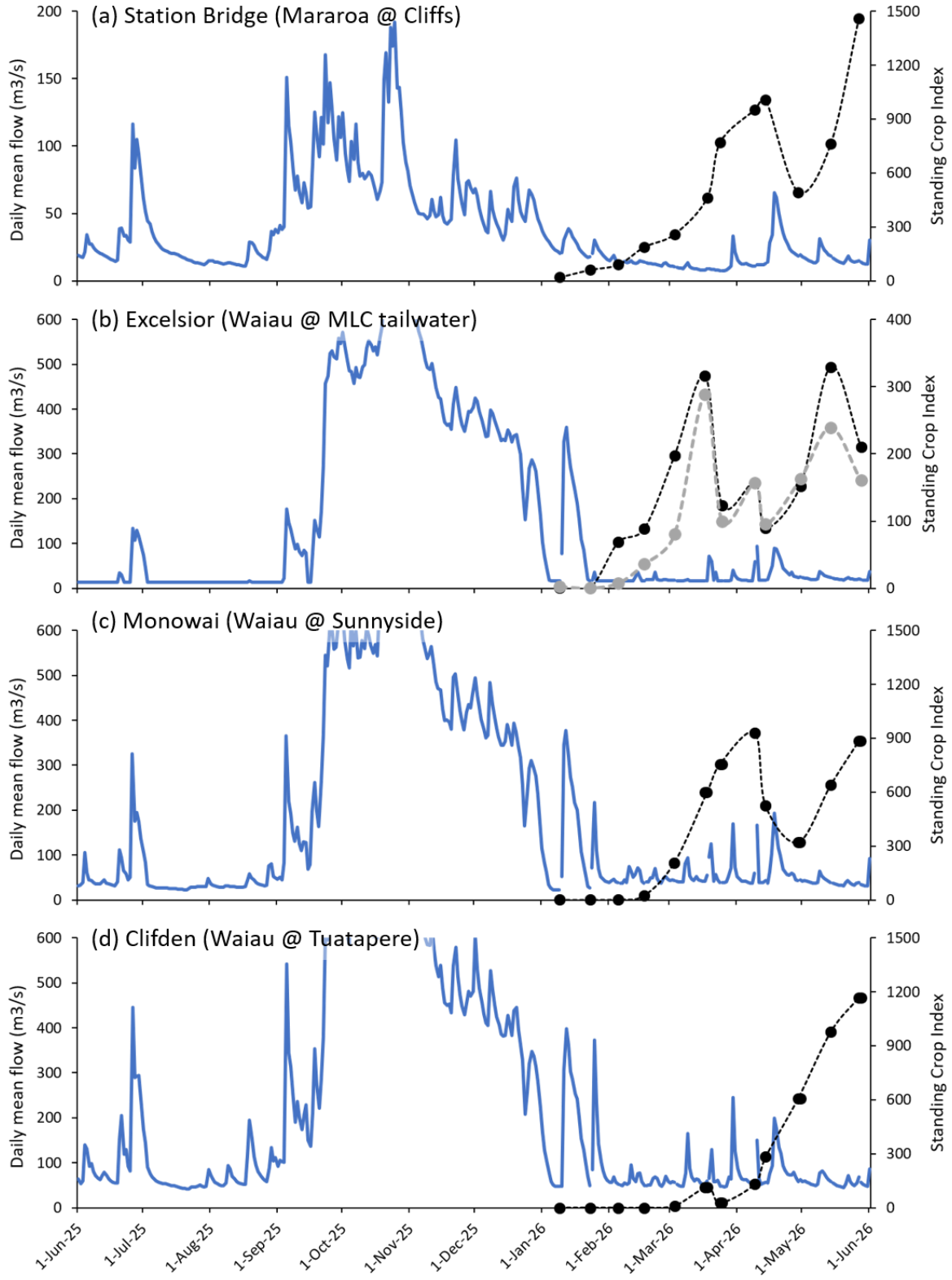


Figure 3-1 Flow (blue lines) and SCI (black/grey dashed lines) recorded at the monitoring sites, June 2025 to June 2026. SCI data are plotted on the same scale (right hand axis) for all sites, except for the two Excelsior sites where a different y-axis is used to allow a better comparison between SCI at the original site (black) and the new site (grey). Flows are truncated at 200 m^3/s (a) and 600 m^3/s (b,c,d) so that the smaller flows can be seen more clearly.

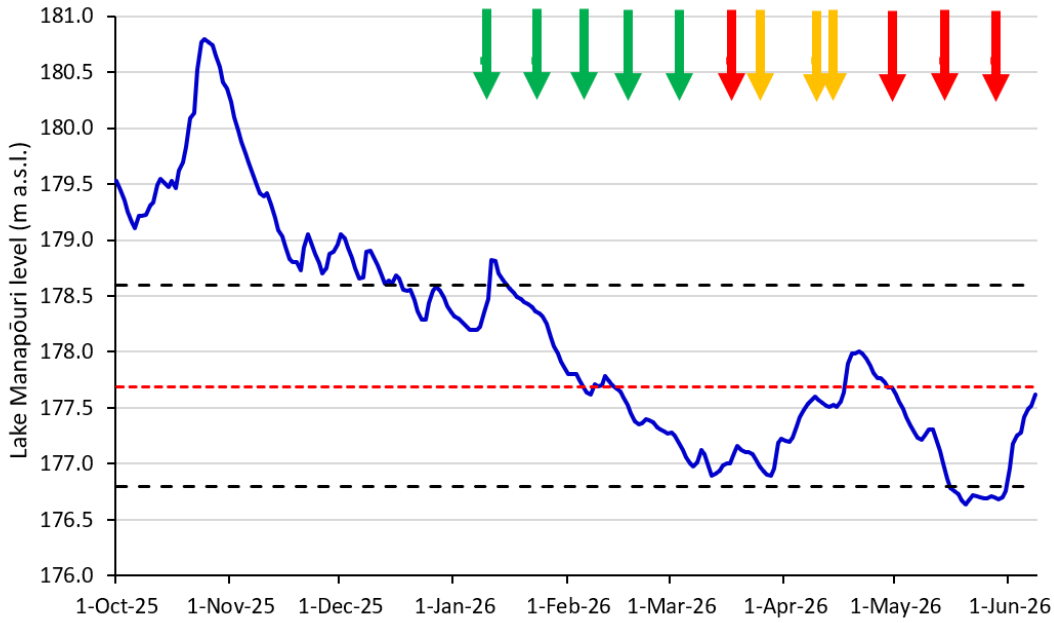


Figure 3.2 Lake Manapōuri water level (at Supply Bay) during the 2025–26 monitoring season. Arrows at the top indicate the days of surveys in the Lower Waiau River, coloured coded according to green, amber, or red status. The red dotted line is the approximate lake level required to enable a supplementary release of the size (at MLC) specified in the protocol (177.69 m). The black dashed lines indicate the main operating range of the lake (from 176.8 to 178.6 m above sea level).

3.3 Supplementary flow releases and natural event augmentation

3.3.1 19 – 20 March 2026

The survey conducted on 3 March returned green status; however, SCI increased substantially at both Excelsior and Monowai, driven by increases in didymo cover and mat thickness. Significant sludge cover was also observed at the existing Excelsior site, while *Microcoleus* cover had increased at trial site (Excelsior_New). As a result, planning proceeded for a supplementary flow release to help maintain green status. A variable hydrograph was selected as Lake Manapōuri levels were below those required to enable a typical supplementary release (Figure 3.2), but the flow was expected to provide benefits for the removal of other periphyton types. Discussions between Meridian and Earth Sciences NZ concluded that this release would have the greatest effects on loosely–attached periphyton and at the most upstream site (Excelsior) because of the size and shape of the hydrograph.

As almost two weeks had passed since the previous survey, a pre–release survey was conducted on 17–18 March to confirm river status and cover of different periphyton types. The survey returned red status, with a substantial increase in SCI across the Lower Waiau River sites (Section 3.2.3). In accordance with the protocol (Appendix A), Meridian liaised by email with Fish & Game, the chairpersons of the Waiau Working Party

and the Guardians of Lakes Manapōuri, Monowai, and Te Anau and a representative of Te Ao Marama regarding the timing of the supplementary flow release.

The supplementary flow commenced at 830 h on 19 March, when Lake Manapōuri was at 177.20 m a.s.l. The release lasted 31 hours and reached a maximum instantaneous flow of 109 m^3/s, with a maximum 24 h flow of 104 m^3/s. The event was equivalent to 3.46 GWh of energy generation. At the end of the supplementary flow release, lake level had fallen to 177.13 m a.s.l. (Appendix G, Figure G.1). The supplementary flow release was followed by a recreational flow release, which commenced on 22 March (Figure 3.3).

The post–release survey on 24–25 March indicated reductions in SCI of 61% at Excelsior to 76% at Clifden, accompanied by decreases in cover of thick mats at both sites. In addition, almost all sludge cover was removed at Excelsior (Figure 3.4), as expected given the loosely attached nature of this type of periphyton type. Some sludge remained in the stream margins (Appendix E). The remaining didymo at Excelsior was described as pale and unhealthy in appearance (Appendix E). In contrast, SCI at Monowai increased by 26%, with didymo mats persisting and increasing in cover and thickness despite the supplementary flow. However, some mats at Monowai appeared to have been affected by the flow release, with small amounts of fine grit trapped within didymo mats likely indicating sediment mobilisation during the event (Appendix E). SCI at Station Bridge in the Mararoa River also increased substantially, rising by 67% (Figure 3.4).

The supplementary flow effectively removed sludge at Excelsior and contributed to improving river status to amber. Given that the Lower Waiau River at MLC was at minimum flows in the 13 days between surveys, it is likely that SCI would been considerably higher at all sites had the supplementary flow not occurred.

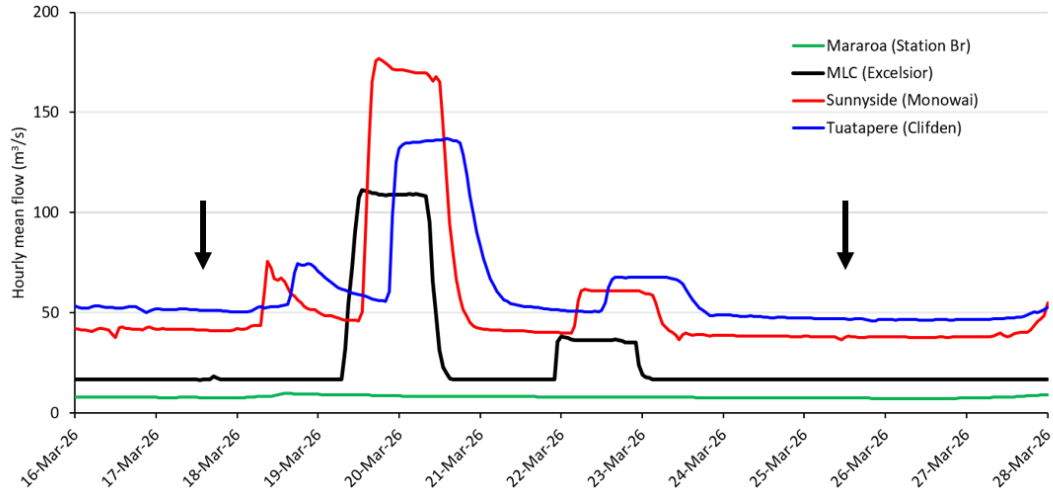


Figure 3.3 Hourly flows in the Lower Waiau River and the Mararoa River before, during and after the supplementary flow release on 19–20 March 2026. The black arrows indicate the approximate times of surveys.

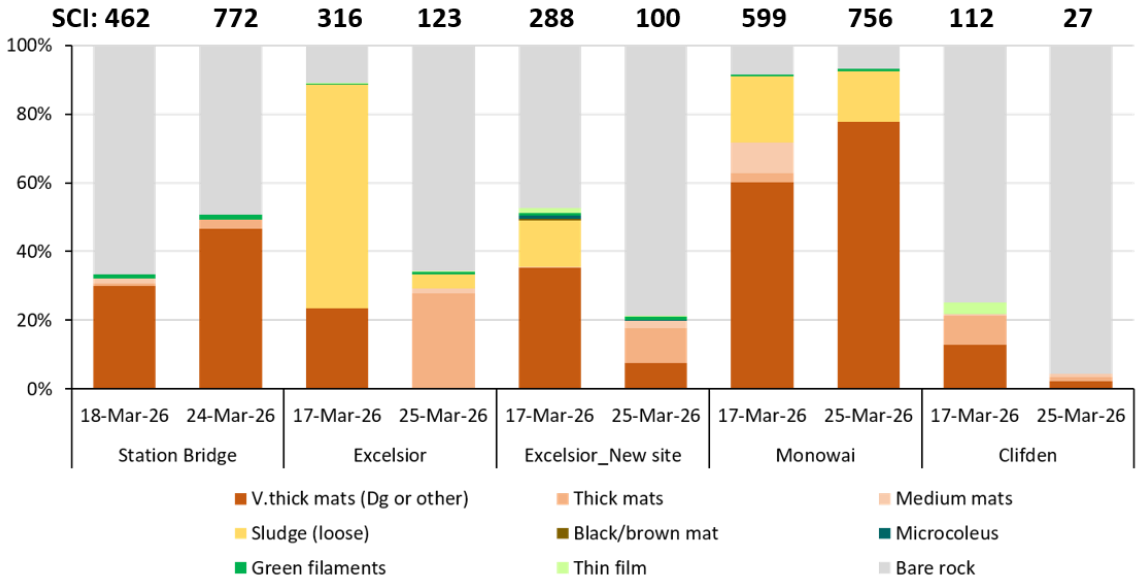


Figure 3.4 Periphyton cover at the monitoring sites before and after the supplementary flow release on 19–20 March 2026. Mean SCI is shown at the top of each bar. Cover is shown in nine categories.

3.3.2 9 – 10 April 2026

Amber status at the survey on 25 March was followed by 14 days of flows less than 3 × median flow at MLC. During that time Lake Manapōuri levels were not high enough to generate a typical supplementary flow release (Figure 3.2); however, alternative options for potential flow releases were discussed between Meridian and Earth Sciences New Zealand. Meridian liaised with Fish & Game, the chairpersons of the Waiau Working Party and the Guardians of Lakes Manapōuri, Monowai, and Te Anau and a representative of Te Ao Marama by email regarding the timing of the supplementary flow release.

The supplementary flow commenced at 1400 h on 9 April, when Lake Manapōuri was at 177.62 m a.s.l. The release lasted 28 hours and reached a maximum instantaneous flow of 159 m^3/s, with a maximum 24 h flow of 132 m^3/s. The event was equivalent to 4.39 GWh of energy generation. At the end of the supplementary flow release, lake level had fallen to 177.60 m a.s.l. (Appendix G, Figure G.2). The post–release survey was carried out on 14 April (Figure 3.5).

SCI decreased at both Excelsior sites (39 to 40%) and at Monowai (44%) between the pre– and post–release surveys (9 April and 14 April, respectively; Figure 3.6), but more than doubled at Clifden. A reduction in sludge cover was evident at the existing (lower velocity) Excelsior site. Declines in *Microcoleus* were observed at both Excelsior sites (Figure 3.6), with a change from "an increase in healthy, new *Microcoleus*" before the supplementary flow release to "minimal *Microcoleus*" post–release noted at the existing Excelsior site (Appendix E). In contrast, the increase in SCI at Clifden reflected an increase in cover of very thick mats. Post–release survey observations at Clifden recorded little didymo debris on the river margins, suggesting the supplementary flow release caused limited sloughing of didymo upstream (Appendix E). In addition, little deposited sediment (or grit) was observed within mats after the release, unlike previous

events, indicating that the supplementary flow consisted largely of 'clean water' (i.e., sediment-free) and therefore likely had limited scouring capacity.

The supplementary flow release effectively reduced SCI at Excelsior and Monowai, including removal of *Microcoleus* and sludge cover at the Excelsior sites, but was not large enough to remove periphyton or prevent mats from developing further downstream at Clifden. Amber status was maintained; however, it is likely that the river status would have progressed to red had the supplementary flow release not occurred.

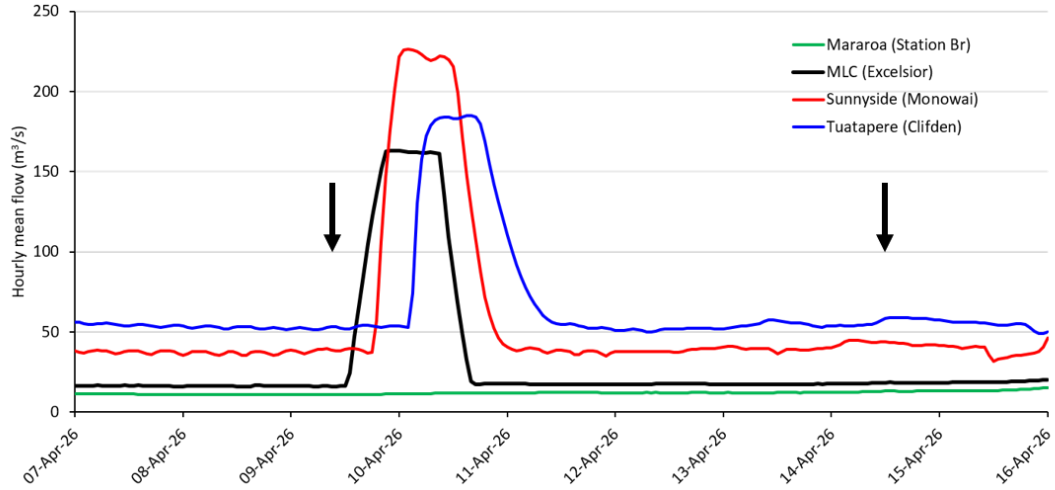


Figure 3.5 Hourly flows in the Lower Waiau River and the Mararoa River before, during and after the supplementary flow release on 9–10 April 2026. The black arrows indicate the approximate times of surveys.

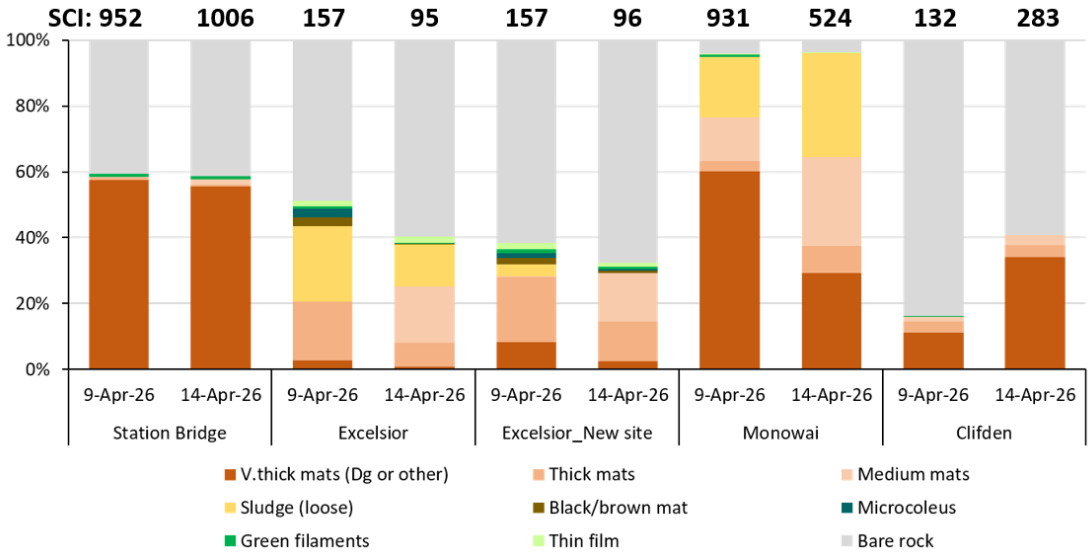


Figure 3.6 Periphyton cover at the monitoring sites before and after the supplementary flow release on 9–10 April 2026. SCI is shown at the top of each bar. Cover is shown in nine categories.

3.3.3 17–22 April 2026 (natural event augmentation)

In response to the continuation of amber status, Meridian began releasing additional flows from the MLC on 17 April to augment a natural flow event down the Mararoa River (Figure 3.7). The flows from MLC were approximately 20 m^3/s greater than the Mararoa River flow for the duration of the event (Appendix G, Figure G.3).

The augmented fresh event peaked at 103 m^3/s, with a maximum 24 h flow of 96 m^3/s. The event was equivalent to 2.42 GWh of energy generation. The augmented natural flow event was followed by a recreational flow release on 26 April (Figure 3.7).

SCI increased at both Excelsior sites and Clifden, but decreased at Monowai; the river returned red status (see Section 3.2.4). Didymo developed at both Excelsior sites, with increased cover of thick mats at the existing site compared to increased cover of medium mats at the new site (Figure 3.8). Similarly, there was increased cover of very thick didymo mats at Clifden. There was no evidence of sloughing observed at these three sites (Appendix E). In contrast, there was a reduction in SCI, accompanying reductions in some areas of didymo mats and sludge cover at Monowai (Figure 3.8). Field observations indicated some reductions in didymo at Monowai, but also noted other didymo mats were fully intact and very thick (Appendix E).

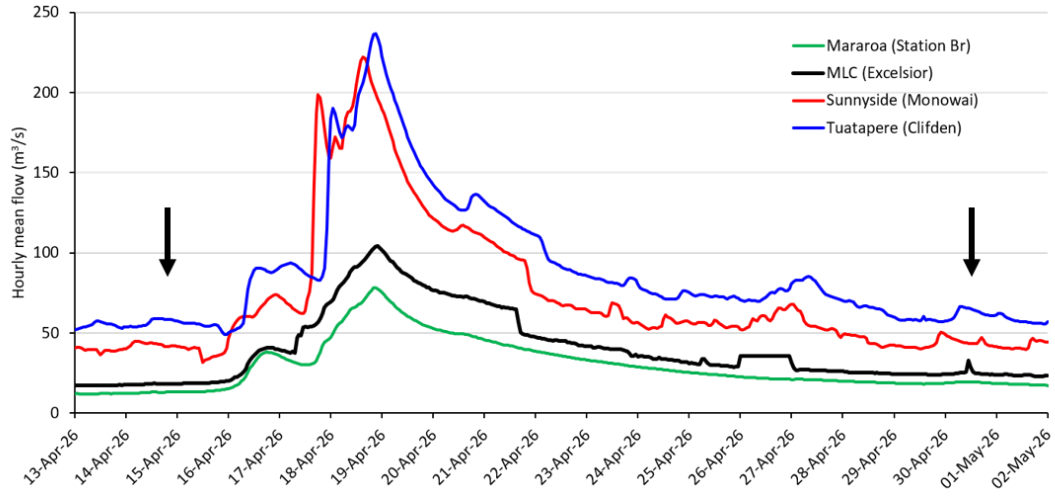


Figure 3.7 Hourly flows in the Lower Waiau River and the Mararoa River before, during and after the high flow event on 17 to 22 April 2026. The black arrows indicate the approximate times of surveys.

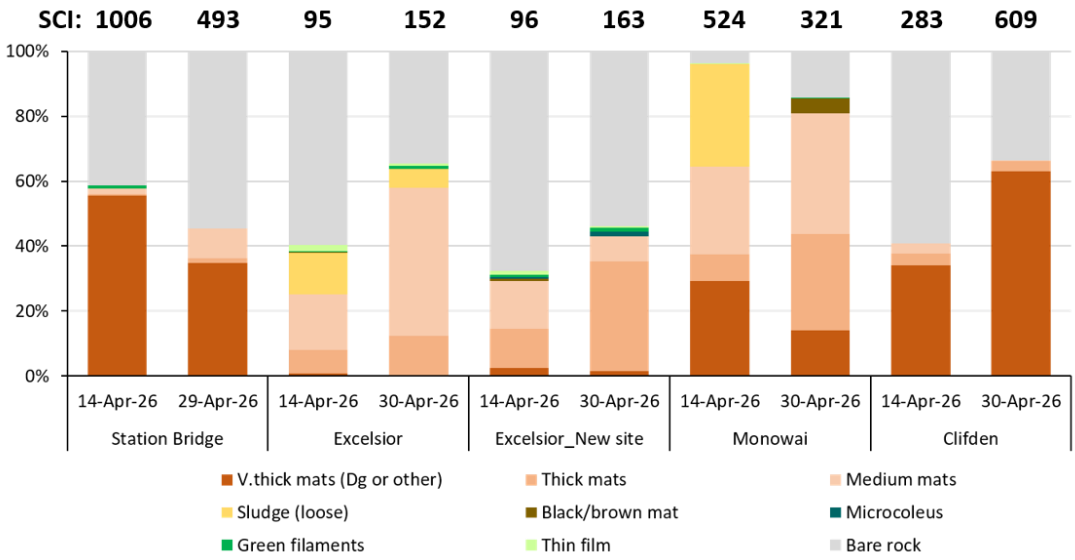


Figure 3.8 Periphyton cover at the monitoring sites before and after the natural high flow event on 17 to 22 April 2026. Mean SCI is shown at the top of each bar. Cover is shown in nine categories.

3.3.4 Commentary on supplementary flow releases in 2025–26

The two supplementary flow releases in 2025–26 represented at total of 7.85 GWh of storage water that would have otherwise been retained for energy generation, which represents 52% of the maximum of 15 GWh specified in the protocol (see Appendix A, clause 5.1). The inclusion of the augmented natural flow event increases the total storage water that would have otherwise been retained for energy generation to 10.27 GWh (or 69% of the maximum of 15 GWh).

A key difference between the two supplementary flow releases in 2025–26 and those in previous seasons were that the releases were variable releases made when Lake Manapōuri was below the level required to generate a typical flow release (as specified in the protocol) and the flows were expected to effectively remove periphyton other than didymo (i.e., loosely attached sludge, *Microcoleus*). Despite pre-planning in several instances, no supplementary flow releases followed green status in the 2025–26 season (i.e., pre-emptive flow releases as in the 2024–25 season, Kilroy and Hogsden 2025). Both supplementary flow releases reduced SCI at some sites and effectively removed different periphyton types. We consider that had the supplementary flow releases not occurred, the river status would have not improved (i.e., red to amber following 19–20 March supplementary release) or been maintained (i.e., amber to amber following 9–10 April supplementary release).

3.4 Periphyton SCI and flows, Mararoa River in 2025–26

SCI in the Mararoa River at Station Bridge was low (<20) in early January with little periphyton development recorded by the 5 February survey, including minimal didymo compared to previous seasons (Figure 3-1, Appendix E). SCI continued to increase through February and March and until late April (Figure 3-1). Following the natural flow event in the Mararoa River in mid–late April, which peaked just above 50 m^3/s, SCI was

reduced by 50% (Figure 3-1, Figure 3.8). Observations from the 30 April survey indicated that older, thicker didymo mats in the river margins were greatly reduced (Appendix E). SCI at Station Bridge increased again through May, almost doubling in the last two weeks from 762 to 1462.

3.5 Periphyton types and patterns in 2025–26

A time series of periphyton cover at the five sites monitored between November 2025 and May 2026 is shown in Figure 3.9, with further observations summarised in Appendix E. The key points from Figure 3.9 and Appendix E follow.

- Periphyton was generally slow to develop at all sites, particularly at Station Bridge and Clifden, with little periphyton or didymo establishment through January and early February. However, didymo cover increased steadily from March onwards at all sites and persisted through to the end of the monitoring season. At Station Bridge, older didymo mats sloughed at the end of April while new didymo colonies continued to establish, resulting in increasing cover and thickness through May.
- Total periphyton cover at the Lower Waiau River sites generally followed similar seasonal trends, increasing during extended periods of stable low flows and responding variably to supplementary flow releases and the augmented Mararoa River fresh. Monowai and Clifden showed greater persistence of thick didymo mats than the two Excelsior sites.
- *Microcoleus* cover was most prominent at the Excelsior sites, particularly Excelsior_New, where localised cover increased at times in February, March and April. Supplementary flow releases reduced *Microcoleus* cover in March and early April, but small amounts persisted in sheltered areas and subsequently redeveloped later in April at both Excelsior sites.
- Periphyton at the existing Excelsior site was dominated by loosely attached sludge and mixed mats, including didymo, for much of the season. Didymo was generally sparse, often pale, brittle, or unhealthy in appearance, and appeared susceptible to sloughing during supplementary flow events. Sludge remained a characteristic feature of this lower-velocity site (when compared to Excelsior_New) throughout the monitoring season.
- Didymo cover increased progressively from March onwards at both Excelsior sites, with low cover *Microcoleus* also developing during summer. Periphyton at the Excelsior_New site was not dominated by sludge and generally appeared healthier and more persistent, reflecting the higher-velocity habitat conditions than at the existing Excelsior site.
- Monowai was characterised by increasing didymo cover and mat thickness from end of February onwards. Although some sloughing occurred following supplementary flow releases, thick and very thick didymo mats persisted on stable substrates, particularly on the tops of larger boulders. Fine sediment

and sludge were also commonly observed in slower-flowing areas of the river margins.

- Clifden remained unusually clean through much of the summer, with very limited periphyton development until March. Thereafter, didymo cover increased rapidly, progressing to extensive thick and very thick mats. Supplementary flow releases had little apparent effect on established mats, and by May the site was characterised by very high didymo cover with very little evidence of sloughing or scouring at the most downstream site.
- Across the monitoring sites, supplementary flow releases were most effective at removing loosely attached sludge, some mixed mats, and *Microcoleus*, particularly at Excelsior. In contrast, established thick didymo mats proved relatively resistant, particularly at Monowai and Clifden, where they continued to increase in cover and thickness following supplementary flow events.

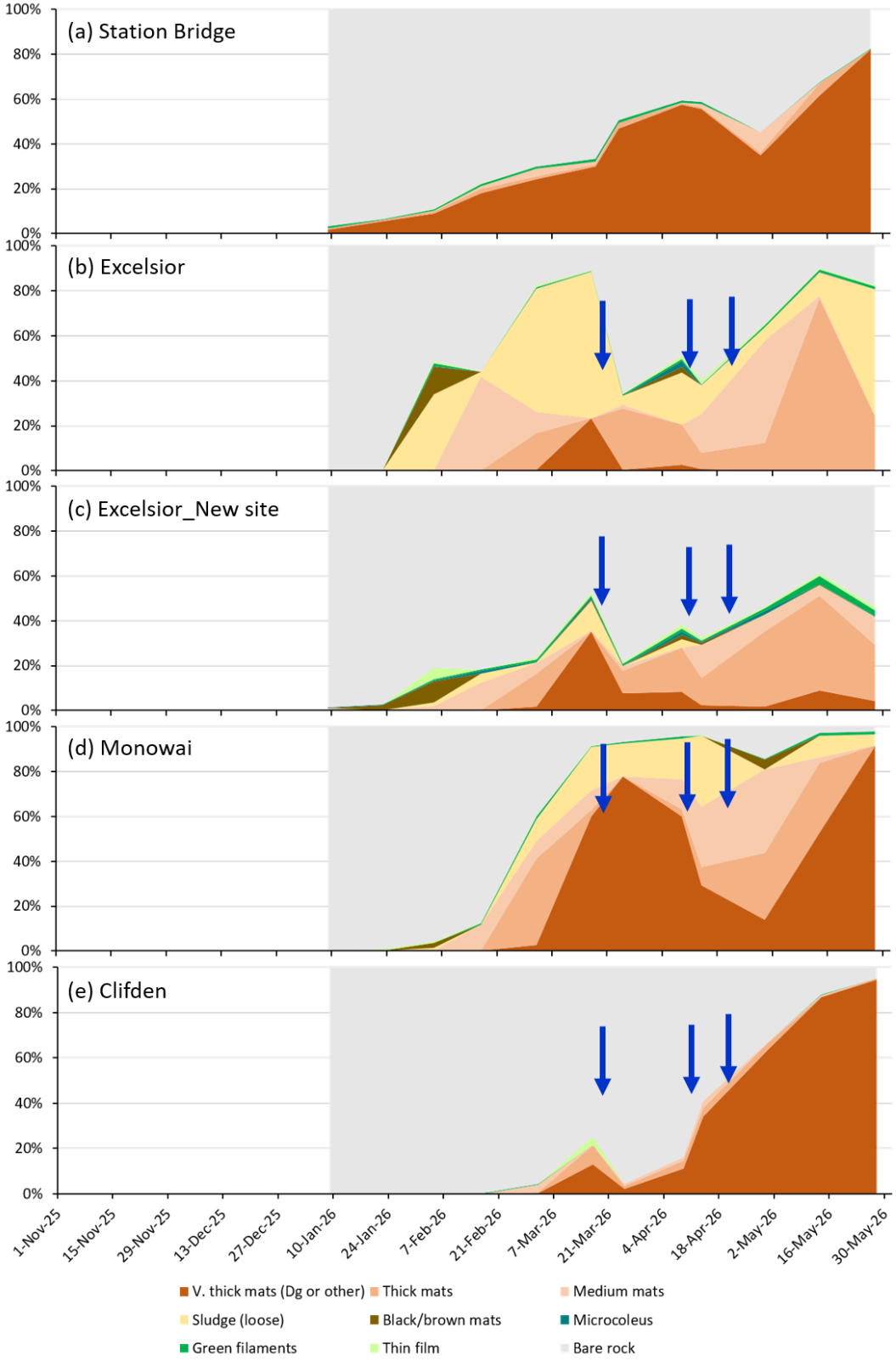


Figure 3.9 Time series of periphyton cover at the five sites monitored in 2025 to 2026. The blue arrows show times of monitored supplementary flow releases and an augmented natural flow event in the Lower Waiau River.

3.6 Comparison of periphyton at Excelsior sites

The trial site, Excelsior_New, supported both *Microcoleus* and didymo during the 2025–26 season (Figure 3.9). The relative abundance of these two nuisance periphyton was similar to that observed at the established Excelsior site, and seasonal development patterns were broadly comparable between the two locations. The main difference was a greater proportion of thick mats later in the season at Excelsior_New. Both sites also exhibited a peak in very thick mat cover in mid–March (Figure 3.9).

The supplementary flow release on 19–20 March more effectively reduced didymo cover at both Excelsior sites than the release on 9–10 March (Figure 3.4, Figure 3.6). This difference may partly reflect variation in the age, growth stage and condition of the didymo mats at the time of each release (Appendix E). Both supplementary flow events were implemented as variable releases in 2025–26, which had lower peak flows, and in the case of the March release a lower 24–hour maximum mean flow, than a typical flow releases as defined in the protocol (i.e., flows peaking above 160 m^3/s with mean flow of 120 m^3/s over 24 hours).

A notable difference in periphyton community composition between the two Excelsior sites was the consistently higher cover of sludge at the existing upstream Excelsior site (Figure 3.9). Field observations described this site as the 'lower velocity' site compared to the downstream trial site (Appendix E), which supports the high proportion of loosely–attached sludge and is consistent with observations made during the 2024–25 season that the existing Excelsior site may have become wider and shallower over time and therefore be less responsive to high–flow events than in the past (Kilroy and Hogsden 2025). For example, prior to the first supplementary flow release in 2025–26, mean sludge cover was 65% at the established site compared to 14% at Excelsior_New (Figure 3.4). This included records of 100% sludge cover in 45% of views at the established site. Because sludge is only loosely attached to the substrate, it was readily removed by the supplementary flow releases, resulting in marked reductions at both sites in the post release survey (Figure 3.4). A similar pattern was observed prior to the secondary supplementary flow release, with higher sludge cover at the existing sites followed by reduction at both locations after the release (Figure 3.6).

Overall, the results indicated that the two Excelsior sites supported similar nuisance periphyton communities and showed broadly similar responses to the supplementary flow releases during 2025–26. While releases were effective for sludge and some *Microcoleus*, they did not provide clear evidence that Excelsior_New experienced greater periphyton removal (including for didymo) during high flow events than the established site. This is partially due to the size and shape of the hydrographs of the supplementary flow releases that were provided and monitored this season (e.g., not 'typical' releases). Consequently, there is insufficient evidence at this stage to support relocating the Excelsior monitoring site to the downstream location as it was not necessarily more representative of managed flow effects on periphyton removal, particularly for didymo.

Continuation of the trial for a further monitoring season is recommended. Additional monitoring would provide the opportunity to assess periphyton removal responses at

both sites under a wider range of flow conditions and, ideally, during one or more typical supplementary flow releases. In addition, periphyton establishment and development in the Lower Waiau during 2025–26 was influenced by a prolonged lake spill event from late September 2025 to early January 2026 followed by a second spill event in January. Given these conditions, an additional season of monitoring at both Excelsior sites is recommended before any decision is made on relocating the site.

3.7 Water clarity

Water clarity monitored at four sites between November 2025 and May 2026 is shown in Figure 3.10 and Figure 3.11 along with data from all previous seasons, with further observations summarised in Appendix E. The key points from Figure 3.10, Figure 3.11 and Appendix E follow.

- Median water clarity was highest at Monowai (5.1 m) and Station Bridge (4.7 m), with Clifden and Excelsior showing lower median clarity (both 3.9 m) (Figure 3.10). Compared to the median values recorded in the 2024–25 monitoring season, these values were higher than those at Monowai and Station Bridge, equal at Excelsior and lower at Clifden, but all were within the range recorded in the last five seasons.
- Water clarity in the Mararoa River at Station Bridge achieved the pSWLP minimum water clarity limit of 1.6 m for hill-fed rivers when flows were below median flow for all surveys (Figure 3.10, Figure 3.11).
- Remnant didymo drifting in the water column and associated sediment likely affected black disk readings at Station Bridge on 9 April and 14 April surveys, which were the lowest recorded at this site across all surveys (i.e., 2.9 m, Figure 3.10, Appendix E).
- At the three Lower Waiau River sites, water clarity generally remained above the pSWLP minimum water clarity limit of 3 m for lake-fed rivers (at lower than median flow). However, occasional low-clarity observations occurred, particularly at Excelsior and Clifden. The water clarity limit was not achieved on one occasion (23 January) at Excelsior, which is shown as a black dot below the red dashed line and to the left of median flow (black line) in Figure 3.11.
- Lower variability in water clarity at Excelsior and Monowai this season may reflect the influence of the MLC:IP project that was underway during surveys the 2025–26 monitoring season and required continuous discharge (5 m^3/s) from Lake Manapōuri to meet consent conditions.
- The low clarity at Excelsior on 23 January occurred following return to minimum flows at MLC following a lake spill. Most measurements at the Lower Waiau sites are clustered within a relatively narrow range indicative of good water clarity.

- Overall, the 2025–26 season was characterised by generally high water-clarity across all monitoring sites, with only one non-achievement of pSWLP guideline values and no evidence of sustained clarity issues.

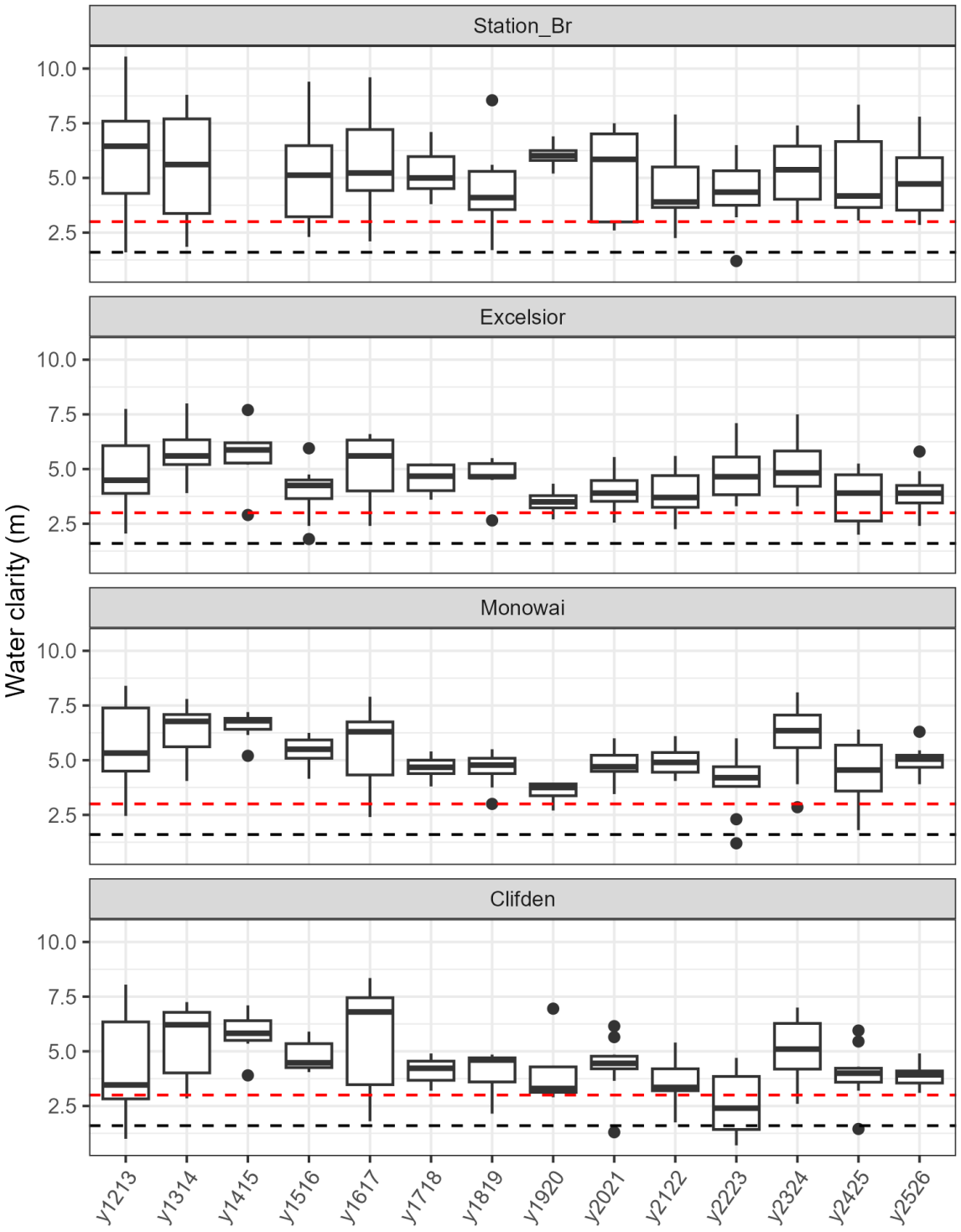


Figure 3.10 Box plots of water clarity measured in each season at the four monitoring sites. Black dashed lines = pSWLP water clarity minimum limit for hill rivers (1.6 m, applicable to the Mararoa River at Station Bridge); red dashed lines = pSWLP water clarity minimum limit for lake-fed rivers (3 m, applicable to Lower Waiau River sites). The limits apply only when flows are less than the

median flow. On the box plots, median clarity is shown by the line within the box, the boxes include data between the 25th and 75th percentiles, the whiskers show data within 1.5 times the interquartile range and dots are outliers (actual values).

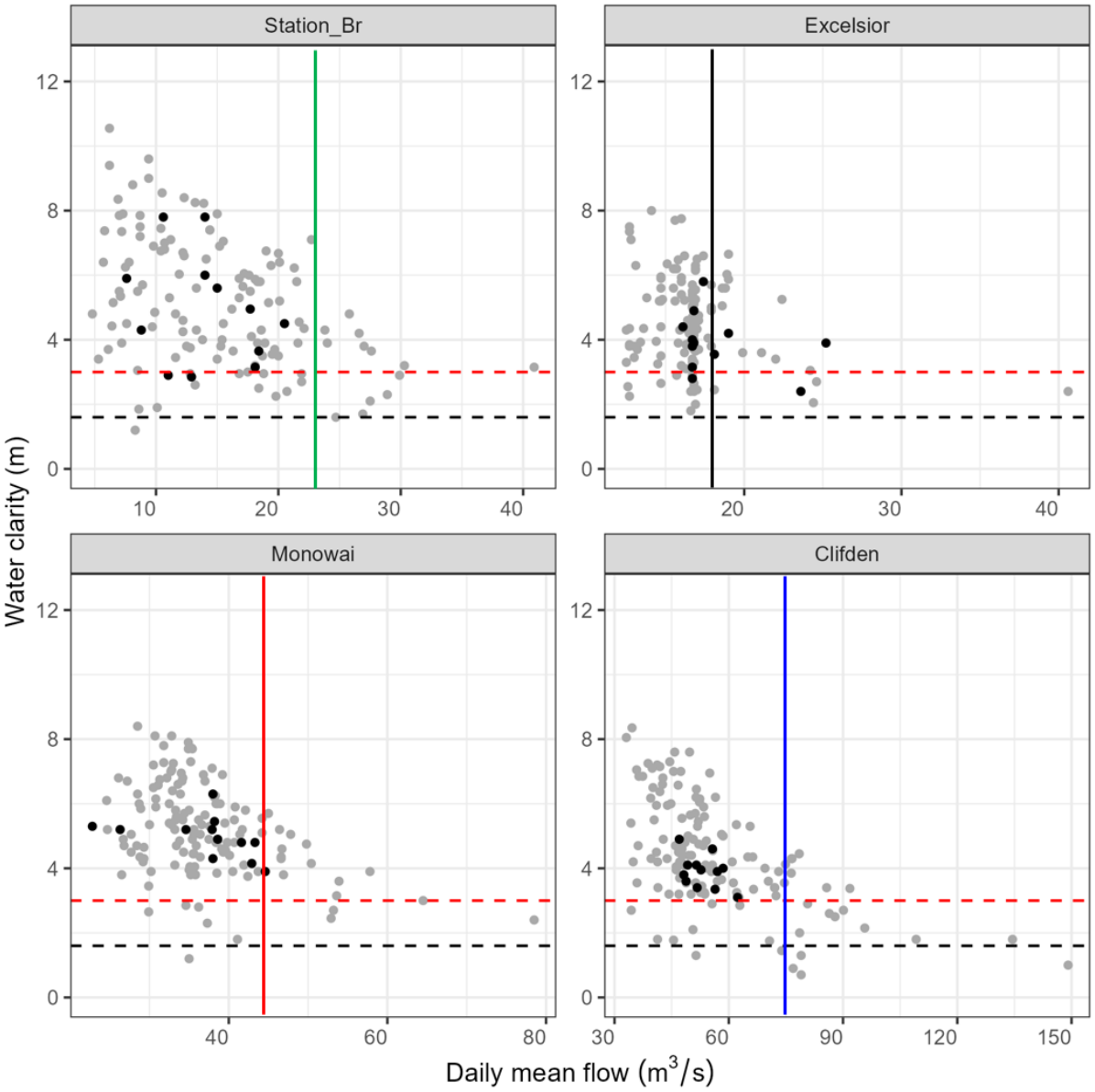


Figure 3.11 Water clarity plotted against flow on the day of sampling at each of the monitoring sites. Data from 2012 to 2026. Data from the current season (2025–26) are plotted in black and data from previous years in grey. Black dashed lines = pSWLP water clarity minimum limit for hill rivers (1.6 m, applicable to the Mararoa River at Station Bridge); red dashed lines = pSWLP water clarity minimum limit for lake-fed rivers (3 m, applicable to Lower Waiau River sites). The pSWLP limits apply only when flows are below median flow (Mararoa, 22.3 m^3/s (green vertical line); MLC, 16.8 m^3/s (black vertical line); Sunnyside, 45.5 m^3/s (red vertical line); Tuatapere, 75.2 m^3/s (blue vertical line). Median flow calculated from daily mean flow 2008 to June 2026. Note the different scales and ranges of flow (x-axis) at the four sites. Water clarity (y-axis) scales are the same so that sites can be compared directly.

4 Summary and recommendations

This report fulfils the annual reporting requirement of Condition 7 of Meridian's resource consent (Water Permit 206156) for MTAD. Condition 7 requires implementation of a protocol for controlled releases of supplementary flows from the MLC (see Appendix A to this report) to the Lower Waiau River to assist with management of nuisance periphyton, primarily didymo.

The 2025–26 season was the first full season in which the proactive approach to supplementary flow management, introduced and trialled in 2024–25, was continued. Under this approach, opportunities for supplementary flow releases were considered when lake levels and operational conditions allowed, including when the river was at green status, rather than waiting for amber or red river status. An additional monitoring site (Excelsior_New, ~70 m downstream of the existing site) was also trialled in 2025–26 to assess its suitability for long-term monitoring.

The monitoring season in 2025–26 was preceded by an extended lake spill from late September 2025 to early January 2026, followed by a second spill event in January. As a result, flows in the Lower Waiau River were high for an extended period. Mean flow at Waiau at MLC during the monitoring season was 140 m^3/s, more than double the long-term mean of 67 m^3/s, and the river exceeded three times the median flow for 39% of the monitoring period (83 days), compared with a long-term average of 20% (42 days). From 18 February 2026, as part of MLC:IP, flows at MLC were managed to vary with Mararoa River flows plus 5 m^3/s, with this flow requirement in place for the remainder of the 2025–26 monitoring season, which differs from previous seasons. The season was classified as a high-flow season. Elevated flows reflected contributions from both Lake Manapōuri and the Mararoa River, together with above-average inflows from downstream tributaries.

Twelve periphyton surveys were undertaken between 9 January and 28 May 2026. All surveys were carried out at the four established sites and the additional trial site at Excelsior.

SCI and river status results indicated that the season was characterised by lower-than-average nuisance periphyton development despite the persistence of didymo later in the season. The river was estimated to be at green status for 61% of the monitoring period, amber status for 19%, and red status for 20%. Green status persisted through to early March following the prolonged spill events and delayed establishment of periphyton across all sites. Mean SCI for the season (276) was lower than the long-term average (346), and the highest SCI recorded during the season (607) was substantially lower than maxima reported in previous seasons (e.g., 1049 in 2024–25, 1413 in 2014–15). Monowai had the highest mean SCI of the Lower Waiau River sites.

Two supplementary flow releases were undertaken during the season (19–20 March and 9–10 April 2026), together with one augmented natural flow event (17–22 April 2026). Together, the supplementary flow releases used 7.85 GWh of storage water, representing 52% of the maximum annual allocation permitted under the protocol. Including the augmented natural flow event, the total increased to 10.27 GWh (69% of

the maximum allocation). Both supplementary flow releases were variable hydrograph releases implemented when Lake Manapōuri levels were below those required to deliver a typical protocol–sized release.

The supplementary flow releases reduced SCI at some sites and were effective at removing loosely attached sludge and *Microcoleus*, particularly at the Excelsior sites. However, established thick didymo mats were comparatively resistant to removal, especially at Monowai and Clifden. Despite their relatively small size (when compared to a typical release), the supplementary flow releases contributed to maintaining or improving river status, and it is considered likely that river status would have deteriorated further in their absence.

Periphyton development during the season differed from that typically observed in the Lower Waiau River. Establishment of didymo was delayed at all sites, particularly at Clifden, which remained unusually clean through much of summer. From March onwards, didymo cover increased at all sites and persisted through to the end of the season. Monowai and Clifden were characterised by extensive thick didymo mats later in the season, whereas the Excelsior sites supported a greater proportion of sludge, mixed mats and *Microcoleus*. High cover of nuisance *Microcoleus*, which has been observed in some previous seasons, did not develop.

Comparison of the existing Excelsior site and the downstream trial site (Excelsior_New) showed that both locations supported similar nuisance periphyton communities and followed comparable seasonal development patterns. The main difference was the much higher cover of loosely attached sludge at the existing site, consistent with field observations that it is a lower–velocity habitat. Although the trial site supported healthy didymo and *Microcoleus* growth and may be better suited to meet the objectives of the programme, the supplementary flow releases did not provide clear evidence that nuisance periphyton removal during high flows was better at the downstream location. Consequently, there is insufficient evidence at this time to support relocation of the Excelsior monitoring site.

Water clarity is included in the monitoring programme under the protocol because it is an easily measured general indicator of water quality. Water clarity was generally high throughout the season and remained above the relevant pSWLP guideline values on all but one occasion. The non–achievement was at Excelsior in January following the return of minimum flows at MLC. Median clarity was highest at Monowai and Station Bridge, and there was no evidence of ongoing water clarity issues during the monitoring period.

The monitoring programme will continue in its current format during the 2026–27 season, as required under Condition 7 of the MTAD consent. Five recommendations arise from the 2025–26 programme:

- where feasible, continue to release supplementary flows with variable hydrographs as well as typical hydrographs, so that the comparative effectiveness of different release shapes can continue to be evaluated;
- continue to make all reasonable efforts to undertake pre–release and post–release surveys as close as practicable to the commencement and completion of

supplementary flow releases, to reduce variability in SCI caused by different accrual times, recognising that delays are sometimes unavoidable because of flow conditions, safety considerations and operational constraints;

- continue to report on supplementary flow outcomes using additional indicators alongside SCI and river status, including the types of periphyton removed and field observations of sloughing, sediment mobilisation and mat condition;
- continue, when possible, to take a proactive approach to releasing supplementary flows to potentially delay periphyton growth and extend green status; and
- continue the trial of the downstream Excelsior site for at least one further monitoring season before any decision is made regarding relocation of the long-term monitoring site. Additional monitoring under a wider range of flow conditions, including one or more typical protocol-sized supplementary flow releases, if possible, would provide a stronger basis for comparison between the two locations.

5 Acknowledgements

This report was commissioned and funded by Meridian Energy Ltd. We thank Jason Holland (Meridian) for discussions over this year's monitoring season and Ed Stead (Meridian) for input over the planning of supplementary flows and providing the plots in Appendix G. The surveys were carried out by Bill Jarvie and Zane Moss of Tohu Environmental, with assistance from Linda Pawsey. All their additional observations on periphyton cover and river conditions (as documented in Appendix E and referred to throughout the report) were much appreciated. We thank Elizabeth Graham for her helpful review comments.

6 References

Davies–Colley, R.J. (1988) Measuring water clarity with a black disk. Limnology and Oceanography, 33: 616–623.

Kilroy, C., Hogsden, K. (2025) Managing nuisance periphyton in the Lower Waiau River. Monitoring and management 2024–25. For Meridian Energy. NIWA Client Report No: 2025247CH.

Appendix A Protocol developed under Water Permit 206156 condition 7: Amended Version, 16 November 2018

MANAPOURI TAILRACE AMENDED DISCHARGE (MTAD)

WATER PERMIT TO DAM AND DIVERT THE WATERS OF LAKE MANAPOURI AND THE WAIAU AND MARAROA RIVERS

(RESOURCE CONSENT NO. 206156)

PROTOCOL FOR:

CONTROLLED RELEASES OF VOLUNTARY[1] SUPPLEMENTARY FLOWS FROM THE MANAPOURI LAKE CONTROL (MLC) STRUCTURE TO THE LOWER WAIAU RIVER

FINAL 9 APRIL 2013

AMENDED 7 NOVEMBER 2014

AMENDED 12 FEBRUARY 2016
AMENDED 16 NOVEMBER 2018

1. INTRODUCTION

This Protocol satisfies Condition 7[2] of Resource Consent No. 206156 held by Meridian Energy Limited (Meridian) to dam and divert the waters of Lake Manapouri and the Waiau and Mararoa Rivers with respect to the Manapouri Tailrace Amended Discharge Project (MTAD).

The Protocol provides for the controlled releases of supplementary flows from the Manapouri Lake Control (MLC) structure to the Lower Waiau River. This is to assist in managing periphyton biomass primarily didymo which has been introduced to the Waiau Catchment since the establishment and operation of the Manapouri Power Scheme. It is accepted by all parties that didymo is not an environmental effect that can be attributed to the establishment and operation of the Manapouri Power Scheme. The use of supplementary flows can assist mitigate the adverse effects of didymo. The parties recognise Meridian is not legally required to provide the supplementary flows but that these will have benefits to overall river health which includes sediment transport, eel migration and general ecosystem health.

Meridian has consulted the Waiau Working Party and the Guardians of Lakes Manapouri, Monowai and Te Anau and Te Ao Marama Inc during the development of this Protocol.

2. CONDITION 7

Condition 7 to Resource Consent 206156 states:

Lower Waiau River Voluntary Supplementary Flows

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[1] For ease of reference the Protocol shall refer to 'supplementary flows' to avoid repetition of 'voluntary' as stated in condition 7 and the title of the Protocol.

[2] Condition 7 was inserted into this MTAD Water Permit (Consent No. 206156) in 2012 by way of a change of consent conditions, to replace Conditions 7 to 13 of the consent originally granted to MTAD in 2010.

The consent holder shall prepare and implement a protocol relating to controlled releases of voluntary supplementary flows from the Manapouri Lake Control (MLC) structure to the Lower Waiau River, in order to assist in managing periphyton biomass. The protocol shall include the following:

(a) Any monitoring to be undertaken to assess periphyton biomass;
(b) The size, duration, frequency and timing of the supplementary flows considered useful to assist in managing periphyton biomass;
(c) The circumstances, relating to periphyton biomass and natural flow occurrences, under which controlled releases of supplementary flows will be considered by the consent holder;
(d) The circumstances, relating to lake levels and security of electricity supply, under which controlled releases of supplementary flows may not be able to be provided by the consent holder;
(e) The procedures to be followed by the consent holder in considering and deciding upon the provision of a controlled release of a supplementary flow, in terms of the circumstances in (c) and (d) above.

The consent holder shall consult the Waiau Working Party the Guardians of Lakes Manapouri, Monowai and Te Anau and Te Ao Marama during the development of the initial protocol and any subsequent changes to the protocol.

The protocol shall be forwarded to Environment Southland for its certification as to compliance with this condition, prior to the 1st of December following the grant of consent to this condition. Any changes to the protocol shall also require certification from Environment Southland prior to implementation. The results of any monitoring undertaken in terms of this protocol shall be forwarded to Environment Southland annually, in conjunction with the monitoring results provided under Condition 7. This shall include the dates and flow parameters of all controlled releases of supplementary flows provided under this protocol by the consent holder in the preceding year.

3. BACKGROUND

Meridian has funded extensive monitoring of periphyton biomass in the Lower Waiau River for the last 10 years. As a result, a basic understanding of biomass and flow relationships has been developed, including the ecology and seasonality of didymo growth and biomass. This information is intended to be used to underpin decisions relating to the provision of supplementary flows to assist in managing periphyton biomass set out in this Protocol. In the event better science becomes available the outcomes of this research will be used to promote changes to the Protocol.

At this time, the primary indicator of periphyton biomass is the Standing Crop Index (SCI). NIWA has related the SCI to the periphyton guidelines and suggested indices to guide the management of periphyton biomass which are approximate to the levels in the New Zealand Periphyton Guidelines[3] (Biggs 2000) .

In general, the main impacts of periphyton biomass as understood at this time are the aesthetic impact, the effect on recreational activities and the effect on river health. As stated above, periphyton biomass is measured as the Standing Crop Index. This is a relationship between the extent of cover and thickness of the periphyton mat.

An SCI of 220 is a similar amount of periphyton to the 35 g ash free dry matter Periphyton Guideline limits for the protection of trout habitat and angling values. An SCI of 600 corresponds approximately to the guideline (120 mg/m^2 Chl α) for aesthetics and trout habitat for visual cover

[3] **Biggs, B.J F., (2000) New Zealand Periphyton Guidelines: Detecting Monitoring and Managing Enrichment of Streams. Report to MFE.**

by filamentous algae. The SCI is used in preference to the exact Guideline values due to the ease of field measurement and production of data, as it does not involve laboratory methods.

"Traffic light" indices for periphyton management have been developed by NIWA specifically for the Lower Waiau River[4]. These are green (all is well), amber (a supplementary flow response should be considered) and red (a supplementary flow response is required). This is based on the SCI index of periphyton biomass which is described from an application perspective later in this Protocol.

The purpose of the Protocol is to provide clarification around when the consent holder will consider providing controlled releases of supplementary flows from the Manapouri Lake Control (MLC) to the Lower Waiau River. It is acknowledged the primary purpose of providing such flows is to assist in the management of the effects of periphyton biomass particularly didymo.

4. REVIEW OF OPTIONS FOR MONITORING 2014

In late 2013 Meridian requested NIWA review options for amending the survey procedure to increase efficiency while still providing the data required by the protocol for decision making over the release of voluntary supplementary flows. Cathy Kilroy of NIWA prepared the report "Managing nuisance periphyton in the Lower Waiau River - review of options for monitoring November 2013 updated July 2014". The report options were discussion at a WWP meeting on 25 July 2014 and subsequently circulated to the parties to the protocol – the Guardians of Lakes Manapouri, Monowai and Te Anau, and Te Ao Marama Inc. The outcome of consultation on this matter was that the options of using existing flow data to guide decision making on the timing of surveys and reduced survey effort (reduced monitoring sites and frequency) based on the existing monitoring protocols would be trialled for a year commencing in November 2014.

Monitoring of periphyton biomass will be undertaken by appropriately qualified, experienced personnel under the direction of the consent holder. The monitoring set out in sections 4.1 to 4.4 below amended the monitoring regime implemented under the Protocol effective from 9 April 2013 and was undertaken as a trial for a year beginning 1 November 2014 through to the end of May 2015. At the completion of this period the efficacy of the amended monitoring was to be reviewed. Subject to confirmation from the parties to this Protocol that the amended monitoring is appropriate, it will be adopted and continued for the following monitoring seasons/years.

4.1. Monitoring sites

The monitoring sites will be:

Lower Waiau River (from downstream): Clifden, Monowai, Excelsior; (three sites in total); and Mararoa River Station Bridge (reinstated November 2015).

The amended monitoring for the trial period removed two sites from the Lower Waiau River (Tuatapere and Jericho) and all the sites on the Mararoa River (Whitestone, The Key, Station Bridge, Normans and Kiwi Burn swing bridge.

The Station Bridge site on the Mararoa River was re-instated following the review of the trial period of the amended monitoring) as a comparison site in an unmanaged river and is not included in decision making under this Protocol.

The timing and frequency for monitoring will be: determined in accordance with the decision support matrix[5] set out in Appendix 1 commencing at the beginning of November through to the

[4] Kilroy, C., Wech, J. (2011) Five Years of an adaptive management programme to mitigate excess periphyton in the Lower Waiau River. NIWA client Report CHC 2011-056. 45p.
[5] Kilroy, C. (2014) Managing nuisance periphyton in the Lower Waiau River – Review of options for monitoring, prepared for Meridian Energy, November 2013, updated July 2014. NIWA Client Report No: CHC2013-151. 50p.

end of May. Antecedent flow data will be checked every two weeks during this period by NIWA who shall advise Fish and Game of the need to survey (with best endeavours of adequate lead in time). The aim is to reduce surveys while the river is in green status while ensuring that periods in the red status are detected and considered for voluntary supplementary flow releases as set out in Appendix 2.

All monitoring will be at times of minimum flow or as close to, (i.e 16 m^3/s measured at the MLC or 50 m^3/s at Sunnyside). If there is a flood[6], monitoring will be undertaken as soon as possible after flows return to minimum flow, and the 2-weekly schedule restarts from the post flood sampling date.

4.2. Monitoring methods

All monitoring will:

- Undertake visual assessments, using the underwater viewer (see Kilroy and Biggs 2008).[7]
- Measure water clarity at each site, using the black disk method (mean of two readings, one per person).

4.3. Post-monitoring procedure

Once monitoring is completed:

- Data sheets from all three monitoring sites will be forwarded for processing after the survey is completed (normally within 24 hours).
- The data will be processed and results (SCI at each site) reported back to Meridian normally within one working day of receipt of the data sheets.
- SCI results will be reported for individual sites, including the assigned collective status according to their traffic light indices provided by NIWA.
- Reporting will include a commentary on growth in the Lower Waiau River (from the SCI results, and from field observations). This will be made available on a monthly basis to the Chairman of the Waiau Working Party and the Chairman of the Guardians of Lakes Manapouri, Monowai and Te Anau;

The traffic light index to be used by the consent holder to determine the timing of supplementary flows is as follows:

Green – all is well: SCI at all sites < 220; or the mean SCI < 200;

Amber – alert- response considered: at least one site with SCI > 220 and the mean SCI >200<300; or the mean SCI is between 200 – 600;

Red – response required: at least two sites with a SCI > 220 and the mean SCI >300, or the mean SCI is > 600.

4.4. Duration of monitoring

Amended monitoring trial 1 November 2014 to May 2015

The amended monitoring programme was undertaken for a trial period of a year commencing in November 2014 until the end of May in the following year (2015). The frequency and number of surveys was determined in accordance with the Decision Support Matrix set out in Appendix 1. A

[6] "Flood" is defined as any flow event greater than 50 m^3/s (daily mean flow) at MLC

[7] **Kilroy, C., Biggs B.J.F (2008). Management of periphyton (didymo) blooms in the Lower Waiau River: an adaptive Management trial 2006 - 2008. NIWA client Report CHC 2008-054. 45p.**

review of the amended monitoring was to occur at the completion of the trial period (end of May 2015).

Review of the amended monitoring trial

NIWA reviewed the implementation of the amended monitoring regime following completion of the trial period at the end of May 2015. The review considered the practicalities of the amended monitoring methodology and whether useful information was lost by reducing the number of surveys and the number of sites surveyed. The review and its findings is in section 3 of the NIWA report "Managing nuisance periphyton in the Lower Waiau River - results for 2014 -15 and review of an amended monitoring protocol"[8]. The review concluded that the amended monitoring methodology is an appropriate approach and recommended that it continue for future monitoring seasons since the trial period had demonstrated that it successfully met the requirements of the consent and the amended Protocol (7 November 2014). The review also recommended re-instating one site on the Mararoa River (Station Bridge) to provide a comparison site in an unmanaged river. The site would not be included in the decision making under Appendix 2 of the Protocol.

The NIWA Report and review findings were presented to the parties to the Protocol, at the Waiau Working Party meeting on 27 November 2015, the Guardians of Lakes Manapouri Te Anau and Monowai meeting on 18 November 2015, and to Te Ao Marama. The parties to the Protocol supported the Review findings and recommendations to continue the amended monitoring methodology and to re-instate one survey site on the Mararoa River at Station Bridge in the monitoring programme.

4.5. Variable Flow Releases

A recommendation regarding more variable flow releases was in made in the NIWA reports on the annual nuisance periphyton program carried out in 2015-16, 2016 17 and 2017-18 seasons under the protocol. The purpose of the recommendation was to promote and investigate the flows releases to assist in managing nuisance periphyton. The recommendation involved a trial based on a more variable flow release by modifying the shape of the flushing flow hydrograph from that typically made under the protocol. To date the flow releases made under the protocol have met its definition specified as "flows peaking between 160 m^3/s and 250 m^3/s with a mean flow of 120 m^3/s over 24 hours." (see section 5.1 below).

Analyses of the effects of nine previous supplementary flow releases in the NIWA annual reports (Kilroy and Wech 2016 and Kilroy 17a) led to the recommendation for trials of supplementary releases that varied from the current specification of the protocol. The NIWA 2018 annual report further recommended the trials and considered that varying the length and/or recession of the flow release hydrograph may assist in dislodging loose didymo remnants that maybe left after a more rapid recession.

The NIWA report "Review of Options for Periphyton Management in the Lower Waiau River" October 2017[9] was commissioned by Meridian following discussions at the Waiau Working Party meetings of 27 November 2015 and 13 December 2016 regarding alternative options to assist in the management of nuisance periphyton. The report discussed three categories of control - higher flows (the current method under this protocol), manipulation of low flows and using chemicals. In regard to the option of high flows, the report reviewed all flow releases made since 2007-08 including releases made under this protocol. It recommended the current programme under the protocol continue to accumulate more data that could help improve the relationships for predicting the effects of supplementary flow releases and other high flows. In conjunction with this option, the WWP meeting further discussed the implementation of the more variable flow releases in the

[8] Kilroy C, (October 2015) Managing nuisance periphyton in the Lower Waiau River – Results for the 2014 – 15 and reiew of an amended protocol. NIWA Client Report CHC 2015-079
[9] Kilroy C, (October 2017) Review of options for periphyton management Lower Waiau River NIWA Client Report 2017112CH)

2017-18 season as recommended by the previous annual reports. However, no flow releases were able to be made in 2017-18 season due to lake levels and water availability.

A further presentation on trialling the variable flow releases was made by Cathy Kilroy of NIWA to the Waiau Working Party (WWP) on 5 June 2018. The meeting resolved to support the trials commencing in the 2018-19 season noting that the trial releases may not meet the protocols specifications for flows peaking between 160 m^3/s and 250 m^3/s with a mean flow of 120 m^3/s over 24 hours and that the water available for releases each season is 15GWh as currently provided for by the protocol.

The NIWA reports and WWP recommendations regarding the trials of the variable flow releases have been provided to the other parties to the protocol. Each party (the Waiau Working Party, Guardians of Lakes Manapouri, Monowai and Te Anau, Te Ao Marama and Southland Fish and Game) has supported and agreed to the amendment of the protocol to enable the trials of the more variable flow releases. The trials are to commence in the 2018-19 season (1 November to 31 May) subject to water availability (as currently occurs under the protocol) for up to a 10 year period to enable the accumulation of sufficient data on the more variable releases to analyse their effectiveness. A conclusion regarding the effectiveness of the variable releases will be made a soon as practically possible given that in previous years 2015-16, 2016 17 and 2017-18, seasons only 1 or 2 releases are often possible, and occasionally no flow releases, due to lake levels and water availability. A short report following each release is provided to the Chairs of the parties to the protocol and the seasons results are analysed the annual report for that season, as currently occurs under the protocol.

5. SUPPLEMENTARY FLOWS CONSIDERED USEFUL TO ASSIST IN MANAGING PERIPHYTON BIOMASS

5.1. Flow size and duration

Based on current knowledge, NIWA has recommended that flows with peaks above 160 m^3/s and a mean of 120 m^3/s are useful to assist in managing periphyton biomass, including didymo (Kilroy 2010)[10]. Flows at or above this magnitude already occur naturally and, under certain conditions, can be released as controlled supplementary flows.

Flows above 250 m^3/s are unable to be generated whilst adhering to the Manapouri lake level guidelines (constrained by the MLC structure capacity) and are entirely reliant on naturally occurring rainfall inflow events that raise the Lake Manapouri level to a height that triggers the flood rules, or raise the Mararoa River flow to high levels.

Controlled releases of supplementary flows with the aim of assisting in managing periphyton biomass are, therefore, defined as flows peaking between 160 and 250 m^3/s and with a mean flow of 120 m^3/s over 24 hours.

Meridian will provide a maximum of 15 GWh of storage water released (i.e. water which otherwise would be retained for optimal energy generation) for all supplementary flows between December and the end of May. This is the equivalent of approximately 4 full artificial supplementary flows per summer of the type described in clause 5.1 of this protocol. More than 4 flows may be provided if releases are in part an augmentation of natural events and the storage flows released overall are provided within the maximum GWh provided[11].

For the purposes of the trials of the more variable flow releases beginning in the 2018-19 season, the releases may not reach the above flows peaking between 160 and 250 m^3/s and with a mean flow of 120 m^3/s over 24 hours. This is due to the variable shape of the release hydrograph which may be over a longer duration than 24 hours and have a different rate of

[10] **Kilroy, C, (2010) Management of nuisance periphyton growths in the Lower Waiau River using flushing flows: an update 2009 – 10. NIWA Client Report CHC 2010-083. 44p.**

[11] 1 GWh equates to 2351020 cubic meters of storage water from Lake Manapouri. Hence 15 GWh equals 35265300 m^3

recession. The maximum of 15 GWh of storage water released (i.e. water which otherwise would be retained for optimal energy generation) for each season remains.

5.2. Flow frequency and timing

Based on current knowledge, NIWA has recommended that supplementary flows may be useful to assist in managing periphyton biomass during the months of December to May. From previous monitoring undertaken, it is considered that natural or artificial flows at or above the flow size presented above are required at approximately 4 week intervals, to maintain periphyton biomass at suitable levels.

To minimise impacts on recreational activities ramping up should generally not commence prior to 22:00 hours on a Sunday and ramping down will be completed by 12:00 hours on a Friday for artificial releases. Releases to augment a natural event will be released to maximise the benefit of the event being augmented.

6. CIRCUMSTANCES RELATING TO PERIPHYTON BIOMASS AND NATURAL FLOW OCCURRENCES

The period agreed by the parties to this Protocol for controlled releases for the management of periphyton biomass if required are generally between 1 December and 1 May in any year: Target dates for 4 supplementary flows will be agreed with Fish and Game New Zealand Southland Region prior to each season for this period. An additional provision is made for circumstances relating to a SCI reading of red in the month of May. For the purposes of this Protocol a natural flow event or an augmented flow within four weeks of the target date with flows peaking over 160 m^3/s and with a mean flow of 120 m^3/s over 24 hours will be considered to have met the requirements of this protocol. No additional controlled release during that time period will be considered necessary under the protocol. The naturally provided flow component of any event will not be considered part of the 15 GWh provision, but the provision of additional water above the operational requirements (e.g. Flood Rules) will be.

Where the SCI for periphyton biomass control is red and has extended into the first three weeks of May then an additional supplementary flow shall be provided by the consent holder unless constrained by matters relating to security of supply. The consent holder obligation to this requirement will only exist if the 15 GWh storage provided for under the Protocol has not been called upon in the preceding months to the degree that the required flow can be provided from this reserve.

7. CIRCUMSTANCES RELATING TO LAKE LEVELS AND SECURITY OF ELECTRICITY SUPPLY

7.1. Lake levels

The levels of Lakes Manapouri and Te Anau are primarily managed in accordance with the Lake Level Guidelines, which are a requirement of their current consent conditions. They set maximum durations for the lakes to be in each range and the minimum elapsed time between events which penetrate each range.

The operation in the main range is not constrained other than by the requirement to maintain continuous variation in lake levels so as to avoid impacts such as wave-cut platforms. The guidelines also require management of the mean lake level to ensure that this falls within the main range limits.

MLC was designed to allow for control of Lake Manapouri level for hydroelectricity generation and to manage flood flows from Lake Manapouri. The ability of MLC to discharge high flows while Lake Manapouri level is not in the flood range is limited by a number of factors, including

the level of Lake Manapouri and headwater level at MLC, Waiau Arm flows, and Mararoa River flows.

When Lake Manapouri is in the low range there is insufficient head to produce controlled releases of supplementary flows of the required size. When the Lake is in the high range, according to the flood rules, discharges from MLC above minimum flows are required and there is sufficient water to enable the provision of these flows.

Meridian will generally not build lake levels in anticipation of controlled releases of supplementary flows. There are a number of issues with pre-emptive attempts to build levels. These include:

Rainfall uncertainty: The lake catchments do not have a seasonal pattern to the rainfall. Significant events may occur at any time of the year. Maintaining lake levels in the upper portion of the main range will significantly reduce the ability to capture events and increase flood risks;

Variability of lake levels: Due to limited lake storage capacity and the variable nature of inflow patterns, the Manapouri Power Scheme (MPS) is regarded as a 'run-of-river' power scheme. Therefore, levels in Lakes Manapouri and Te Anau also generally reflect the variable nature of inflows and limited storage capacity. This variability is important for the maintenance of lakeshore vegetation, aquatic macrophytes and shoreline geomorphology.

Building and maintaining the lake levels in the upper portion of the main range is inconsistent with this approach to lake level management. As a result, building of Lake Manapouri levels would only be considered by Meridian in exceptional circumstances and in light of all relevant information regarding environmental and generation supply factors.

7.2. Electricity supply

There are 2 main areas of security of supply concern in relation to providing controlled releases of supplementary flows. These are risks to generation supply due to potential low water supplies and distribution constraints.

8. PROCEDURES FOR CONTROLLED RELEASES OF SUPPLEMENTARY FLOWS

The procedures outlined below will be followed when deciding upon the provision of a controlled release of supplementary flows for periphyton management.

8.1. Steps to be Followed

Four controlled releases of supplementary flows will be provided during 1 December to 1 May identified in Clause 6 of this Protocol if the SCI conditions fall within the amber or red indices specified in section 3.4 of the Protocol and if the lake levels and electricity supply security circumstances allow. A fifth flow on May will be considered if the circumstances described in paragraph 6 of this protocol exist.

Lake levels, catchment hydrology, hydro risk curves, distribution and line constraints including the likelihood of outages will be considered by the consent holder for each potential controlled release of a supplementary flow. A fifth flow in May will be considered if there is an SCI reading of red during the third week and if there are sufficient GWh remaining as set out in clause 6 of this protocol.

Prior to undertaking a supplementary flow release the consent holder will liaise with a nominated representative of Fish and Game Council and inform the Chairman of both the Waiau Working Party, the Guardians of Lakes Manapouri, Monowai and Te Anau and Te A O Marama of the timing of the supplementary flows.

All decisions made will be documented, giving the reasons for the decision. The decision will follow the process in **Appendix 2**.

If a flow cannot be provided, Meridian will, in exceptional circumstances, make endeavours to manage lake levels to provide the flow (in accordance with the responses set out in **Appendix 2**). Any such a flow will meet the 4 week lead-up to the subsequent flow release and consequently be considered to meet that flow requirement.

9. REPORTING

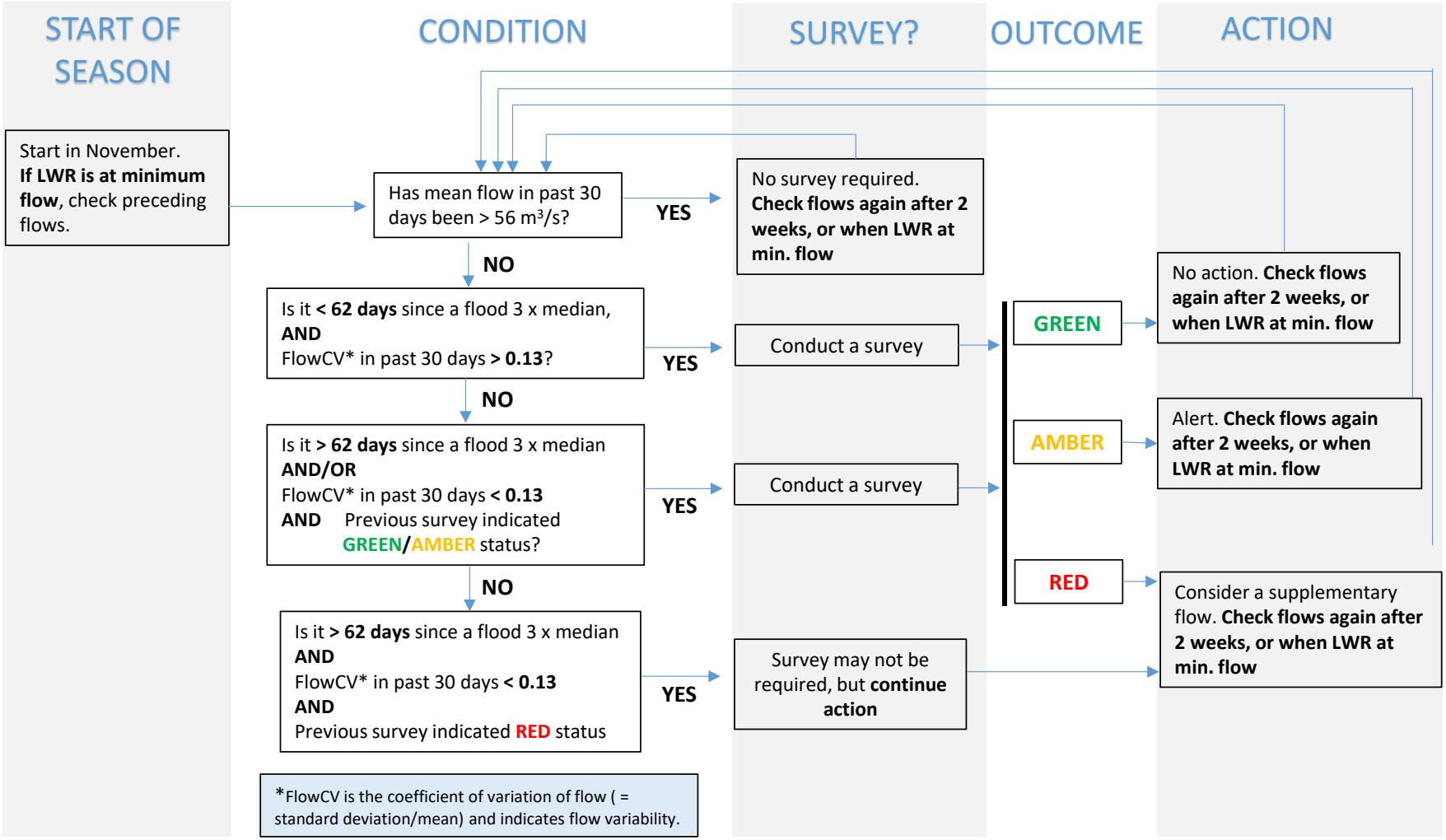
After each supplementary flow Meridian shall provide a report stating the number of GWh used and the remaining GWh left for the rest of the season. A copy of the report shall be forwarded to the nominated representative of Fish and Game Council, the Chairman of the Waiau Working Party, the Chairman of the Guardians of Lakes Manapouri, Monowai and Te Anau and Te Ao Marama.

The results of all monitoring undertaken in terms of this Protocol will be forwarded to Environment Southland annually[12], in conjunction with the results of other monitoring required by the conditions of consent for MTAD. A copy of the results shall also be forwarded to the Chairman of the Waiau Working Party and the Chairman of the Guardians of Lakes Manapouri, Monowai and Te Anau, and Te Ao Marama.

[12] NIWA Report entitled "Managing nuisance periphyton in the Lower Waiau River" prepared under MTAD consent 2061546 condition 7.

APPENDIX 1 of protocol for controlled releases of supplementary flows from the MLC structure to the Lower Waiau River

Flow chart to guide decision making over when to conduct periphyton surveys in the Lower Waiau River



APPENDIX 2. PROCEDURES FOR IMPLEMENTATION

Note to be read in conjunction with Appendix 1 – The consent holders' obligation under this protocol to provide supplementary flows equates to a maximum 15 GWh total storage for the season

Concern	Lower Waiau River Environmental Indices	Agreed Supplementary Flow Release	Electricity Supply Concerns	Agreed Response
Green	None SCI at all sites < 220; or mean SCI < 200	None	Not Applicable	None

Concern	Lower Waiau River Environmental Indices	Agreed Supplementary Flow Release	Electricity Supply Concerns	Agreed Response
Amber	Controlled releases of supplementary flows could assist in managing periphyton biomass. At least one site with SCI > 220 AND mean SCI >200<300, OR Mean SCI 200 - 600	Consideration of the release of a supplementary flow of 160-250 peak m^3/s with a mean flow of 120 m^3/s across 24 hours (*unless a flow of this peak and mean has occurred within the prior 4 weeks for any programmed flows)*	Manapouri lake levels above the level to produce flows of 160 m^3/s **and** no hydro risk curve concerns for the next 9 months.	Either release the flow on a timed basis (*The flow is to be commenced at 10pm during a week day avoiding week ends).* Or supplement a Lake Manapouri flood flow or a Mararoa River turbidity event with a controlled release (only *if Lake Manapouri at levels which achieve overall peak and mean needs*)
			Manapouri lake levels below level to produce flows of 160 m^3/s **and** no hydro risk concerns for the next 9 months.	Meridian to assess options for awaiting inflows sufficient to provide a controlled release of a supplementary flow
			Hydro risk for the next 9 months show security risks	None (*flow would only occur as a result of Mararoa River turbidity flows or Lake Manapouri flood flows and would not be supplemented with any controlled release)*

Concern	Lower Waiau River Environmental Indices	Agreed Supplementary Flow Release	Electricity Supply Concerns	Agreed Response
Red	Controlled releases of supplementary flows would assist in managing periphyton biomass. At least two sites with SCI > 220 AND mean SCI >300, OR Mean SCI > 600	Controlled release of a supplementary flow of 160-250 peak m^3/s with a mean flow of 120 m^3/s across 24 hours (*unless a flow of this peak and mean has occurred within the prior 4 weeks for any programmed flows)*	Manapouri lake levels above level to produce flows of 160 m^3/s **and** no hydro risk curve concerns for the next 9 months.	Either release the flow on a timed basis (*The flow is to be commenced at 10pm during a week day avoiding week ends).* Or supplement a Lake Manapouri flood flow or a Mararoa River turbidity event (*only if Lake Manapouri at levels which achieve overall peak and mean needs*)
			Manapouri lake levels below level to produce flows of 160 m3/s **and** no hydro risk concerns for the next 9 months	Meridian to consider reasonable endeavours (such as generation withdrawal) to conserve storage levels to provide a controlled release of a supplementary flow
			Hydro risk curves for the next 9 months show security risks	Meridian to assess options for awaiting inflows or conserving storage levels such as generation withdrawal) sufficient to provide a controlled release of a supplementary flow

Appendix B Background: periphyton in the Lower Waiau River and development of the protocol for periphyton management

Periphyton in the Lower Waiau River

Periphyton is the algae–dominated community that grows attached to submerged surfaces in aquatic habitats. Periphyton is a natural part of river ecosystems but excessive biomass – i.e., nuisance periphyton – can degrade instream values such as ecological health or recreational use. Guidelines have been set for amounts of periphyton under which these values are protected. In particular, the National Policy Statement for Freshwater Management (NPS–FM) (New Zealand Government 2020) includes an attribute for periphyton (measured as chlorophyll *a* to represent biomass).

Two factors that can lead to nuisance periphyton are enrichment of waters with nitrogen and phosphorus, and river flow regimes that lack enough high flows to periodically remove periphyton before it can develop to nuisance levels. Both these factors can occur naturally or as a result of anthropogenic changes. For example, natural lake–fed rivers often support high periphyton biomass because the buffering effect of upstream lakes reduces flood size and frequency (Jones 2010). Rivers with regulated flows (by dams) may support higher periphyton biomass than unregulated sections of the same rivers (Tonkin et al. 2009).

Nuisance periphyton has long concerned local stakeholders of the Lower Waiau River, Southland. Until 2004, mats of the benthic cyanobacterium *Microcoleus* (previously known as *Phormidium*) were the primary issue. Since October 2004, the non–indigenous, bloom–forming diatom *Didymosphenia geminata* (didymo) has dominated periphyton in river. Didymo led to unprecedented levels of periphyton standing crop (Kilroy et al. 2009), which still occur from time to time, although *Microcoleus* mats are becoming a concern again (e.g., Kilroy and Hogsden 2024). Meridian Energy Limited (hereafter Meridian), as operator of the Manapōuri Power Scheme (MPS), has worked with local stakeholders, such as the Waiau Working Party, for over 20 years to monitor and assist with the management of nuisance periphyton in the Lower Waiau River.

The Lower Waiau River is the natural outlet of Lakes Manapōuri and Te Anau. The Manapōuri Lake Control (MLC) structure allows diversion of water from the Mararoa River (which joins the Lower Waiau upstream of the MLC) through Lake Manapōuri to the Manapōuri Power Station from where it is discharged into Doubtful Sound. Downstream of the MLC, the Lower Waiau River receives minimum flows of 12 m^3/s in winter (1 May to 30 September), 14 m^3/s in October and April and 16 m^3/s in summer (November to March), with monthly recreational releases (~35–45 m^3/s) in summer (October to April). Natural lake floods from Lake Manapōuri occur occasionally, with, on average, about 1.1 events per year peaking in the range 200–300 m^3/s, and one event

per year in the range 300–500 m^3/s. Large lake floods exceed 500 m^3/s and occur, on average, ~0.9 times per year.[4]

Under minimum flows, the Lower Waiau River receives water from the Mararoa River and, when flow in the Mararoa River is lower than the minimum flow, Lake Manapōuri. When Mararoa flow exceeds the Lower Waiau minimum flow, excess Mararoa River water may be diverted into Lake Manapōuri. However, the more turbid waters of high Mararoa River flows are always required to be passed directly through the MLC to the Lower Waiau River, a strategy enabled by continuous turbidity monitoring in the Mararoa River near the flow recording station (Mararoa at Cliffs), just upstream of the MLC. The turbidity monitoring allows identification of times when turbid Mararoa River needs to be directed into the Lower Waiau River, which also introduces smaller natural flood events to the Lower Waiau River. Under the discharge permit for the Manapōuri Lake Control Improvement Project (MLC:IP) which was granted resource consent by Environment Southland in 2024, positive flows must be maintained through the Waiau Arm (from Lake Manapōuri towards the MLC) during the parallel channel excavation works and throughout any management activities (Consent 20233670–01, Condition 5). These positive flows are intended to prevent movement of suspended sediment generated during these works towards Lake Manapōuri.

The tool trialled for management of nuisance periphyton in the Lower Waiau River since late 2006 has been the release of flushing flows (termed "supplementary flows", "supplementary flow releases" or "flow releases") to supplement the naturally occurring floods from Lake Manapōuri or the Mararoa River. Supplementary flows are released at appropriate times (i.e., when periphyton standing crop exceeds a defined threshold), provided sufficient water is available. Supplementary flows released to date have generally led to short–term reductions in periphyton standing crop, thereby assisting in maintaining periphyton at acceptable levels (e.g., Kilroy 2023). The surveys carried out before and after supplementary flows and used to assess their effects are referred to as the pre–release and post–release surveys.

Protocol developed under Water Permit 206156 condition 7

In 2010, Environment Southland granted a resource consent (Water Permit 206156) to Meridian to operate the Manapōuri Amended Tailrace Discharge (MTAD). MTAD increased the maximum allowable discharge from the MPS to Doubtful Sound and was first exercised on 23 October 2012. Condition 7 in Water Permit 206156 required Meridian to develop and implement "a protocol relating to controlled release of voluntary supplementary flows from the Manapōuri Lake Control (MLC) structure to the Lower Waiau River, to assist in managing periphyton biomass". The protocol was required because a consequence of MTAD was predicted to be lower frequency of flows ranging from 150 to 599 m^3/s (URS 2009), potentially extending the duration of periphyton blooms.

[4] Statistics calculated from daily mean flows, Waiau at MLC, 1997 to 2023; events with <7 days between them counted as a single event. 1997 was taken as the start date for the calculation as this was the first full year following commencement of minimum flows in the Lower Waiau River in December 1996. The numbers change very little from year to year and are re–calculated every few years.

The protocol developed under condition 7 comprised a plan and methodology for monitoring, decision–making and responses. The protocol was based on the monitoring and decision–making system operating over the 2012–13 survey period, including a definition of a supplementary flow[5]. Starting with the first trials in 2006, the system had evolved in an adaptive management process. The protocol continues to evolve, with changes approved and documented in earlier reports (e.g., Kilroy and Wech 2011, 2012, Kilroy 2014, 2017, 2019). The protocol was agreed by Environment Southland, following consultation with the Waiau Working Party, the Guardians of Lakes Manapōuri, Monowai and Te Anau, and Te Ao Marama (parties to the protocol), and first became effective from April 2013. The most recent approved version of the protocol (16 November 2018) is reproduced as Appendix A of this report.

The most recent amendment to the protocol has been to allow trials of "variable" supplementary flows by modifying hydrographs from those specified in the protocol and potentially not meeting the definition in the protocol. The amendment followed an analysis of the effectiveness of supplementary flows released since the start of the programme (summarised in Kilroy 2019), and consideration of the effects of flushing flow releases in other rivers (e.g., Opuha River, Measures and Kilroy 2014) that had shorter–duration peaks but longer recessions than the supplementary flow defined in the protocol. A comparison of the effects of two modified supplementary flows in 2019 with those of previous supplementary flows concluded that "…the effectiveness of individual supplementary flows depends on multiple factors, but hydrograph shape (an extended recession in this case) may be another contributing factor" (Kilroy 2019). Further trials of variable hydrographs were recommended. It is also noted that further supplementary flows with a hydrograph meeting the original definition in the protocol (hereafter referred to as "typical" supplementary flows) are also important for comparison purposes.

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Jones, N.E. (2010) Incorporating lakes within the river discontinuum: longitudinal changes in ecological characteristics in stream–lake networks. Canadian Journal of Fisheries and Aquatic Sciences, 67(8): 1350–1362. 10.1139/f10–069.

[5] Supplementary flows are defined in the protocol as "flows peaking between 160 and 250 m^3/s with a mean flow of 120 m^3/s over 24 hours." The definition is appropriate because the peak flow magnitude exceeds the threshold flow of 153 m^3/s for mobilising sand in the reach downstream of the MLC, as estimated by Hicks et al. (2009) (see Table 4.5 in that report). The threshold for mobilisation of fine bed substrate approximately coincides with the threshold at which periphyton starts to be removed (Hoyle et al. 2017).

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Appendix C Details of monitoring methods

Sites

The general site locations have been used since the start of the programme, with occasional adjustments to allow for changes in river conditions. For example, in November 2022, the site at Station Bridge site was relocated 150 m downstream, the Monowai site was relocated 90 m upstream, and the Clifden site was relocated 60 m upstream (Kilroy 2023). In the 2025–26 monitoring season, additional transects were trialled ~70 m downstream of the existing Excelsior site to allow for comparative analysis of periphyton results and assess the suitability of moving the site for long-term monitoring and to achieve programme objectives, as recommended in Kilroy and Hogsden (2025). Site details are provided in Table 2.1 in the main report text.

Periphyton monitoring frequency and timing

The complete flow-based decision-making system for determining whether a survey takes place is found in Appendix 1 of the protocol (reproduced in Appendix A of this report). The system is based on at least fortnightly "flow checks" carried out to determine whether a survey is required.

The protocol requires two-weekly monitoring, except when flow metrics indicate that a survey may be suspended or delayed. The criteria for considering a delayed survey are:

- if the average of daily mean flows in the Waiau @ MLC Tailwater over the previous 30 days exceeds 56 m^3/s. The 30 days always includes a high flow large enough to have removed periphyton to well below nuisance levels, assuring green or amber status;
- if the time elapsed since a flow exceeding 3 × median flow is more than 62 days, because periphyton levels are always high (red status) under these conditions;
- if the coefficient of variation of flow (CV_flow) over the past 30 days is less than 0.13, provided river status is already red. The CV of flow is a measure of variability of flow, calculated as the standard deviation standardised to the mean flow.

The two-week monitoring interval is short enough to capture different rates of accrual during minimum flows at MLC, and the effects of natural and supplementary flows.

Field procedures

Surveys were conducted by staff from Tohu Environmental. Each survey comprised visual assessments of periphyton cover at each site and a water clarity measurement.

The visual assessment procedure has been carried out using a consistent methodology since the 2007–08 monitoring season, with minor modifications. At each site, periphyton cover was assessed in 20 areas of the riverbed using an underwater viewer with a 300 mm diameter window. Percentage cover of periphyton was estimated visually in different categories based on texture and colour (Table C.1). The thickness of

very thick mats was measured using a narrow ruler. In the Lower Waiau and Mararoa Rivers, mats are usually dominated by didymo. Other types of mats do occur, and non-didymo algae were noted by the survey team on the field recording sheets.

Table C.1 Periphyton categories used in the visual assessments. Abbreviations are used in figures in the main text. The categories have been adjusted over the years to accommodate new observations. Dg = didymo.

Periphyton category	Description	Abbreviation
Bare rock	No visible algae, not slippery or slimy.	Bare rock
Thin films, green/yellow	Green–yellow slimy covering, less than 0.5 mm thick.	Thin film
Thin films, black/brown	Black–brown slimy covering, less than 0.5 mm thick.	Thin film
Green filaments	Long or short green filamentous algae.	Green filaments
Sludge	Loosely attached, unconsolidated mats including dead and deposited didymo and deposited sediment.	Sludge
Medium mats, black/dark brown	Definite layer of algae, up to 3 mm thick (predominantly *Microcoleus*).	*Microcoleus*
Medium mats, light brown	Definite layer of algae, up to 3 mm thick (predominantly didymo but may include other algae, which is noted).	Medium dg/lt br
Thick mats, black/dark brown	Thick layer of dark brown algae up to 5 mm (usually not *Microcoleus*).	Black/br mats
Thick mats, light brown	Thick layer of algae up to 5 mm, mainly didymo; non–didymo mats are noted on the field sheets.	Thick dg/lt br
Very thick didymo mats	Mats >5 mm thick, including an estimate of average thickness in mm; almost always didymo; non–didymo mats are noted on the field sheets.	V. thick dg

Data: Periphyton percentage cover and standing crop index (SCI)

Data from the 20 views were used to calculate mean percentage cover of each periphyton category at each site. Cover by medium and thick mats and sludge were combined into a standing crop index (SCI), which is the product of percentage cover and vertical thickness of periphyton in mm. Medium mats (all types) and sludge were assigned a mean thickness of 2 mm, and thick mats 4 mm. Mean thickness of very thick mats (>5 mm) was estimated from measurements. For example, mean cover of 10% thin film, 30% sludge and 60% cover by very thick didymo (mean thickness of 10 mm) has an SCI of (30 × 2) + (60 × 10) = 660.

The SCI is open–ended but, in practice, the vertical thickness of didymo mats is typically not more than 45 mm, so maximum SCI is about 4500 (i.e., equivalent to 100% cover by mats 45 mm thick).

SCI was developed as an index for use in rivers dominated by didymo (Kilroy et al. 2006). In the Lower Waiau River, non–didymo mats can contribute to SCI from time to time, and this is recorded by the survey team.

Reporting: Post-monitoring

Following each survey, river status (red, amber or green) was determined from mean SCI at each site, as described in Section 2.3.1. That is:

i. Green – SCI at all three sites < 220; **OR** mean SCI < 200;

ii. Amber –at least one site with SCI > 220 **AND** mean SCI 200–300; **OR** mean SCI 200–600;

iii. Red – at least two sites with SCI > 220 AND mean SCI > 300; **OR** mean SCI > 600.

The alternative criteria (i.e., **OR**; using mean SCI) were used only when the primary criteria were not exactly met. For example, scores from three sites of 95, 210 and 655 have a mean SCI of 320, and one site exceeds 220. The combination does not fit the primary criteria for amber or red status. The alternative criterion places the river at amber status because mean SCI is in the range 200–600.

The thresholds of SCI of 220 and 600 were derived from relationships between SCI and periphyton ash-free dry mass (AFDM) and chlorophyll *a*. SCI of 220 is equivalent to about 35 g/m^2 AFDM (Kilroy et al. 2006), which was the threshold above which river angling and recreational values were judged to be impaired, in the Ministry for the Environment periphyton guideline (Biggs 2000). Based on data from Kilroy et al. (2015), SCI of 220 in the Lower Waiau River, is equivalent to chlorophyll *a* of, on average, 80 mg/m^2, SCI of 300 to ~100 mg/m^2, and SCI of at least 600 is equivalent to chlorophyll *a* approaching 200 mg/m^2. Chlorophyll *a* of 80–100 mg/m^2 lies between the thresholds of 50 and 120 mg/m^2 that respectively define bands B and C in the periphyton attribute in the NPS-FM)[6]. Chlorophyll *a* of 200 mg/m^2 is the threshold defining band D, which is the national bottom line for periphyton (i.e., concentrations >200 mg/m^2 more than once per year on average are considered unacceptable).[7]

Reporting: Data analysis

Comparison between river status and flow metrics

SCI data collected in 2025–26 were used to estimate the proportion of time in days the river was at green, amber or red status, from 1 November 2025 to 31 May 2026. These proportions were compared qualitatively with those in previous seasons, relative to flows.

River status was estimated on the days between surveys based on expected growth or removal of SCI calculated from measured SCI and taking flows into account. For

[6] The relationship between SCI and chlorophyll *a* is variable and probably river or even site-specific. The correspondence also depends on the form of the relationships used. Based on data collected at two sites in the Lower Waiau River (Excelsior and Blackmount, the latter site located between Excelsior and Monowai) between 2008 and 2015, and simple linear regression (no data transformation), chlorophyll *a* of 200 mg/m^2 corresponded to SCI of 632 (95% confidence interval 495 – 770). Data from one site only (Blackmount) showed the strongest relationship and with chlorophyll *a* of 200 mg/m^2 corresponding to SCI of ~850 on average.

[7] To assign an NPS-FM periphyton band to a site requires at least 3 years of monthly observations of chlorophyll *a*. The metric used is the 92nd percentile which means that, to be assigned to a band, chlorophyll *a* must not exceed the band threshold (such as 200 mg/m^2 for band C) for more than about 8% of the time, or three times in three years.

example, at minimum flows, SCI at low levels (i.e., at green status) is expected to increase in a roughly logarithmic pattern. If the subsequent survey indicated amber or red status, we estimated SCI at each site on each intervening day following a smooth logarithmic curve connecting the two measured values. It was then possible to estimate the day on which the combined SCI from the three sites transitioned from green to amber or amber to red status.

Water clarity

Measurements of water clarity have been included in the monitoring since the 2010–11 season and were included in the initial version of the protocol. Water clarity is an easily measured general indicator of water quality that is strongly influenced by flow but can also be affected by other factors, such as instream engineering works, vegetation removal or suspended algae.

Box plots of water clarity presented in the report for the 2023–24 season (Kilroy and Hogsden 2024) were updated with the data for the current season. An assessment was made of water clarity in relation to the limits set out in the proposed Southland Water and Land Plan (Court Version May 2024) (pSWLP[8]). The limits for clarity apply to flows below median flow and are 3 m for lake-fed and mountain rivers and 1.6 m for hill and lowland hard-bed rivers. The Lower Waiau River is classed as lake-fed along its entire length except for a short lowland/coastal section near to the outlet to the sea. The lower part of the Mararoa River (including the reach at Station Bridge) is classed as hill.

References

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[8] Most of the pSWLP became operative from 27 May 2024. See Southland Water and Land Plan to be made operative – Environment Southland (es.govt.nz).

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Appendix D Summary of all SCI assessments and river status, Lower Waiau River 2006 to 31 May 2026

Table D.1 Mean SCI reported from Excelsior, Monowai and Clifden in 216 surveys between 1 November 2006 to 31 May 2026. Grey numbers for the first 11 surveys under Monowai are data from Jericho (farther upstream). Surveys at Monowai commenced in January 2008. The regular fortnightly schedule also started in January 2008. Under Supplementary flow releases (SFR), DMF = daily mean flow; "Status, no SFR" is an estimate of river status if a supplementary flow had not been released. The rightmost column shows mean SCI at Station Bridge, Mararoa River (data since November 2010, except for November 2014 to May 2015). Horizontal lines separate surveys in successive seasons (November to March, starting in 2008–09). Data from Excelsior_New trial site in 2025–26 not shown.

		Survey results						Supplementary flow releases (SFR)					
	Survey date	SCI at Excelsior	SCI at Monowai	SCI at Clifden	Mean SCI	sites>220	Status	Preceded by SFR	Date	Max. flow (DMF)	Status, no SFR	Notes	SCI at Station Bridge
1	9-Nov-06	262	755	356	458	3	red				red		
2	23-Dec-06	19	610	124	251	1	amber	yes	17-Nov-06	238	red		
3	12-Jan-07	9	1729	310	683	2	red				red		
4	5-Feb-07	154	375	930	486	2	red				red		
5	12-Mar-07	201	1598	1090	963	2	red	yes	8-Mar-07	48	red	Recreational flow	
6	10-May-07	528	465	307	433	3	red				red		
7	15-May-07	401	275	125	267	2	amber	yes	12-May-07	48	red	Recreational flow	
8	30-May-07	245	398	209	284	2	amber	yes	28-May-07	102	red		
9	1-Aug-07	175	341	228	248	2	amber				amber		
10	11-Sep-07	0	531	0	177	1	green				green		
11	19-Nov-07	0	0	0	0	0	green				green		
12	25-Jan-08	958	2509	376	1281	3	red				red		
13	29-Jan-08	241	2016	357	871	3	red				red		
14	11-Feb-08	243	1828	413	828	3	red				red		
15	28-Feb-08	333	1499	652	828	3	red				red		

		Survey results						Supplementary flow releases (SFR)						
	Survey date	SCI at Excelsior	SCI at Monowai	SCI at Clifden	Mean SCI	sites>220	Status	Preceded by SFR	Date	Max. flow (DMF)	Status, no SFR	Notes	SCI at Station Bridge
16	13-Mar-08	153	102	0	85	0	green	yes*	2-Mar-08	122	red	*Mararoa event (natural flood)	
17	4-Apr-08	321	253	137	237	2	amber				red		
18	22-Apr-08	452	392	312	385	3	red				red		
19	15-May-08	188	739	281	402	2	red				red		
20	31-Oct-08	56	51	3	36	0	green				green		
21	13-Nov-08	175	62	20	85	0	green				green		
22	28-Nov-08	184	103	50	112	0	green				green		
23	12-Dec-08	238	235	100	191	2	green				green		
24	28-Dec-08	177	323	237	245	2	amber				amber		
25	30-Jan-09	0	74	5	26	0	green				green		
26	16-Feb-09	104	359	87	183	1	green				green		
27	2-Mar-09	514	567	86	389	2	red				red		
28	18-Mar-09	1155	797	313	755	3	red				red		
29	31-Mar-09	134	752	302	396	2	red	yes	27-Mar-09	98	red		
30	17-Apr-09	240	1019	459	573	3	red				red		
31	7-May-09	143	275	162	193	1	green	yes	30-Apr-09	206	red		
32	7-Jul-09	85	241	0	109	1	green				green		
33	29-Sep-09	10	73	23	35	0	green				green		
34	14-Oct-09	190	140	53	128	0	green				green		
35	29-Oct-09	279	205	147	210	1	amber				amber		
36	13-Nov-09	423	157	335	305	2	red				red		
37	26-Nov-09	96	169	250	172	1	green				green		

		Survey results						Supplementary flow releases (SFR)						
	Survey date	SCI at Excelsior	SCI at Monowai	SCI at Clifden	Mean SCI	sites>220	Status	Preceded by SFR	Date	Max. flow (DMF)	Status, no SFR	Notes	SCI at Station Bridge
38	1-Dec-09	16	91	109	72	0	green	yes	27-Nov-09	125	amber	Prior flood led to green on 26 Nov	
39	18-Dec-09	58	159	217	144	0	green				green		
40	1-Feb-10	0	179	67	82	0	green				green		
41	18-Feb-10	146	538	406	363	2	red				red		
42	11-Mar-10	266	1342	610	739	3	red	yes	3-Mar-10	111	red		
43	30-Mar-10	466	1236	361	688	3	red				red		
44	24-May-10	0	0	0	0	0	green				green		
45	3-Nov-10	0	30	181	70	0	green				green		2
46	15-Nov-10	1	39	245	95	1	green				green		8
47	1-Dec-10	0	119	840	320	1	amber				amber		1
48	15-Dec-10	4	328	997	443	2	red				red		3
49	12-Jan-11	27	600	138	255	1	amber	yes	23-Dec-10	135	amber	Followed by major lake spill	13
50	26-Jan-11	59	281	145	162	1	amber	yes	18-Jan-11	108	amber		28
51	21-Feb-11	7	123	2	44	0	green	yes	3-Feb-11	100	green	Followed by natural flood	135
52	7-Mar-11	119	532	121	257	1	amber				amber		371
53	22-Mar-11	173	715	206	365	1	amber	yes	15-Mar-11	117	red	Combined with Mararoa flow	721
54	6-Apr-11	587	774	454	605	3	red				red		749
55	19-Apr-11	793	1284	594	890	3	red				red		1544
56	2-May-11	1696	1693	1304	1564	3	red				red		1849
57	24-May-11	2034	1202	948	1394	3	red				red		2289
58	8-Jun-11	202	928	704	611	2	red				red		845
59	14-Nov-11	32	532	70	211	1	amber				amber		426

		Survey results						Supplementary flow releases (SFR)					
	Survey date	SCI at Excelsior	SCI at Monowai	SCI at Clifden	Mean SCI	sites>220	Status	Preceded by SFR	Date	Max. flow (DMF)	Status, no SFR	Notes	SCI at Station Bridge
60	28-Nov-11	44	318	169	177	1	red				red		315
61	13-Dec-11	70	361	445	292	2	red				red		354
62	28-Dec-11	70	638	1241	649	2	red				red		707
63	11-Jan-12	126	647	1602	792	2	red				red		499
64	25-Jan-12	202	825	1154	727	2	red				red		1173
65	7-Feb-12	92	726	289	369	2	red				red		559
66	21-Feb-12	148	1021	279	483	2	red				red		1234
67	5-Mar-12	260	441	134	278	2	amber				amber		434
68	20-Mar-12	286	566	190	347	2	red				red		292
69	2-Apr-12	275	661	418	451	3	red				red		391
70	16-Apr-12	375	892	888	718	3	red				red		499
71	2-May-12	597	603	985	728	3	red				red		904
72	15-May-12	359	472	785	538	3	red				red		904
73	26-Nov-12	7	27	32	22	0	green				green		0
74	10-Dec-12	157	53	40	83	0	green				green		2
75	19-Dec-12	218	92	103	138	0	green				green		7
76	30-Jan-13	1	15	7	8	0	green				green		0
77	18-Feb-13	138	82	116	112	0	green				green		12
78	4-Mar-13	258	233	153	214	2	amber				amber		25
79	18-Mar-13	214	512	216	314	1	amber				amber		103
80	2-Apr-13	384	1071	285	580	3	red				red		532
81	15-Apr-13	466	1367	376	736	3	red				red		716

		Survey results						Supplementary flow releases (SFR)					
	Survey date	SCI at Excelsior	SCI at Monowai	SCI at Clifden	Mean SCI	sites>220	Status	Preceded by SFR	Date	Max. flow (DMF)	Status, no SFR	Notes	SCI at Station Bridge
82	30-Apr-13	591	1819	271	893	3	red				red		440
83	14-May-13	114	1312	164	530	1	amber	yes	6-May-13	90	amber	Combined with natural high flow	430
84	24-Jun-13	5	425	0	143	1	green				green	Followed lake spill, peak DMF 232 m^3/s	0
85	19-Nov-13	0	0	0	0	0	green				green		0
86	2-Dec-13	0	3	0	1	0	green				green		0
87	18-Dec-13	23	112	0	45	0	green				green		8
88	3-Feb-14	95	415	0	170	1	green				green		191
89	19-Feb-14	470	1011	11	497	2	amber				amber		330
90	3-Mar-14	776	1231	77	694	2	red				red		546
91	17-Mar-14	416	1695	340	817	3	red				red		837
92	2-Apr-14	1032	1869	642	1181	3	red				red		1303
93	15-Apr-14	844	2078	622	1181	3	red				red		1244
94	27-Jun-14	0	2	0	1	0	green	yes	8-May-14	119	green	Lake spill >600 m^3/s before survey	152
95	11-Nov-14	209	42	23	91	0	green				green		
96	12-Jan-15	81	97	0	59	0	green				green		
97	26-Jan-15	155	215	19	130	0	green				green		
98	16-Feb-15	259	620	105	328	2	red				red		
99	23-Feb-15	213	533	165	304	1	amber	yes	18-Feb-15	116	red		
100	9-Mar-15	366	1044	489	633	3	red				red		
101	25-Mar-15	725	1334	1089	1049	3	red				red		
102	8-Apr-15	959	1671	1609	1413	3	red				red		
103	6-Nov-15	12.5	152	19	61	1	green				green		767

		Survey results						Supplementary flow releases (SFR)					
	Survey date	SCI at Excelsior	SCI at Monowai	SCI at Clifden	Mean SCI	sites>220	Status	Preceded by SFR	Date	Max. flow (DMF)	Status, no SFR	Notes	SCI at Station Bridge
104	19-Nov-15	54	175	112	114	1	green				green		710
105	2-Dec-15	48	435	360	281	2	amber				amber		349
106	16-Dec-15	42	762	1009	604	2	red				red		237
107	28-Dec-15	10	565	782	452	2	red	yes	22-Dec-15	140	red	Peak instantaneous flow of 197 m^3/s	485
108	12-Jan-16	22	836	826	561	2	red				red		381
109	9-Feb-16	215	917	147	426	1	amber	yes	26/27-Jan-16	124	red	Peak 185 m^3/s + flood, lower river	1464
110	23-Feb-16	586	1146	272	668	2	red				red		991
111	18-Mar-16	117	201	10	109	0	green				green	Followed lake spill, peak DMF 780 m^3/s	665
112	14-Apr-16	508	341	169	339	2	red				red		1331
113	26-Apr-16	906	347	595	616	3	red				red		1385
114	4-May-16	372	335	477	395	3	red	yes	27/28-Apr-16	121	red	Peak flow 210 m^3/s	1218
115	2-Nov-16	0	21	0	7	0	green				green		1
116	15-Nov-16	23	29	3	18	0	green				green		12
117	1-Dec-16	17	74	48	46	0	green				green		8
118	14-Dec-16	38	381	210	210	1	amber				amber		35
119	23-Dec-16	24	174	100	99	0	green	yes	21/22-Dec-16	131	red	Inst. peak 177 m^3/s	91
120	5-Jan-17	112	389	879	460	2	red				red		165
121	21-Jan-17	129	316	49	165	1	green	yes	18/19-Jan-17	141	red	Inst. peak 235 m^3/s incl. natural flood. No survey in Mararoa, high flows	–
122	6-Mar-17	105	335	51	164	1	green				green	Followed lake spill, early survey	983
123	21-Mar-17	626	608	279	504	3	red				red		1196
124	5-Apr-17	1219	790	935	981	3	red				red		2453

		Survey results						Supplementary flow releases (SFR)					
	Survey date	SCI at Excelsior	SCI at Monowai	SCI at Clifden	Mean SCI	sites>220	Status	Preceded by SFR	Date	Max. flow (DMF)	Status, no SFR	Notes	SCI at Station Bridge
125	15-May-17	392	841	36	629	2	red				red		630
126	13-Nov-17	12	312	18	114	1	green				green		508
127	30-Nov-17	6	419	118	181	1	green				green		270
128	14-Dec-17	30	598	318	315	2	red				red		308
129	28-Dec-17	22	972	884	626	2	red				red		346
130	9-Feb-18	46	191	28	89	0	green				green		291
131	12-Mar-18	114	104	27	82	0	green				green		294
132	17-Jan-19	3	583	302	296	2	amber				amber		306
133	29-Jan-19	35	780	729	515	2	red				red		355
134	4-Feb-19	48	288	587	308	2	red	yes	30 Jan–1 Feb	117	red	Inst. peak 153.5 m^3/s, "variable" flow	352
135	18-Feb-19	137	431	1515	695	2	red				red		702
136	25-Feb-19	307	568	381	419	3	red				red		1017
137	1-Mar-19	84	287	396	256	2	amber	yes	25–27 Feb 19	115	red	Inst. peak 145.8 m^3/s, "variable" flow	816
138	18-Mar-19	230	841	391	487	3	red				red		1747
139	8-Apr-19	186	246	97	176	1	green				green		348
140	16-Apr-19	153	319	123	198	1	green				green	(No survey in Mararoa, high flows)	–
141	13-Mar-20	84	102	85	90	0	green				green	[3 subsequent surveys missed due to COVID-19 lockdown and elevated flows.]	97
142	19-May-20	154	560	348	354	2	red				red	SFR not feasible due to low lake level	33
143	10-Jun-20	276	505	392	391	3	red				red	SFR not feasible due to low lake level	25
144	26-Jun-20	155	409	266	277	2	amber				amber	SFR not feasible due to low lake level	42

		Survey results						Supplementary flow releases (SFR)					
	Survey date	SCI at Excelsior	SCI at Monowai	SCI at Clifden	Mean SCI	sites>220	Status	Preceded by SFR	Date	Max. flow (DMF)	Status, no SFR	Notes	SCI at Station Bridge
145	18-Nov-20	77	117	113	102	0	green				green		1
146	30-Nov-20	136	95	195	142	0	green				green		2
147	17-Dec-20	62	121	174	119	0	green				green		9
148	31-Dec-20	95	232	156	161	1	green				green		22
149	14-Jan-21	135	267	0	134	1	green				green		23
150	4-Feb-21	81	425	1	169	1	green				green		143
151	15-Feb-21	106	439	14	186	1	green						332
152	1-Mar-21	235	668	174	359	2	red				red	SFR not feasible due to low lake level	729
153	18-Mar-21	232	397	578	403	3	red				red	SFR not feasible due to low lake level	1680
154	9-Apr-21	271	207	515	331	2	red				red	SFR not feasible due to low lake level	2677
155	5-May-21	230	214	502	315	2	red				red		1417
156	25-May-21	164	239	139	181	1	green	yes	17-18 May 21	140	amber	High trib. flows post-release delayed survey	263
157	9-Nov-21	57	68	176	100	0	green				green		**2**
158	2-Dec-21	36	93	26	51	0	green				green		3
159	17-Dec-21	51	75	132	86	0	green				green		9
160	6-Jan-22	57	267	655	326	2	red				red		30
161	13-Jan-22	3	337	794	378	2	red	yes	12 Jan 22	126	red		39
162	24-Jan-22	18	447	850	438	2	red				red	SFR not feasible due to low lake level	76
163	9-Feb-22	137	617	1037	597	2	red				red	SFR not feasible due to low lake level	139
164	23-Feb-22	143	877	1542	854	2	red				red	SFR not feasible due to low lake level	435

	Survey results							Supplementary flow releases (SFR)					
	Survey date	SCI at Excelsior	SCI at Monowai	SCI at Clifden	Mean SCI	sites>220	Status	Preceded by SFR	Date	Max. flow (DMF)	Status, no SFR	Notes	SCI at Station Bridge
165	11-Mar-22	166	591	1526	761	2	red				red	SFR not feasible due to low lake level	1225
166	27-Apr-22	193	241	82	172	1	green				green		120
167	10-May-22	197	333	191	240	1	amber				amber	SFR not feasible due to low lake level	236
168	26-May-22	198	228	292	239	2	amber				amber		634
169	1-Jun-22	9	256	440	235	2	amber	yes	30-31 May 22	132	amber		622
170	16-Nov-22	1	24	35	20	0	green				green		1
171	12-Dec-22	4	332	386	241	2	amber				amber		4
17	19-Dec-22	0	368	249	206	2	amber	yes	14-16 Dec 22	130	red	Hourly peak 158 cumecs. "Variable" flow	4
173	5-Jan-23	68	903	810	594	2	red				red		10
174	1-Feb-23	156	341	112	203	1	amber				amber		44
175	13-Feb-23	105	67	0	57	0	green	yes	9-10 Feb 23		amber	Small tributary event preceded SFR	253
176	27-Feb-23	99	104	8	70	0	green				green		623
177	15-Mar-23	834	438	2	424	2	red				red		1462
178	4-Apr-23	66	226	0.1	98	1	green	yes	29-30 Mar 23	140	amber	Tributary flows preceded SFR, but possibly not a big effect at Excelsior	282
179	20-Apr-23	420	677	78	392	2	red				red		295
180	2-May-23	966	937	246	716	3	red				red		449
181	20-Nov-23	17	23	40	27	0	green				green		1
182	4-Dec-23	21	88	74	61	0	green				green		3
183	18-Dec-23	43	254	202	166	1	green				green		5
184	9-Jan-24	71	952	915	646	2	red				red		11

	Survey results							Supplementary flow releases (SFR)					
	Survey date	SCI at Excelsior	SCI at Monowai	SCI at Clifden	Mean SCI	sites>220	Status	Preceded by SFR	Date	Max. flow (DMF)	Status, no SFR	Notes	SCI at Station Bridge
185	21-Feb-24	1	95	0	32	0	green	yes	18-19 Jan 24	149	green	SFR followed by lake spill	14
186	12-Mar-24	157	175	0	111	0	green				green		124
187	3-Apr-24	1270	684	277	744	3	red				red		93
188	24-Apr-24	42	304	1	116	1	green				green		89
189	10-May-24	283	622	57	321	2	red				red		169
190	17-May-24	91	451	226	256	1	amber	yes	15-16 May 24	133	red?	Could easily have advanced to red with no SFR	230
191	28-May-24	89	635	253	326	2	red				red		309
192	21-Jun-24	88	609	267	321	2	red	yes	5-6 Jun 24	133	red	Stayed red despite all the high flows	238
193	26-Nov-24	28	29	3	20	0	green				green		5
194	9-Dec-24	158	85	216	153	0	green				green		16
195	17-Dec-24	31	1	136	56	0	green	yes	11-12 Dec 24	135	green	SFR followed by further (smaller) lake spill	9
96	9-Jan-25	73	153	226	151	1	green				green		17
197	20-Jan-25	15	227	254	165	2	green	yes	15-17 Jan 25	130	red	Variable flow, very likely red status had flow not occurred	28
198	31-Jan-25	112	457	799	456	2	red				red	SFR not feasible due to low lake level	146
199	13-Feb-25	176	495	1116	596	2	red				red	SFR not feasible due to low lake level	305
200	6-Mar-25	164	1150	1832	1049	2	red				red	SFR not feasible due to low lake level	1132
201	28-Mar-25	259	503	105	289	2	amber				amber	SFR not feasible due to low lake level	2069
202	29-Apr-25	100	237	769	369	2	red	yes	22-23 Apr 25	132	red	SFR preceded by small to moderate tributary flows affecting all three sites	894
203	16-May-25	49	184	1	78	0	green	yes	13-14 May 25	136	green	SFR preceded by large tributary flow event	1009

	Survey results							Supplementary flow releases (SFR)					
	Survey date	SCI at Excelsior	SCI at Monowai	SCI at Clifden	Mean SCI	sites>220	Status	Preceded by SFR	Date	Max. flow (DMF)	Status, no SFR	Notes	SCI at Station Bridge
204	26-May-25	74	166	3	81	0	green				green		1303
205	9-Jan-26	0.9	0.3	0	0.4	0	green				green		19
206	23-Jan-26	0.1	0.4	0	0.2	0	green				green		60
207	5-Feb-26	68	3	0	24	0	green				green		89
208	17-Feb-26	88	24	0	38	0	green				green		188
209	3-Mar-26	198	208	11	139	0	green				green		259
210	17-Mar-26	316	599	112	342	2	red				red		462
211	25-Mar-26	123	756	27	302	1	amber	yes	19-20 Mar 26		red?	Could have advanced to red if no SFR	772
212	9-Apr-26	157	931	132	407	1	amber				amber		952
213	14-Apr-26	89	524	283	299	2	red	yes	9-10 Apr 26		red		1006
214	30-Apr-26	152	321	609	360	2	red				red		493
215	14-May-26	330	640	978	649	3	red				red		762
216	28-May-26	210	887	1169	755	2	red				red		1462

Appendix E Summary of observations at each site, 2025–26

Summary of comments made by the field survey team at each site in 12 surveys carried out between 9 January 2026 and 28 May 2026. Comments were summarised from notes on field data sheets and additional emailed remarks. Dg = didymo.

Date	Station Bridge	Excelsior	Excelsior New	Monowai	Clifden
09–Jan–26	Fine. Site moved ~ 10m u/s due to minor gradient change. Minimal Dg growth (of varying sizes and thickness), some green filaments.	Fine. River flow "normal". Small *Microcoleus* patches on caps of larger rocks. One Dg colony, ~ 8mm diameter in river margin but not at a survey point. No other Dg observed.	Fine. River flow "normal". NEW site has slightly greater velocity. Medium mats very minor, poorly attached growths. Slightly more periphyton cover than at existing site. No Dg observed.	Fine. Small Dg colonies observed at one point in margin and at depth on some boulders. Minor bank erosion from high flows. Overall, site is similar to previous seasons.	Fine. River flow "normal" to low. Significant change to active river channel and immediate floodway adjacent and u/s to survey site used in previous seasons. Site moved approx. 70m downstream. No algae observed.
23–Jan–26	River flow normal. Light rain. No great Dg development. Minimal establishment of younger Dg colonies.	Some *Microcoleus* developing on larger boulders. Early development of thin light brown mat (not *Microcoleus*) noted. Fine sediment was mostly fine grit.	Light rain. Thin mats were very thin, light brown in colour.	Occasional light rain. River level normal to low. Medium Dg was very small colonies established in specific points, not observed elsewhere on transects. Initial establishment of green/yellow mats.	River normal to low flow. Passing periods of steady rain. Fine sediment is all grit (amongst larger grit). Very clean.
5–Feb–26	Fine. River flow normal to low. Filamentous greens increasing near shore, with very minimal initial growths elsewhere. Dg of varying sizes increasing. Still minimal establishment of Dg (and filamentous greens) compared to other seasons.	Fine, cool overcast. One colony of Dg recorded. Thin light brown mat was unattached growth. Filamentous green was initial growth of no measurable length. Minimal *Microcoleus*, pale in colour. More sludge recorded.	Fine, cool overcast. Thin light brown mat was unattached growth. Very minimal Dg recorded, individual colonies only. Green filaments initial growth on substrate, no length.	Fine, overcast. Green filaments minimal (initial growth, no length). Low numbers of net building caddis present. Noticed for the first time a few patches of very thin, silt covered Dg at waters' edge. Most likely established during extended period of high flows.	Fine and bright conditions. River normal to low. Occasional tufts of green filaments around site, only one recorded in transects. Substrate very clean. Net building caddis present.

Date	Station Bridge	Excelsior	Excelsior New	Monowai	Clifden
17–Feb–26	Fine, overcast, cool. River normal–low. Older very thick Dg at margins beginning to slough. One area of Dg remnants recorded. Appearance of minute Dg colonies. Small increase in filamentous greens.	Fine, cool, overcast. Medium light brown non–Dg is very loose, very fine growth sitting unattached on substrate. Dg mats were extremely sparse, individual small growths.	Fine, cool, overcast. Medium light brown non–Dg species consists of very loose, very fine growth sitting unattached on substrate. Dg mats were extremely sparse, individual small growths. Larger mats of *Microcoleus* have developed.	Fine, overcast, cool. River flow 'normal' after recent higher flow. An increase in very fine sediment in near shore margins. Medium light brown mats were fine, loose growth. Minimal establishment of very small, individual Dg colonies in a few points.	Fine overcast, cool. River up since previous survey. Virtually no colonisation, except occasional, individual small filamentous green growths across the site.
3–Mar–26	Normal flow. Slight increase in numbers of very small Dg colonies. Increased sloughing of older, thicker Dg in shallow margins.	River flow normal. Increase in sludge, non– Dg and Dg mix reflective of the lower velocity at this (old) site. Some increase in *Microcoleus* cover.	River flow normal Noticeable increase in Dg cover from previous survey and starting to merge into mats. Increase in *Microcoleus,* especially over larger boulders.	Very fine sediment amongst sludge. Dg all very pale in colour with some sloughing. Still significantly less Dg mats compared to previous seasons, but some Dg mats have increased in thickness.	River flow up slightly from first survey. Dg recorded as 1% was less than that. Individual Dg colonies in very low numbers, sometimes only one colony. Results at this site continue to be vastly different from other seasons.
17–Mar–26	Fine, cool, bright. Minor amount of Dg drift, possibly due to slight increase in flow. Minor sloughing of very thick Dg.	Fine, cool, partly cloudy. Dg and *Microcoleus* starting to slough. All Dg pale and brittle. Sludge dominating the nearshore (lower velocity) points.	Partly cloudy, fine and cool. Increase in Dg mat cover with colonies merging. Some sloughing of Dg and *Microcoleus* All Dg pale and brittle.	Fine, cool, fog to low cloud. Existing Dg mats now mostly 'very thick'. Dg remnants left from sloughing of very thick mats recorded as medium mats.	Fine, foggy, cool. River up slightly from previous survey. Significant increase in very thick Dg, especially along shallow margins. Minimal green filaments.
19–20 Mar–26	Supplementary flow release				
25–Mar–26	Fine, sunny, bright. River 'low'. Significant amount of fine Dg drift. The more midstream Dg mats now all recorded as 'thick or 'very thick'.	Fine, bright, high overcast. River flow 'normal'. Sludge still present in margins of this lower velocity site. Evidence of Dg scouring, with remnants recorded as medium and thick	Fine, bright high overcast. River flow 'normal'. Evidence of Dg mat scouring remnants recorded as medium and thick remnants. Minimal, small *Microcoleus* mats seen in areas	Fine and bright. River 'normal' flow. Dg in optimum positions in current atop boulders. Very thick extensive Dg mats. Other mats appear impacted by flushing flow. Small amount of	Fine and sunny. River not 'low'. Occasional areas of very small Dg colonies. Very clean substrate.

Date	Station Bridge	Excelsior	Excelsior New	Monowai	Clifden
		Dg. Remaining Dg mats pale and unhealthy in appearance. Green filaments were extremely small growths.	sheltered from effects of higher flows. Remaining Dg mats pale and unhealthy in appearance. Green filaments were extremely small growths.	fine grit trapped in the Dg fibres suggests mobilisation during flushing flow.	
9–Apr–26	Overcast, cool. River flow 'normal'. Dg mat development (Med/Thick/Very thick). Greem filaments thickening. Notable Dg drift likely impacting black disc reading.	Fine. Dg mats continue to appear unhealthy, typical of this site with normal minimum flows. An increase in mat thickness and cover. An increase in healthy, new *Microcoleus*.	Fine. River flow normal. An increase in *Microcoleus* mats but not significant.	Fine, cloudy, cool. An increase in Dg mat thickness. Clear development of very 'healthy' very thick Dg especially atop larger boulders. Some sloughing. Remnant mats recorded as medium mats.	Overcast, cool. River flow normal. An increase in size/area of medium, thick and very thick Dg mats. Still minimal green filaments.
9–10 Apr–26	Supplementary flow release				
14–Apr–26	River flow normal. Some sloughing of older, earlier established nearshore Dg. Slight increase in Dg mats over the rest of site. Small Dg fibres in drift and associated sediment impacting black disk reading.	Overcast, cold. Minor sloughing of Dg mixed mats. Greater amount of sludge at this lower velocity site. Minimal *Microcoleus*.	Overcast, cold. Minor sloughing of Dg. Remnants recorded as medium mats. Reduction in *Microcoleus*.	Fine and cool. River up slightly after rain. Clear sloughing of Dg mats – remnants recorded as medium. Less affected Dg mats atop large boulders. High level of fine sediment recorded in slacker areas nearshore.	Fine and cool. River up slightly after rain. Negligible Dg debris on shore after flushing flow, indicating low level of sloughing upstream. Not a lot of change.
17–22 April 26	Augmented natural Mararoa River flow event				
30–Apr–26	Cold, overcast, light rain. Minimal Dg observed in drift. Very fine sediment reduced. Older very thick Dg in margins greatly reduced. Dg remnants recorded as medium mats. No green filaments.	Fine, cool. Flow above normal. Rising slightly when onsite. Non–Dg mix dominant in this lower velocity site. Less sludge.	Flow above normal. Rising slightly when onsite. Dg mats largely increased in cover at this new site, with greater flow. Minimal *Microcoleus* in sheltered places. No sloughing observed.	Fine, cool. River very slightly up on previous survey. Clear sloughing of some Dg mats. Remnants recorded as medium mats. Dg mats generally reduced (sloughed) but some fully intact,	Clear and sunny. River up slightly from rain previous day. Significant increase in cover of mats. No green filaments. Close to nil sloughing observed.

Date	Station Bridge	Excelsior	Excelsior New	Monowai	Clifden
				very thick mats present.	
14-May-26	Fine. Dg recorded was dark/healthy in appearance. Very small amount of new Dg recorded as medium mats. The much older, very thick Dg previously dominant in the shallow margins is largely gone. Still minimal green filaments and of very short length.	Fine. River up slightly. Marked difference between this 'old' site and the new.	Fine, windy. River slightly up. Increase in Dg mat thickness and coverage. Generally healthy-looking Dg at this higher velocity site (compared to other Excelsior site). A significant increase in green filaments.	Fine and windy. Areas where Dg had been thinned rather than fully removed with flushing flows, have been infilled by new Dg growth recorded as thick mats. Older intact mats continue to thicken.	Fine, sunny and bright. Near 100% Dg mat cover. Close to nil evidence of Dg scouring. No Dg debris on bank. Near absence of green filaments.
28-May-26	Cool, fine, bright. River normal flow. All Dg recorded as very thick, as colonies of varying ages thicken. Very minimal Dg drift.	Fine and frosty. Loose mixed mats and sludge reflect low velocity environment.	Fine and frosty. Some sloughing of *Microcoleus* and Dg. Dg mats reverting to a friable, unhealthy state typical of the Excelsior (old) site.	Fine, cool, bright. Continued increase of Dg cover and thickness. Minor amount of Dg sloughing. Small area of sloughed Dg recorded as medium remnants.	Clear and frosty. River a little up. Some rain in the catchment. Virtually 100% Dg cover. No Dg drift debris noted. Minimal green filaments.

Appendix F List of all flow checks and surveys carried out between 1 November 2025 and 31 May 2026

The table below was used to report back the results of each survey to Meridian and Tohu Environmental after each flow check and each set of survey results. Under "Flow criteria indicating survey", the green-shaded cells highlight flow conditions under which green river status was generally predictable, and the pink-shaded cell when red or amber status was predictable (from the analyses in Kilroy 2017) and when no survey was required according to the protocol. Surveys may be carried out under these conditions to check that the predictions are holding. Cells with dates are shaded blue. Dark grey shaded cells show mean SCI from the three Lower Waiau River (LWR) sites. Excelsior New site was trialled in 2025–26. Column Avg LWR – with Excelsior New presents average for three LWR sites (Excelsior New, Monowai, Clifden).

Flow criteria indicating survey (daily mean flows at MLC)						Standing crop index (SCI)								
Date of flow check	Minimum flow criterion met? (flow ~16 m^3/s)	30-day mean flow (<56 m^3/s)	Time since >3 × median flow (<62 days)	30-day CV of flow (>0.13)	Decision	Date of survey	Survey result	Excelsior	Excelsior New	Monowai	Clifden	Average LWR	Average LWR – with Excelsior New	Station Br (Mararoa comp.)	Comments
4-Nov-25	> minimum flow	656.0	0	0.27	Wait for Min. Flow										Lake spill event since mid Sept. (over minimum flow from 17/9/25). Check for timing of first survey when minimum flows resume.
18-Nov-25	> minimum flow	644.1	0	0.30	Wait for Min. Flow										Levels dropping generally, but still high (~360 cumecs on 17 Nov). Check for timing of first survey when minimum flows resume.
1-Dec-25	> minimum flow	440.9	0	0.19	Wait for Min. Flow										Lake spill continuing. Recent peak at 437 cumecs (22 Nov), now decreasing. Check for timing of survey when minimum flows resume.
15-Dec-25	> minimum flow	371.5	0	0.08	Wait for Min. Flow										Lake spill continuing. Last peak at 416 cumecs (12 Dec2025), now decreasing. Check for timing of survey when minimum flows resume.
5-Jan-26	YES, CHECK STATS	261.2	0	0.44	Wait for Min. Flow										After an extended lake spill since September 2025, levels reached minimum flow (16 cumecs) 5 January 2026. Survey to be carried out 9 January to establish a baseline. 30-day mean flow level criterion

Flow criteria indicating survey (daily mean flows at MLC)						Standing crop index (SCI)								
Date of flow check	Minimum flow criterion met? (flow ~16 m^3/s)	30-day mean flow (<56 m^3/s)	Time since >3 × median flow (<62 days)	30-day CV of flow (>0.13)	Decision	Date of survey	Survey result	Excelsior	Excelsior New	Monowai	Clifden	Average LWR	Average LWR – with Excelsior New	Station Br (Mararoa comp.)	Comments
															still predicts Green status.
						9-Jan-26	GREEN	0.9	2.5	0.3	0.0	0.4	0.9	19.0	Survey carried out 9 January 2026, four days after the river reached minimum flow level. SCI for all lower Waiau sites was very low as expected. An additional site at Excelsior was added and the SCI averages for each of the Excelsior sites are presented. Little to no Didymo was observed in the LWR, while the Mararoa had varying amounts of low percentage coverage.
19-Jan-26	> minimum flow	175.0	0	0.64	Wait for Min. Flow										After the survey carried out on 9 January, lake spill commenced on 10 January and peaked at 359 cumecs on 12 January and now decreasing. 30-day mean flow level criterion still predicts Green status.
						23-Jan-26	GREEN	0.1	0.2	0.4	0.0	0.2	0.2	60.3	Survey carried out 23 January 2026 at minimum flow. SCI for all lower Waiau sites was again low with very little Didymo observed. The Mararoa SCI has increased. Green status.
2-Feb-26	YES, CHECK STATS	91.6	12	1.21	GREEN STATUS PREDICTED										Green status still predicted (until ~13 Feb), but survey indicated as soon practical, flows permitting.
						5-Feb-26	GREEN	68	8	3	0	24	4	89	Survey was carried out 5 February 2026 at minimum flow. SCI for Excelsior and Monowai sites have increased from last survey, while Clifden is unchanged. Mararoa increase of filamentous green algae. Green status.

Flow criteria indicating survey (daily mean flows at MLC)						Standing crop index (SCI)								
Date of flow check	Minimum flow criterion met? (flow ~16 m^3/s)	30-day mean flow (<56 m^3/s)	Time since >3 × median flow (<62 days)	30-day CV of flow (>0.13)	Decision	Date of survey	Survey result	Excelsior	Excelsior New	Monowai	Clifden	Average LWR	Average LWR – with Excelsior New	Station Br (Mararoa comp.)	Comments
16-Feb-26	> minimum flow	35.6	25	1.21	Wait for Min. Flow										Minimum flow from 26 January 2026 was sustained until 12 February. Brief flow release in Waiau Arm of 35 cumecs for 48 hours from 13 February. Green status is predicted. Survey to be carried out 17 February 2026.
1-Mar-26	YES, CHECK STATS	19.5	39	0.25	SURVEY										Survey indicated for as soon as practicable, subject to suitable flows.
						3-Mar-26	GREEN	198	81	208	11	139	100	259	Survey carried out 3 March 2026. All lower Waiau sites had a significant increase in SCI, with the Excelsior and Monowai scores more than doubling. The Mararoa SCI also increased. Didymo increasing at all sites. *Microcoleus* increased at the new Excelsior site. Green status.
15-Mar-26	YES, CHECK STATS	19.3	53	0.24	SURVEY										River flow levels have been at minimum flow since the survey carried out 3 March 2026. Survey indicated for as soon as practicable, subject to suitable flows.
						17-Mar-26	RED	316	288	599	112	342	333	462	RED Status. Survey carried out 17 March 2026 for the Waiau sites and 18 March 2026 for the Station Bridge Mararoa site. A substantial increase in mean SCI across all sites. A pre-planned flushing flow of ~110 cumecs was carried out from 1pm on the 19th March to 9am on the 20th March ahead of the next survey to be carried out 25 March 2026. A lower recreational flow was released for 24 hours on Sunday 22nd March 2026.

Date of flow check	Flow criteria indicating survey (daily mean flows at MLC)					Date of survey	Standing crop index (SCI)								Comments
	Minimum flow criterion met? (flow ~16 m^3/s)	30-day mean flow (<56 m^3/s)	Time since >3 × median flow (<62 days)	30-day CV of flow (>0.13)	Decision		Survey result	Excelsior	Excelsior New	Monowai	Clifden	Average LWR	Average LWR – with Excelsior New	Station Br (Mararoa comp.)	
					POST-FLUSH SURVEY	25-Mar-26	AMBER	123	100	756	27	302	294	772	AMBER Status. Survey carried out 24 March 2026 for the Mararoa Station bridge site, and 25 March 2026 for the Waiau sites. Decrease in SCI for Excelsior sites, and Clifden, but an increase at the Monowai site and the Mararoa Site. Water clarity increased at all sites except the Excelsior.
6-Apr-26	YES, CHECK STATS	22	17	1	SURVEY										River flow levels continue to be at minimum flow. Survey indicated for as soon as practicable.
						9-Apr-26	AMBER	157	157	931	132	407	407	952	AMBER Status. Survey carried out 9 April 2026 ahead of a flushing flow also scheduled for 9 April 2026. An increase in SCI across all sites.
					POST-FLUSH SURVEY	14-Apr-26	AMBER	89	96	524	283	299	301	1006	AMBER Status. Survey carried out 14 April 2026 following a flushing flow on 9–10 April 2026 for 28 hours. SCI for Excelsior and Monowai sites was reduced, while Clifden SCI more than doubled.
					POST-FLUSH SURVEY	30-Apr-26	RED	152	163	321	609	360	364	493	RED Status. Post natural flow augmentation survey carried out 30 April 2026 for LWR sites. River level was slightly elevated due to increased flow in the Mararoa. An increase in SCI at Excelsior and Clifden.
10-May-26	> minimum flow	33	19	1	SURVEY										Survey indicated for as soon as practicable, subject to suitable flows.
						14-May-26	RED	330	240	640	978	649	619	762	RED Status. An increase in SCI at all sites.
24-May-26	> minimum flow	24	33	0	SURVEY										Survey indicated for as soon as practicable, subject to suitable flows.

Date of flow check	Flow criteria indicating survey (daily mean flows at MLC)					Date of survey	Standing crop index (SCI)								Comments
	Minimum flow criterion met? (flow ~16 m^3/s)	30-day mean flow (<56 m^3/s)	Time since >3 × median flow (<62 days)	30-day CV of flow (>0.13)	Decision		Survey result	Excelsior	Excelsior New	Monowai	Clifden	Average LWR	Average LWR – with Excelsior New	Station Br (Mararoa comp.)	
						28-May-26	RED	210	160	887	1169	755	739	1462	RED Status. The final Survey for the season was carried out on the 27th (Mararoa River) and 28th of May 2026 (Waiau sites). The SCI for both Excelsior sites decreased slightly, while the Clifden, Monowai and the Mararoa sites had an increase in SCI.

Appendix G Technical details of supplementary flows and natural flow augmentation event

Hydrographs provided by Meridian (Ed Stead, hydrologist) of the supplementary flows released during the 2025–26 monitoring season, showing instantaneous and average flow for Lower Waiau at MLC Tailwater and Mararoa at Cliffs (Figure G.3 only), with Lake Manapōuri level (for supplementary flows only) and potential energy spilled also indicated.

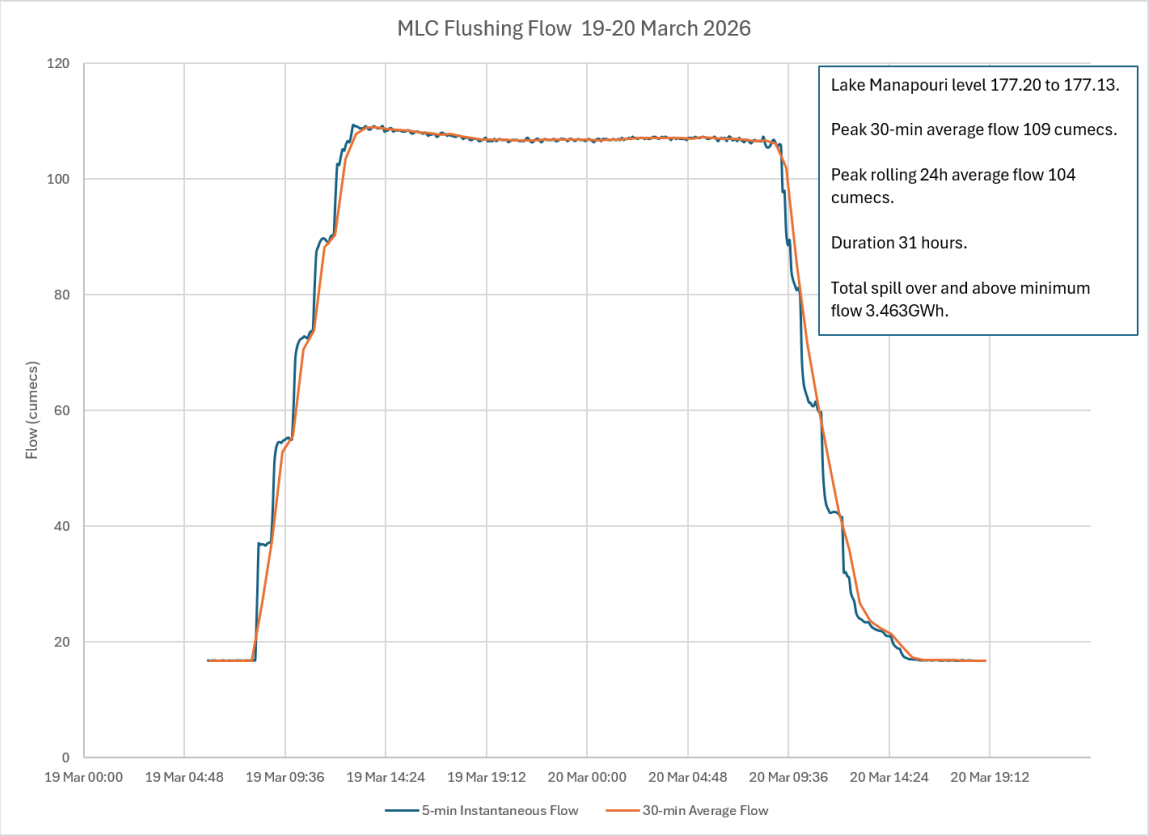


Figure G.1 Detailed hydrograph of supplementary flow in the Lower Waiau River, 19–20 March 2026. Hydrograph shows instantaneous flow and average flow data. This was a "variable" flow release with a total duration of 31 h.

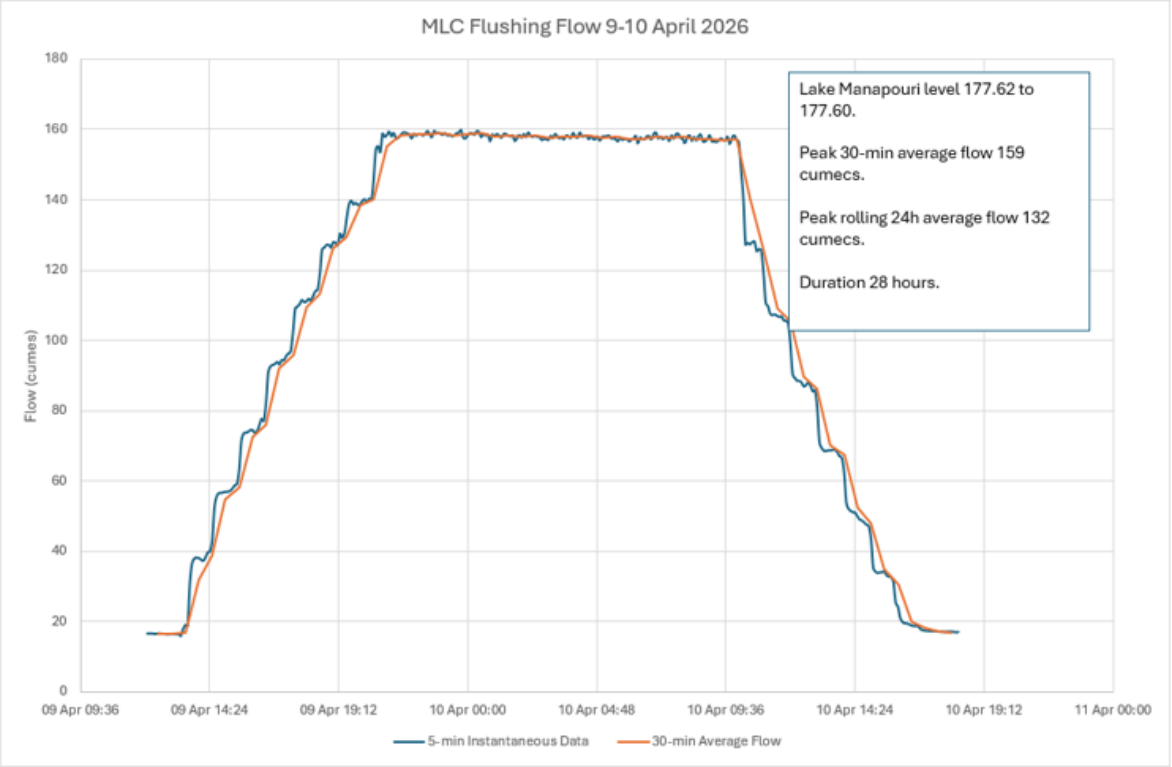


Figure G.2 Detailed hydrograph of supplementary flow in the Lower Waiau River, 9–10 April 2026. Hydrograph shows instantaneous flow and average flow data. This was a "variable" flow release with a total duration of 28 h.

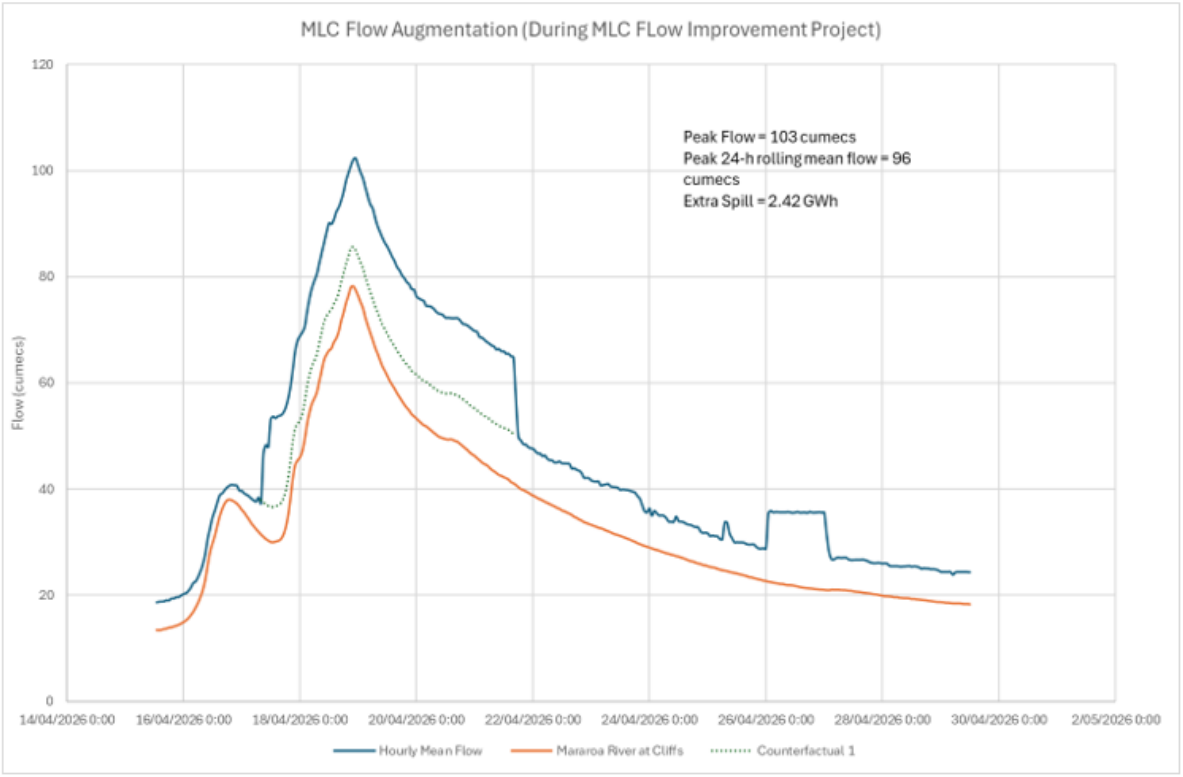


Figure G.3 Detailed hydrograph of augmented natural flow event the Lower Waiau River, 17-22 April 2026. Hydrograph shows hourly mean flow at MLC and at Mararoa River (at Cliffs recorder). This flow augmentation event occurred during the MLC Improvement project. The MLC:IP required diversion of Mararoa River flows plus 5 m^3/s from Lake Manapōuri, at times, to meet resource consent conditions.