IN THE MATTER of the Resource Management Act 1991

AND

IN THE MATTER of an application by Meridian Energy Limited for the resource consents related to the construction of a new channel to enable a permanent diversion of part of the flow of the Waiau Arm and the associated removal of bed material and gravels, together with any maintenance and ancillary activities.

STATEMENT OF EVIDENCE IN CHIEF OF KRISTY HOGSDEN

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INTRODUCTION

1. My full name is Kristy Lynn Hogsden.

2. I hold the qualifications of Bachelor of Science (Honours) from Trent University (Canada), Master of Science in Ecology and Environmental Biology from the University of Alberta (Canada) and a PhD in Ecology from the University of Canterbury. I am a member of the New Zealand Freshwater Science Society.

3. I am a Periphyton Ecologist and Group Manager (Freshwater Ecology) at NIWA where I have worked since 2019. I previously worked as a research associate and postdoctoral fellow in freshwater ecology at the University of Canterbury (2013 to 2018) and as an Environmental Scientist at Fundy Engineering and Consulting (2007 to 2008).

4. My work involves assessing environmental impacts on water quality and aquatic communities (periphyton, macroinvertebrates and fish) in streams and lakes. I have worked across a range of environmental issues related to freshwater ecosystems, including mining, acidification and agriculture. I design and undertake field surveys, monitoring programmes, data analysis and reporting to support freshwater research and consultancy projects.

5. To date, I have authored 18 peer-reviewed scientific papers, a book chapter and numerous technical reports on river and lake water quality and ecology, including 12 reports in the Waiau Catchment in Southland.

BACKGROUND

6. I confirm that I have been part of the team at NIWA which has been considering Meridian Energy Limited's (**Meridian**) proposed Manapōuri Lake Control Structure Improvement Project (**MLC:IP** or **the Project**). This work has included preparation of the Assessment of Environmental Effects: Freshwater Ecology (which I will refer to as the **Freshwater Ecology Report** or **my Report**). I am familiar with the Phytoplankton Risk Assessment Report (the **Phytoplankton Report**) that was

prepared by my colleague Dr Cathy Kilroy. These reports are attached as Appendices D[1] and E[2] to resource consent applications for the MLC:IP.

7. My role in the MLC:IP Project has been as a freshwater ecology expert. My involvement began with a benthic ecology survey that NIWA completed in the lower Waiau Arm, including the Project Area, in March 2022. I analysed the macroinvertebrate data from the survey and co-authored the report.

8. I am familiar with the Project Area, including the Waiau Arm, Manapōuri Lake Control Structure (**MLC**), and Lower Waiau River and last visited the area in October 2022.

9. I also confirm that I have been the freshwater scientist and Project Manager at NIWA for the Waiau Arm water quality monitoring programme since 2020. My role is to interpret and report on the water quality monitoring data and provide advice to Meridian on next steps for management action.

10. In preparing this evidence I have read the statements prepared on behalf of Meridian for this hearing by:

    (a) Mr Andrew Feierabend (Meridian);

    (b) Dr Dougal Clunie (Damwatch);

    (c) Dr Jo Hoyle (NIWA);

    (d) Dr Mike Hickford (NIWA); and

    (e) Mr Daniel Murray (Tonkin + Taylor).

CODE OF CONDUCT

11. Although this is not an Environment Court hearing, I confirm that I have read the 'Code of Conduct for Expert Witnesses' contained in the Environment Court Consolidated Practice Note 2023. I agree to comply with this Code of Conduct. In particular, unless I state otherwise, this evidence is within my sphere of expertise,

[1] Available here
[2] Available here

and I have not omitted to consider material facts known to me that might alter or detract from the opinions I express.

SCOPE OF EVIDENCE

12. In my evidence I will:

    (a) Describe the existing environment in terms of plant and macroinvertebrate communities and their values in the Waiau Arm and the Lower Waiau River;

    (b) Describe the effects of the Project on water quality, plants and macroinvertebrates and confirm my assessment of effects;

    (c) Describe the existing state of phytoplankton within the Waiau Arm and the effect of MLC flow releases on phytoplankton;

    (d) Summarise the assessment of the risk of phytoplankton blooms in the Waiau Arm immediately upstream of the MLC following construction of a new parallel channel;

    (e) Respond to issues raised by submitters;

    (f) Respond to issues raised in the Officers' Report; and

    (g) Provide my conclusions.

13. I note that the evidence of my colleague Dr Hickford summarises the assessment of freshwater fish effects and that the evidence of my colleague Dr Hoyle explains the proposed management response in terms of the generation of suspended sediment and deposited fine sediment.

14. The existing configuration of the Waiau Arm, the MLC and the Lower Waiau River, as well as the proposed Project site location are described in Sections 2, 4 and 5 of the Assessment of Effects on the Environment (**AEE**) and in Mr Feierabend's evidence and are not repeated in detail here.

SUMMARY OF EVIDENCE

Existing environment

15. Near the Project Area in the Waiau Arm, plant communities are primarily macrophytes, dominated by non-native weed species (primarily *Elodea canadensis*) in shallow waters and native characean algae. The macroinvertebrate communities are dominated by *Potamopyrgus* snails and oligochaete worms, with low numbers of the At-Risk kākahi (freshwater mussel) found during a recent survey.

16. Downstream of the Project Area in the Lower Waiau River, plants are primarily periphyton, which is dominated by didymo and can reach nuisance levels. Macroinvertebrate communities are considered of moderate to poor quality relative to national standards. Together, the existing ecological value of plants and macroinvertebrates in the Project Area in the Waiau Arm and in the Lower Waiau River is considered low, except for the kākahi, which is high.

Assessment of effects

17. The primary motivation for the Project is to improve the conveyance and reliability of flushing flows to assist with managing nuisance periphyton and improve ecological health in the Lower Waiau River.

18. Effects of the Project are considered for two phases: during construction and post construction. Construction includes the one-off, short-duration establishment of the parallel channel in the Waiau Arm.

19. The direct and indirect effects of higher suspended and deposited fine sediment levels and lower water velocities (as anticipated from the construction of the Project) were assessed considering the location and magnitude of the effect, the intrinsic value of taxa, and the potential for recovery following excavation of the parallel channel.

20. Bed disturbance associated with excavation of the breakout areas will remove macrophytes, periphyton and macroinvertebrates, and temporarily destroy habitat. This effect is considered minor due to the small and localised area, and because communities in this part of the Waiau Arm do not have any special ecological value and will recover. The risk for kākahi will be managed through appropriate measures

(i.e., recovery and relocation) set out in the Freshwater Fauna Management Plan (**FFMP**).

21. Elevated levels of suspended sediment during particular times in the construction period will primarily reduce water clarity. The potential effects on water quality (beyond the direct sediment effects) will be minor, temporary and within the range of natural variation.

22. Elevated levels of suspended and deposited fine sediment during the construction period are expected to reduce periphyton growth and increase potential for sloughing of existing mats. This effect is considered less than minor given the existing state of periphyton (i.e., frequent nuisance growth), and the short duration of potentially elevated sediment following excavation of the breakout areas.

23. Elevated levels of deposited fine sediment are expected to have a greater effect than suspended sediment on macroinvertebrates, through habitat alteration and reduced food availability and quality. This effect is considered minor given sediment effects are expected to be temporary during construction (five to seven weeks during the breakout excavation phase), likely to be greatest closest to MLC where deposited sediment can already be high at times, and sediment will be remobilised and moved downstream with flow events.

24. Lower water velocities further upstream in the Waiau Arm (away from MLC) during excavation activities may increase the risk of phytoplankton blooms in that area. The increased risk is expected to be small given the likely timing of the activities (mid-autumn to early spring) is during a low-risk period for bloom development due to cooler water and low light conditions.

25. Modelling and risk analysis showed that there is an increased risk of phytoplankton blooms following completion of the Project due to predicted lower water velocities in the new parallel and existing channels. It should be noted that this risk is often lower than the risk of blooms in the Waiau Arm as a whole, based on water velocities. Proposed conditions have been set out to monitor and mitigate the increased risk of phytoplankton blooms in the channels in the Lower Waiau Arm through managed flow releases. The risk is also expected to be mitigated by the increased conveyance and reliability of flushing flows following completion of the Project. Flow releases reset the risk of phytoplankton blooms developing by reducing the accumulation of phytoplankton biomass and removing bloom-affected water.

26. Overall, the construction effects of the Project on macrophytes, periphyton, phytoplankton and macroinvertebrates are assessed to be minor, provided effects are adaptively managed as set out in the sediment management framework and with flow releases. Following construction, plants will gradually recover with upstream communities providing propagules for recolonisation and macroinvertebrates will also recolonise the area; some will recolonise relatively rapidly whereas others may take longer depending on the taxa and their mobility.

OVERVIEW OF PLANT AND MACROINVERTEBRATE VARIABLES AND DATA

27. Plant communities include macrophytes, periphyton, and phytoplankton:

    (a) Macrophytes are aquatic plants that grow in or near the water and are either emergent, submergent or floating. Macrophytes provide food, habitat, and cover for macroinvertebrates and fish and help stabilise shorelines and riverbeds. Macrophytes are often measured by species occurrence, percent cover of different species, and depth of occurrence.

    (b) Periphyton comprises primarily algae growing on substrates in the riverbed and is a natural component of freshwater ecosystems. Periphyton is an important primary producer and food resource for macroinvertebrates, but excessive growth of periphyton can have detrimental effects on water quality, habitat, biodiversity and recreational use in rivers. Certain types of periphyton are linked to human health values (e.g., toxic cyanobacteria). Periphyton is usually measured as chlorophyll *a* (biomass) and by percent cover of different types of periphyton (e.g., films, mats, filaments).

    (c) Phytoplankton are microscopic, free-floating algae found in the upper layers of the water column in freshwater ecosystems and are important primary producers. Rapid increases in the abundance of phytoplankton to nuisance levels are called blooms. Phytoplankton is measured as chlorophyll *a* concentration in samples collected from surface waters.

28. Macroinvertebrates are aquatic invertebrates living in a river that are more than 500 µm in size and include insect larvae, worms, crustaceans, and molluscs (e.g., snails, mussels). Macroinvertebrates are widely used as indicators of river health because many taxa have known sensitivity or tolerance to water quality or habitat conditions. Macroinvertebrate communities are often described by abundance, community

composition and using metrics, such as the Macroinvertebrate Community Index (**MCI**) and its quantitative variant (**QMCI**). These metrics are based on the tolerance of different taxa to organic enrichment, with the former based on taxa presence and the latter on taxa abundance. Higher scores indicate better river health conditions.

29. The plant and macroinvertebrate data used in my assessment came from the following sources:

    (a) A one-off benthic ecology survey of macrophytes and macroinvertebrates in the Waiau Arm in March 2022;

    (b) Monthly periphyton and annual macroinvertebrate samples in the Lower Waiau River collected by Environment Southland as part of their State of the Environment (**SOE**) monitoring programme; and

    (c) Monthly phytoplankton (as chlorophyll *a*) samples collected in the Waiau Arm by Environment Southland (year-round, from July 2018) and during summer by Meridian (January–March, from January 2020) as part of their consent monitoring programme. I note that chlorophyll *a* was voluntarily added to the Meridian programme in 2020 based on a recommendation from NIWA.

30. The National Policy Statement for Freshwater Management (**NPS-FM 2020**) defines numeric attributes for periphyton (trophic state), phytoplankton (trophic state) and macroinvertebrates (MCI and QMCI). Numeric attribute states for these variables are used to describe the existing environment and in my assessment of effects. The attribute states are shown in Appendix A (Table A-1) to my evidence.

31. Phytoplankton in lakes is measured as chlorophyll *a* concentration. Chlorophyll *a* is one indicator of the trophic status of lakes, which can range from ultra-microtrophic to hypertrophic, indicating progressively more phytoplankton biomass (Appendix A, Table A-2) and lower water quality. This indicator is also used in waterbodies that have lake-like characteristics (e.g., Waiau Arm).

EXISTING ENVIRONMENT

32. The following description of the existing environment specifies taxa of special ecological value (e.g., Nationally Threatened, At Risk or Uncommon) and, where applicable, specifies gradings of sites against attributes in the NPS-FM.

Plant communities

Waiau Arm

33. Macrophytes currently dominate the benthic plant communities within the Project Area. These are primarily the non-native weed (*Elodea canadensis*) and two native characean algae (*Nitella* sp.aff. *cristata* and *Chara australis*), with other tall vascular plants (e.g., *Myriophyllum triphyllum*, *Potamogeton orchreatus*) also common in the surveyed area in 2022.

34. Beds of *Elodea canadensis* dominated vegetation at the wetted margins of all transects, while characeans were the most widespread taxa across all depths. *E. canadensis* had the highest cover on three transects within ~600 m of MLC, with mean cover estimated at <25% to >75% of the bed in waters up to 3 m deep. Transect locations in the vicinity of the Project Area are shown in Appendix B (Figure B-1) to my evidence.

35. Across all transects, plant communities were most abundant and diverse within the shallow waters (≤2.5 m) of the transects with low cover of few species (mostly native characeans) present across deeper channels. Plant abundance was generally greater in upstream areas (control transects) likely due to more fine bed sediment that provided suitable attachment substrate.

36. The macrophyte taxa present in the Waiau Arm have no special ecological value.

37. Periphyton was not surveyed in 2022 but is likely present at low abundance, with the community previously considered species-poor, comprising thin films and of no special ecological value[3]. There is no reason to expect the community has changed

[3] Kilroy,C., Suren, A. (2002) Biological survey of the Waiau River upstream of the Lake Manapouri control structure prior to degravelling operations. Client report prepared for Meridian Energy Limited. CHC02/18. 20 p

since surveyed in 2002, except for the arrival of the non-native diatom *Didymosphenia geminata* (didymo) in 2004.

38. From July 2018 to April 2023, phytoplankton abundance (as chlorophyll *a*) at all monitored sites in the Waiau Arm ranged from 0.1–6.7 mg/m^3, representing ultra-microtrophic to eutrophic conditions. Based on year-round data during this period, chlorophyll *a* was <2 mg/m^3 for 73% of the time, was between 2–5 mg/m^3 for 25% of the time, and rarely exceeded 5 mg/m^3 (2% of time). Based on median annual chlorophyll *a* measurements, all sites would be placed in Band A of the NPS-FM for the phytoplankton attribute (Table A-1). Band A corresponds to microtrophic to oligotrophic conditions (Table A-2) that are characterised by low algal biomass, very clear water and good water quality.

Lower Waiau River

39. The plant community in the Lower Waiau River downstream of the MLC is primarily periphyton, which is dominated by didymo. Nuisance levels of didymo are regularly attained in the Lower Waiau River in summer as indicated by high percent cover (at times up to >60%) and biomass[4]. Flushing flows are provided to assist with reducing nuisance levels of periphyton in the Lower Waiau River. Overall, periphyton biomass ranges were often moderate to high (up to 232 mg/m^2), placing sites in Band B or C of the NPS-FM[5] for the periphyton attribute (Table A-1). Bands B or C are indicative of occasional or periodic, short-term nuisance blooms that can degrade river health. The site monitored in the Lower Waiau River upstream of Excelsior Creek was close to the threshold separating Bands B and C for the periphyton attribute.

40. The potentially toxic cyanobacterium *Microcoleus autumnale* (previously *Phormidium*) can proliferate in summer to levels sufficient to warrant public health warnings in the Waiau River at the site monitored upstream of Excelsior Creek[4].

41. The periphyton taxa present in the Lower Waiau River have no special ecological value.

[4] Kilroy, C. (2022). Managing nuisance periphyton in the Lower Waiau River. Monitoring and management 2021-22. Client report prepared for Meridian Energy Limited. 2022250CH.

[5] Hogsden, K., Kilroy, C., Haddadchi, A., Robb, J. (2023). Waiau catchment water quality, periphyton and invertebrates – Three-year update report. Amended June 2023. Client report prepared for Meridian Energy Limited. 20211400CH.

Macroinvertebrates

Waiau Arm

42. Macroinvertebrate communities near the Project Area are currently dominated by native mud snails (*Potamopyrgus antipodarum*), planktonic crustaceans and oligochaete worms. These taxa are tolerant of low-quality habitat, fine substrate and slow-flowing water. A total of 41 taxa were identified in the 2022 survey. Similar macroinvertebrate communities were reported in a survey in 2002[3], suggesting little change in the community composition over the past 20 years. These taxa are common and have no special ecological values.

43. Low numbers of kākahi (freshwater mussels, likely *Echyridella menziesii*) were present in the 2022 survey. Individuals were found in the proposed Project Area (transects T1 and T2) and in the upstream area (control transects). Kākahi have a conservation status of At Risk – Declining and are considered to have high ecological value.

Lower Waiau River

44. Macroinvertebrate community health (as MCI) in the Lower Waiau River is considered moderate to poor and sites are categorised as either Bands C or D for the NPS-FM macroinvertebrate attribute (MCI) (Table A-1). Limited data available from the site upstream of Excelsior Creek suggest the macroinvertebrate community state is similar (i.e., close to the national bottom line). Over the past five years, the most locally abundant taxa at sites monitored in the Lower Waiau River, from upstream of Excelsior Creek to Tuatapere, were oligochaete worms, chironomids, *Deleatidium* mayflies, *Hydropsyche* caddisflies and *Potamopyrgus* snails. All these taxa except *Deleatidium* are considered tolerant of poor or degraded habitat conditions. The taxa present are common and have no special ecological values.

ASSESSMENT METHODOLOGY

45. The primary motivation for the Project is to improve the conveyance and reliability of flushing flows to assist with managing nuisance periphyton growth and improve ecological health in the Lower Waiau River.

46. The methodologies and assumptions for the assessment undertaken in support of the resource consent applications are detailed in the Freshwater Ecology Report. Briefly, the assessment was based on findings from a literature review, synthesis of information from the existing environment and outcomes from the trial excavation. The monitoring methods and results from the trial excavation related to suspended and deposited fine sediment are presented in Dr Hoyle's evidence.

47. The general effects of suspended and deposited fine sediment on plants and macroinvertebrates were reviewed in the available literature, with existing sensitivity thresholds identified for acute and chronic effects on individual taxa or taxa groups.

48. I also note the sediment generation potential and sediment management framework for the Project are outlined in Dr Hoyle's evidence.

49. The sediment thresholds and exceedance allowances set out in the sediment management framework are designed to keep suspended sediment and deposited fine sediment within the range of conditions that are experienced naturally in the Lower Waiau River and are set at levels and durations aimed to protect biota from both acute and chronic effects. For example, the deposited fine sediment threshold level (i.e., increase in 20% cover above a baseline) was justified based on the loss of habitat and food for macroinvertebrates, which are more sensitive to deposited than to suspended fine sediment. Reductions in macroinvertebrate abundance have been reported following increases in deposited fine sediment of 12–17%[6] and also when cover increases from already high levels (~80%)[7].

50. The assessment considered how plants and macroinvertebrates in the affected areas might be affected by higher suspended and deposited fine sediment and lower water velocities (as anticipated from the Project), the magnitude of the effect, the intrinsic value of the taxa/communities and the potential for recovery following the excavation.

51. The assessment of level of effect was based on expert opinion, combining the ecological values in the existing environment with the type, magnitude and duration

[6] Ryan, P.A. (1991) Environmental effects of sediment on New Zealand streams: a review. New Zealand Journal of Marine and Freshwater Research, 25: 207-221.

[7] Matthaei, C.D., Weller, F., Kelly, D.W., Townsend, C.R. (2006) Impacts of fine sediment addition to tussock, pasture, dairy and deer farming streams in New Zealand. Freshwater Biology, 51(11): 2154-2172. 10.1111/j.1365-2427.2006.01643.x

of effects. This approach generally followed the Environment Institute of Australia and New Zealand (**EIANZ**) guidelines on Ecological Impact Assessment[8].

EFFECTS OF THE PROJECT ON WATER QUALITY, PLANTS AND MACROINVERTEBRATES

52. The following potential direct and indirect effects from the Project on water quality, plants and macroinvertebrates, were considered, as appropriate:

    (a) Bed disturbance in the Project Area of the Waiau Arm;

    (b) Elevated levels of suspended sediment in the lower Waiau Arm and downstream in the Lower Waiau River;

    (c) Deposited fine sediment in the lower Waiau Arm and downstream in the Lower Waiau River; and

    (d) Lower water velocities farther upstream in the Waiau Arm during excavation activities and in the channels just upstream of the MLC after the completion of the Project.

53. I note that the predicted effects on plants and macroinvertebrates assume that suspended and deposited fine sediment thresholds and exceedance durations will be monitored and managed according to a sediment management framework.

54. I note that predicted risks of phytoplankton blooms will be monitored in the Waiau Arm after construction of the Project. Following completion of the parallel channel, the predicted risk of phytoplankton blooms are expected to be mitigated by improved conveyance and reliability of flushing flows, which is the primary purpose for the Project, as described in Mr. Feierabend's evidence.

Water quality

55. Increased suspended sediment during construction works will reduce water clarity, which is expected to be the primary effect of the Project on water quality. The increase in suspended sediment may also result in slight increases in water

[8] Roper-Lindsay, J., Fuller S.A., Hooson, S., Sanders, M.D., Ussher, G.T. 2018. Ecological impact assessment. EIANZ guidelines for use in New Zealand: terrestrial and freshwater ecosystems. 2nd edition.

temperature (as suspended sediments absorb heat energy) and changes in dissolved oxygen (due to a decrease in photosynthesis by aquatic plants via reduced light transmission). Increases in phosphorus concentrations, which easily adsorb to fine sediment in the river, could also be expected. The phosphorus would mostly be biologically unavailable, as total phosphorus.

56. Nitrogen variables (nitrate, total nitrogen) and *E. coli* are not expected to be affected by sediment mobilised by the Project.

57. I consider that these potential indirect effects on water quality (beyond the direct sediment effects that will be managed through the sediment management framework) will be minor, temporary and within the range of natural variation.

Plant communities

58. Bed disturbance will occur during excavation of the breakout areas and will destroy existing habitat and remove any macrophytes and periphyton present at the location of those excavations. These direct effects will be confined to the relatively small, localised areas where the breakout areas join the existing Waiau Arm. This potential direct effect on plants is considered minor due to (a) the small and localised nature of the disturbance, (b) the taxa currently present having no special ecological value and being present elsewhere in the Waiau Arm, and (c) the gradual recovery of plants expected following the Project, with upstream communities providing propagules for recolonisation.

59. Elevated suspended sediment and deposited fine sediment are expected to affect the macrophytes in the Project Area and periphyton in the Lower Waiau River primarily through a reduction in growth (due to reduced light penetration reducing photosynthesis) and partial smothering of plant material. This potential effect is considered temporary as any increase in flows in the Waiau Arm during or following the excavation will help to flush the sediment and clear deposited material, which will allow the plants to recover and continue growing.

60. Elevated suspended sediments are also expected to increase the potential for sloughing (i.e., detachment) of existing periphyton mats. Given the existing state of periphyton in the Lower Waiau River (i.e., frequent nuisance growths in summer) and the relatively short duration of potentially elevated sediment inputs during construction, these effects are considered less than minor.

61. I understand that during the excavation activities, no Mararoa River flows will enter the Waiau Arm and Meridian will endeavour to maintain low positive flows down the Waiau Arm. As a result, lower water velocities in the Waiau Arm during excavation activities may increase the risk of phytoplankton blooms upstream of the Project Area. Given the likely timing of the instream excavation activities (5–7 week period, between autumn (late May) to early spring (September) for breakout areas), the risk is considered small compared to the risk under typical summer conditions, when warmer water temperatures and light conditions favour bloom development. Meridian's existing compliance monitoring in the Waiau Arm will detect any changes in water quality and increases in chlorophyll *a* related to developing blooms during the summer months of the construction works (from January–March), which can be managed by flow releases. This effect is considered less than minor.

62. Lower water velocities may also result in an increased risk of phytoplankton blooms in the existing main and south channels of the lower Waiau Arm and the new parallel channel post construction. The assessment of phytoplankton bloom risk is addressed in detail below (paragraphs 89–104). The increased risk of phytoplankton blooms is expected to be mitigated by flow releases, with mitigation improved by the increased conveyance and reliability of flushing flows that will be enabled following completion of the Project.

63. A combination of lower water velocities predicted in the channels of the lower Waiau Arm just upstream of the MLC following the Project and deposition of fine sediment, or either factor alone, may result in a more favourable environment for macrophyte establishment than currently exists. Given that the plant communities in the Waiau Arm are currently macrophyte dominated, this effect is considered negligible.

64. Overall, I consider the potential effects on plant communities are minor. I expect the increase in flushing flows post construction will have positive effects on periphyton in the Lower Waiau River by reducing nuisance growth.

Macroinvertebrates

65. Bed disturbance will occur during the excavation of the breakout areas and will destroy and remove any macroinvertebrates present during excavation works and temporarily destroy potential habitat. These direct effects will be confined to the relatively small, localised areas where the breakout areas join the existing Waiau Arm. This potential effect is considered minor due to (a) the small and localised

nature of the disturbance (i.e., negligible effect), (b) the taxa currently present having no special ecological value (except kākahi; paragraph 43) and being present elsewhere in the Waiau Arm, and (c) expected recolonisation of the area by macroinvertebrates. Depending on the taxa and their mobility, some will recolonise relatively rapidly, whereas less mobile taxa may take longer.

66. The excavation of the breakout areas will result in loss of potential habitat for kākahi, but similar habitat remains nearby. The magnitude of the effect on the population is negligible, based on the size of area being impacted, but the ecological value of kākahi is high (At Risk – Declining status). This effect will be managed by steps (i.e., survey, recovery and relocate) set out in the Freshwater Fauna Management Plan (**FFMP**) to avoid and minimise effects on kākahi[9]. If these steps are implemented, I consider the potential effects on kākahi are not of concern.

67. The timing of instream works (excavation of the breakout areas, as noted in paragraph 61) will largely avoid the critical spawning period of kākahi from early spring to summer. The predicted effects of elevated suspended and deposited fine sediment are primarily downstream of the Project Area in the Lower Waiau River, areas unlikely to have favourable habitat for kākahi.

68. Elevated suspended and deposited fine sediment will potentially affect macroinvertebrates downstream of the Project Area in the Lower Waiau River as entrained sediments drop out of suspension and deposit on the substrate/riverbed. High levels of suspended sediment and increased deposition may result in increased drift, with some taxa moving downstream (e.g., sensitive *Deleatidium* mayflies)[10].

69. The deposition of fine sediment alters habitat by covering or burying substrate, infilling interstitial spaces, and reducing habitat availability. Food availability and quality may also be reduced due to limited periphyton growth (refer to paragraph 59). The settling and incorporation of sediment into periphyton mats may also reduce food quality.

[9] NIWA has previously been involved in successful kākahi relocations associated with excavation and dredging activities. It is considered an effective mitigation method for kākahi.

[10] Clapcott, J., Wagenhoff, A., Neale, M., Storey, R., Smith, B., Death, R., Harding, J., Matthaei, C., Quinn, J., Collier, K., Atalah, J., Goodwin, E., Rabel, H., Mackman, J., Young, R. (2017) Macroinvertebrate metrics for the National Policy Statement for Freshwater Management. Prepared for the Ministry for the Environment. Cawthron Report No. 3073.

70. These effects on macroinvertebrates are expected to be temporary as the key sediment-generating phase of the Project is expected to last only five to seven weeks. Effects are likely to be greatest closest to the MLC (depending on flow conditions), where deposited fine sediment cover can already be high at times, and the deposited fine sediment will gradually move downstream as it is remobilised by flow events. Macroinvertebrates are expected to recolonise from upstream and tributaries following completion of the Project.

71. Overall, I consider the potential effects on macroinvertebrates are minor. Post construction, the increased reliability in flushing flows is expected to reduce nuisance periphyton (primarily didymo mats) which should help improve macroinvertebrate habitat downstream of the MLC.

EFFECTS OF THE PROJECT ON PHYTOPLANKTON

72. Due to reduced velocities predicted in channels of the lower Waiau Arm because of construction of the parallel channel, potential effects on phytoplankton were identified and additional analysis was warranted. The phytoplankton risk assessment completed for the Project is presented in the Phytoplankton Report.

Existing state of phytoplankton in the Waiau Arm

73. The risk of phytoplankton blooms is already a concern in the Waiau Arm during times of low flows. Extended periods of very low to no water velocity (i.e., increased residence time) are a pre-requisite for phytoplankton blooms. A reduction in the amount of water going in either direction (i.e., positive flow towards MLC or negative flow towards Lake Manapōuri) could increase the risk of blooms in the Waiau Arm.

74. Phytoplankton growth in the Waiau Arm is also influenced by water temperature, season, and nutrient availability. Bloom development is typically favoured during summer months when water temperatures are warmer and light levels are high. Nutrient inputs from Home Creek and Mararoa River may stimulate phytoplankton growth in the Waiau Arm.

75. Since the early 2000s there have been concerns from local stakeholders over the risk of poor water quality, including low clarity and phytoplankton blooms developing in the Waiau Arm, and the potential ecological effects of these blooms on other aquatic communities, especially in summer.

76. In response to observations of a “major algal bloom / water quality issue in the lower Waiau Arm” in May 2003[11], Meridian commissioned a water quality monitoring study in 2004–2005[12] to assist with refining their operational strategy for flows in order to preserve water quality in the Waiau Arm. The results of the study indicated that phytoplankton (as chlorophyll *a*) was highly seasonal and approached levels that could be cause for concern during the late summer period, when solar radiation was high, and water temperatures had increased. The study also showed that nutrient and sediment inputs were important considerations (alongside flows) to aid in interpretation of water quality patterns and maintain water quality in the Waiau Arm.

77. Predicted changes to the flow regime associated with the Manapōuri Tailrace Amended Discharge (**MTAD**) (i.e., increase in number and duration of ‘parked’[13] events and increased duration of Mararoa River flow towards Lake Manapōuri) were predicted to increase the risk of phytoplankton blooms in the Waiau Arm, especially at times of low inflows to the catchment[14]. A condition of the MTAD consent[15] was continuation of water quality monitoring in the Waiau Arm during summer, which had already been undertaken on a voluntary basis since 2004 (paragraph 76), and in accordance with Appendix 1 (A4 Waiau Arm) of the Manapōuri Power Scheme 1996 operational consents. Water quality and clarity criteria were established to identify conditions that indicate the increasing risk of development of phytoplankton blooms. Annual water quality monitoring in summer under the MTAD consent has been reported on since 2011.

78. The monitoring results from 2011 to 2023 suggest water clarity is generally high in the Waiau Arm. Likely causes for declines in clarity during monitoring included incursion of lower clarity water from the Mararoa River, increased turbidity following a heavy rainfall event, and increased phytoplankton abundance. The relatively brief durations (ranging from 1 to 3 weeks) of lower clarity events observed during

[11] Reference to communications from Ms Jan Riddell (witness for the Waiau Working Pary, 7 September 2009) in Sutherland et al. (2011). Water quality monitoring in the Waiau Arm of Lake Manapōuri – November 2011 to March 2012. NIWA Client Report prepared for Meridian Energy.

[12] Spigel, B., Sorrell, B., Sutherland, D. (2006) Waiau Arm Water Quality Study: September 2004 – May 200. NIWA Client Report CHC2006-013. Prepared for Meridian Energy Ltd.

[13] When flows are less than 8 m^3/s (in either direction).

[14] Sutherland, D.L., Graynoth, E. (2009) Assessment of the effects of the Manapōuri Tailrace Amended Discharge on the ecosystems of Lakes Te Anau, Manapōuri and the Waiau Arm. For Meridian Energy Ltd. NIWA Client Report CHC2008-055.

[15] MTAD consent 206156, Condition 6 and Appendix A, Clause B) ii), clauses 10 and 11.

monitoring were considered unlikely to have measurable ecological effects in the Waiau Arm[16].

79. Current data (chlorophyll *a*) from all monitoring sites from 2018 to 2023 indicates the state in the Waiau Arm is often good to very good (i.e., oligotrophic to microtrophic conditions, <2 mg/m^3 for most of the year; refer to paragraph 38), with some seasonal risk of increased chlorophyll *a*, primarily in summer when conditions are ideal for growth.

Effect of flow releases on phytoplankton

80. Meridian releases flows through the MLC to the Lower Waiau River in accordance with existing resource consent conditions (the Manapōuri Power Scheme operational consents). The types of flow releases include minimum flows, lake and flood flows, recreational flows and flushing flows.

81. Managed flow releases that replace the water in the Waiau Arm with water from Lake Manapōuri are larger flushing flows to assist in managing periphyton biomass and smaller recreational flows. These flow releases reduce the accumulation of phytoplankton biomass (by dilution and flushing algal cells downstream towards MLC) and reset the risk of phytoplankton blooms developing in the Arm to a low level.

82. Flushing flows, defined in the current protocol[17], as mean 24 h flow >120 m^3/s, peaking at >160 m^3/s, will replace all the water in the Waiau Arm with lake water in 6–12 hours depending on lake level and flow in the Mararoa River[18].

83. Flushing flows of this size would reduce phytoplankton biomass and re-set the risk of blooms to very low with a residual effect of several days, as lake water with low chlorophyll *a* (often <0.5 mg/m^3 in summer) would persist in the Waiau Arm after the flushing flow and extend the time required for bloom development.

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[16] Hogsden, K., Kilroy, C., Molineux, M (2023). Waiau Arm water quality monitoring 2023. NIWA Client Report 2023099CH. Prepared for Meridian Energy.

[17] Water Permit 206156 Condition 7 (Protocol for controlled releases of voluntary supplementary flows from the Manapōuri Lake Control (MLC) structure to the Lower Waiau River. Final 9 April 2013, Amended 7 November 2014,12 February2016, and 16 November 2018).

[18] Following calculations in Spigel, B., Sorrell, B., Sutherland, D. (2006) Waiau Arm Water Quality Study: September 2004 – May 2005. NIWA Client Report CHC2006-013. Prepared for Meridian Energy Ltd.

84. The current protocol provides for the release of four flushing flows in each season (November to May), with provision for a fifth supplementary flow release in May under specific periphyton and operational conditions[17]. On average, fewer than 1.5 flushing flows per season were released between November 2016 and May 2023, and the primary purpose of the Project is to improve the reliable delivery of these flows in future.

85. Monthly recreational flows are typically 35–45 m^3/s (at MLC) for 24 hours. If the entire recreational flow is provided from Lake Manapōuri, then all water in the Waiau Arm would be replaced at lake levels up to 177.5 m. This would reduce phytoplankton biomass and reduce the risk of blooms to very low.

86. The effectiveness of a recreational flow in reducing bloom risk decreases when lake levels are higher or if some of the flow is provided from the Mararoa River. If Mararoa water has been diverted into the Waiau Arm (i.e., negative flow in the Waiau Arm) then the water for the recreational flow includes a high proportion of Mararoa River water. Reversing the flow (i.e., negative flow) to enable the recreational release at MLC results in lower water velocities in the preceding days and does not reduce the risk of blooms.

87. Monthly recreational flows are scheduled for the fourth Sunday in each month from October to April and have been provided relatively consistently. Between 2017 and 2023, 28 of 40 potential recreational flows were released. Releases did not occur due to high flows on the scheduled release day (seven occasions) or low lake levels (five occasions).

88. In the 31 summer monitoring surveys undertaken by Meridian in the Waiau Arm from 2020 to 2023, there were five surveys when chlorophyll *a* >2 mg/m^3 was recorded at any of one of the three sites in the Waiau Arm and a flushing flow or recreational flow occurred before the next survey. This allowed for consideration of the effectiveness of the flow releases on phytoplankton. In three surveys, chlorophyll *a* had decreased at all sites by the following survey. In two surveys, chlorophyll *a* had increased or no change was reported for at least one site.

Assessment of risk of phytoplankton blooms from the MLC:IP

89. The risk of development of phytoplankton blooms (i.e., increased chlorophyll *a* concentrations) in the Waiau Arm immediately upstream of MLC following completion of the new parallel channel was assessed in the Phytoplankton Report.

90. The assessment was based on hydraulic modelling of water velocities in the new parallel channel and two existing channels (main and south) under eight scenarios of flow in the Waiau Arm and lake level in Lake Manapōuri[19]. The predicted water velocities in the three channels following excavation were compared with that in the existing channels.

91. In the paragraphs below, I summarise key steps and assumptions used in the assessment.

92. Chlorophyll *a* data collated from the Environment Southland and Meridian datasets were used to establish a relationship between chlorophyll *a* and estimates of mean water velocity in the Waiau Arm. These water velocity estimates were derived from modelling carried out in an earlier study[12].

93. The frequency of occurrence of chlorophyll *a* concentrations >2 mg/m^3 was used as an indicator of the risk of phytoplankton blooms in the Waiau Arm for two reasons:

    (a) 2 mg/m^3 is the threshold separating Bands A and B of the phytoplankton attribute (for annual median chlorophyll *a*) in the NPS-FM, which indicates a change in lake ecological communities from those similar to reference conditions to those slightly impacted by additional algal growth;

    (b) Chlorophyll *a* in Lake Manapōuri has never exceeded 2 mg/m^3 during summer monitoring (since 2020), which is consistent with the lake state (microtrophic to oligotrophic) assessed using Environment Southland SOE data[5]. Lake Manapōuri was considered the baseline state for comparison with conditions in the Waiau Arm. Lake Manapōuri itself is consistently classed as microtrophic to oligotrophic.

[19] Clunie, D. (2023) MLC Waiau Arm Excavation – Hydraulic modelling of alternative channel. Memo to Meridian Energy (Issue 3), 31 May 2023.

94. It should be noted that the chlorophyll *a* criterion is based on a relatively low chlorophyll *a* concentration. In other words, it is a high bar for defining risk of phytoplankton blooms. Chlorophyll *a* of 2 mg/m^3 is relatively low compared to many other New Zealand lakes[20] and would rarely be considered a problematic concentration in most lakes. However, the Waiau Arm is effectively an extension of Lake Manapōuri, and a former river channel, both of which would normally have very low chlorophyll *a* concentrations in the water column.

95. Four reasonable assumptions were made in the phytoplankton risk analysis as related to the modelled velocities:

(a) The chlorophyll *a* – velocity relationships and thresholds derived from chlorophyll *a* observations at sites further upstream in the Waiau Arm also apply in the lower Waiau Arm near the Project Area (Appendix C, Figure C-1);

(b) The modelling outputs outlined by Spigel et al. (2006) were comparable to modelled velocities provided by Damwatch;

(c) Estimated water velocity averaged over the water column in the deeper parts of the Arm has the same relationship to velocity in surface waters (where phytoplankton blooms are usually observed) as the average water velocity modelled by Damwatch in the shallower channels nearer to the MLC;

(d) Water temperatures in the channels post-excavation will be at least comparable to (or possibly higher than) those measured in surface waters of the deeper parts of the Waiau Arm under similar water velocities. This is an important assumption because modelled water depth in the channels (2.2 m to 2.6 m) is relatively shallow compared to the depth at monitored sites in the Waiau Arm (6.5 m to 14 m) depending on lake level and site location. Therefore, under slow water velocities the same solar radiation may have an enhanced warming effect in shallower water compared to that in deeper waters.

96. The assessment was based on (a) the modelled velocities in the channels (see paragraph 90), (b) the relationship between chlorophyll *a* and estimated water velocity in the Waiau Arm shown in Appendix D (Figure D-1) and (c) a matrix of

[20] Whitehead, A., Fraser, C., Snelder, T., White, R. (2021) Water quality state and trend in New Zealand lakes. Analyses of data ending in 2020. NIWA Client Report 2021297CH. Prepared for the Ministry for the Environment.

durations (as percentage of time in a year) of different lake level / flow combinations (calculated from 7-year hydrological records).

97. The assessment focused on the period from September to May because the Waiau Arm data showed that the 2 mg/m^3 threshold was rarely exceeded in winter (refer to Phytoplankton Report).

98. Risk was assessed in three steps:

(a) The modelled water velocities in the channels were assigned a level of phytoplankton bloom risk, derived from the data shown in Figure D-1:

(i) High risk = water velocity of 0.02 or <0.02 m/s;

(ii) Some risk = water velocity of 0.03–0.04 m/s;

(iii) Low risk = water velocity >0.04 m/s;

(b) Modelled water velocities in the channels at the eight different combinations of lake level and flow were then overlaid on a matrix of durations of different lake level / flow combinations. Risk was assigned for each channel under existing conditions (two channels) and for the three channels post-excavation of the parallel channel;

(c) Total percentage of time expected at each risk level was calculated for each scenario and converted to days per year (excluding winter[21]).

99. The risk values calculated were the average risks based on seven years of data.

Potential effects of the modelled water velocities on the risk of phytoplankton blooms

100. Together, the modelled velocities in the channels and the chlorophyll *a* – velocity relationship (Figure D-1) suggested that when excavation work is completed there will be a substantially increased risk of phytoplankton exceeding 2 mg/m^3 in the new and existing channels (main and south) compared to the existing channels. Specifically, there is a predicted increase of three to five times the number of days

[21] Due to low risk of blooms identified in winter, regardless of flow. Winter defined June to August.

under high-risk conditions in the channels following excavation over the risk in existing channels (see Table 1).

Table 1: Assessment of the number of days per year (on average) when each channel under each excavation scenario may be under high, some or low risk of developing chlorophyll a *>2 mg/m^3. Assessment shown for days per year, excluding winter and including winter (shown for completeness).*

		Days per year (excluding winter)			Days per year (including winter)		
Excavation scenario	**Channel**	**High risk**	**Some risk**	**Low risk**	**High risk**	**Some risk**	**Low risk**
Existing	Main	12	48	213	16	64	284
	South	26	41	206	34	53	277
Parallel channel	Main	61	81	131	82	98	184
	South	73	86	113	97	106	162
	New	78	92	103	101	127	137

101. The shallow depths in the new and existing channels may further increase the risk of blooms because of the risk of warmer temperatures at times when water velocities are low.

102. This phytoplankton risk pattern is complex because, following the Project, the flow will be split between three channels compared to the existing two. The proportion of flow carried in each of the three channels will vary depending on the combination of Waiau Arm flow and Lake Manapōuri level.

103. Based on water velocities alone, the overall risk of phytoplankton blooms post-construction in the new and existing channels is often lower than in the Waiau Arm, as a whole.

104. I note that the risks of phytoplankton blooms developing in the Waiau Arm, including channels upstream of MLC, will be lower in years when lake inflows are higher and vice versa.

105. It is expected that the increased risk of phytoplankton will largely be offset by the release of more effective (i.e., improved conveyance and reliability) flushing flows during summer than are possible at present, which is the primary motivation for the Project. These additional flow releases, in combination with the releases currently

possible, will provide a core set of flow events that will, in most cases, reduce and/or delay the risk of phytoplankton blooms developing in the channels just upstream of the MLC following completion of the Project.

106. A proposed water quality monitoring programme has been recommended through conditions for the detection of phytoplankton blooms in the channels of the Lower Waiau Arm for a defined period following completion of the Project. The proposed condition sets out monitoring and management actions (i.e., phytoplankton-specific flow releases) to address the potential increased risk of phytoplankton blooms. The full draft condition is addressed in the evidence of Mr Murray and set of conditions appended to his evidence.

RESPONSES TO ISSUES IN SUBMISSIONS

107. I have read all the submissions lodged on the Project relevant to my area of expertise. To the extent not already addressed in my evidence, I will respond to submissions that raised issues or concerns related to macroinvertebrates, noting these were specific to kākahi, and the risk of phytoplankton blooms.

Kākahi

108. Two issues were raised by submitters as related to kākahi (At Risk – Declining). The issues were regarding:

(a) Data used in the proposal (application) and assessment of effects; and

(b) Management of kākahi during the construction and excavation phases of the Project.

109. The **Department of Conservation** (**DOC**) raised a concern regarding the insufficiency of information provided on kākahi, which resulted in the proposal not adequately identifying or addressing the potential adverse effects on this species within the footprint of the site.

110. In response, I agree that, in general, there is little data available on kākahi within the Waiau Arm and surrounding area but note that all available data that NIWA was aware of in the vicinity of the Project was used in the assessment. The most recent

survey of benthic communities in the Waiau Arm[22] was commissioned by Meridian and included transects within the current Project Area in 2022 (Figure B-1).

111. Using the available data, I have addressed the potential adverse effects of the Project on kākahi in my evidence in terms of bed disturbance, habitat loss, and spawning (refer to paragraphs 66–67). It is my opinion that survey, recovery and relocation methods, which will be documented in an FFMP prior to construction works, will avoid and minimise the effects of the construction and excavation activities on kākahi in the Project area. The fact that kākahi are largely immobile in their juvenile and adult life stages will be considered in the development of the FFMP.

112. Four submitters (**DOC, Waiau Working Party, Waiau Fisheries and Wildlife Habitat Enhancement Trust**, and **Guardians of Lakes Manapōuri, Monowai and Te Anau** (**Guardians**)[23]) noted that the potential adverse effects on kākahi should be avoided by inspection, salvage and relocation during the construction phase. I agree and consider this approach to be best practice and appropriate for kākahi. I note that as a species of conservation concern, kākahi is afforded the same protection from disturbance and taking as freshwater fish species in New Zealand[24].

113. I understand that the FFMP will be developed with input from a suitably qualified freshwater ecologist and implemented with measures to avoid and minimise effects on kākahi, if present, during the construction and excavation phases of the Project. The FFMP will include a survey prior to commencement of excavation works, with the survey findings used to inform appropriate measures and actions, such as kākahi relocation to suitable alternative habitat that exists nearby, if kākahi are present. I consider the proposed draft condition for the FFMP, as set out in the conditions appended to the evidence of Mr Murray, to be appropriate to avoid and minimise effects on kākahi. I also consider that the FFMP will sufficiently address this concern raised by submitters.

[22] DeWinton, M., Hoyle, J., Smith, B., Hogsden, K., Lambert, P. (2022) Benthic ecological survey of the lower Waiau Arm. Client report prepared for Meridian Energy Limited. 2022057CH.

[23] I note that the legal standing of the Guardians of Lakes Manapōuri, Monowai & Te Anau to participate in these processes is disputed. This submission point and other submission points raised by the Guardians have therefore been addressed in my evidence for completeness while this issue is outstanding.

[24] Ministry for the Environment (2021) National works in waterways guideline. Prepared for the Ministry for the Environment by Boff Miskell Limited. Wellington: Ministry for the Environment.

114. Furthermore, I agree with the request of the **Waiau Fisheries and Wildlife Habitat Enhancement Trust** and support the development of a consent condition that gives effect to kākahi management in the FFMP as described above (paragraph 113).

Phytoplankton blooms

115. Several submitters raised issues related to the risk, monitoring and mitigation of phytoplankton blooms during construction and following completion of the Project. I address these issues below.

Risk of blooms during construction

116. The **Waiau Working Party**, **Guardians**, and **Waiau Fisheries and Wildlife Habitat Enhancement Trust** noted concerns during the construction phase of the Project. I addressed the risk of blooms during the construction and excavation works in my evidence (see paragraph 61). I consider that the risk is low during the period of excavation activities as cooler water temperatures and lower light conditions from mid-autumn to early spring limit phytoplankton growth and bloom development. It is my opinion that the ongoing water quality monitoring in the Waiau Arm will detect warning signs of blooms (i.e., reduced water clarity and increased chlorophyll *a* concentrations) during summer months in the construction phase. Flow releases, including flushing flows, will be possible during the Project to mitigate the potential sediment generation and could also be implemented to manage phytoplankton blooms.

Risk of blooms following construction (ongoing risk)

117. The **Waiau Working Party** and **Guardians** requested the analysis that supports the assertion that the risk of phytoplankton blooms in the Waiau Arm in the vicinity of the MLC *"is likely to be offset by the release of more effective flushing flows during summer than are possible at present"* (Freshwater Ecology Report, pg 55) and that the number of flows will be sufficient to avoid the buildup of blooms in the Arm.

118. In response, there was no formal analysis completed, but the conclusions were reached based on consideration of the following points:

    (a) Flushing flows will be able to be released at lower lake levels following construction of the parallel channel, which has constrained releases in the

past particularly in warmer and drier summer months which are most suitable for bloom development. Noting that releases will still be subject to operational constraints and may not be possible at some low lake levels.

(b) There will be an increase in the reliability of flushing flows by 40% (from the current 30% to 70%). The assumption was made that this would increase the number of flushing flows released per season to four (i.e., 70% of up to five allowed for under the current protocol[17]). This is an increase in the number of flushing flows from the fewer than 1.5 per season, on average, that were released from 2016 to 2023.

(c) If four flushing flows could be released each summer, the average period of high-risk conditions for phytoplankton blooms would decrease by 25 days or more, assuming a 5–7 day residual effect after each flow. The residual effect assumes the doubling time of phytoplankton cells of two days or more. This would effectively extend the time required for phytoplankton to develop into a bloom.

(d) Flushing flows will be a component of the managed flow regime with monthly recreational flows, which can also reduce phytoplankton biomass and re-set bloom risk.

119. Furthermore, I acknowledge that while flushing flows are provided to assist with managing nuisance periphyton in the Lower Waiau River, there are also benefits for managing phytoplankton bloom risk. Our analysis showed that 'Red' status (determined based on periphyton monitoring results at three sites in the Lower Waiau River, as defined in the protocol[17], as the status at which a response is required as nuisance levels have been identified) for periphyton in the Lower Waiau coincided with high-risk conditions for phytoplankton in the Arm for about 40% of the time.

120. Whether the increased flow conveyance capability is sufficient to offset the increased risk of blooms depends on timing of the flushes with timing of blooms. However, I note that, a draft condition is proposed that sets out a flow release specific to phytoplankton concentrations in the vicinity of the Project Area in the Waiau Arm (paragraph 106). This proposed condition will ensure that monitoring and mitigation is implemented for the predicted increased risk of blooms due to the Project.

121. The **Waiau Working Party** wishes to understand how increased water temperature, light penetration and shallower depths will impact the number of days under high-risk conditions. This has been addressed, in part, in my evidence (paragraph 95). Proposed monitoring following completion of the Project will include collection of water temperature data at two sites (one in the new and one in the existing channel) that will improve our understanding of this factor and the risk of blooms in the area of concern.

122. I note that **DOC**, **Waiau Rivercare group**, **Waiau Working Party** and **Waiau Fisheries and Wildlife Habitat Enhancement Trust** request that monitoring and mitigation of phytoplankton blooms in the new and existing channels be required through conditions. With respect to this request, the **Waiau Working Party** note that at least one monitoring site should be included in monitoring and that this site should be located in the vicinity of the Project, and the **Guardians** suggest a chlorophyll *a* threshold is established as part of the consent conditions.

123. I agree and consider that the proposed condition related to phytoplankton monitoring and management response will mitigate the increased risk of blooms in the channels of the Lower Waiau Arm. The proposed condition suggests monitoring at two representative sites in the channels during the high-risk summer period. A chlorophyll *a* trigger level (>5 mg/m^3) is specified and directive for a flow release. This trigger level represents eutrophic conditions and is the threshold in the NPS-FM between Bands B and C which is indicative of a change from slightly to moderately impacted. The monitoring programme will include other water quality and clarity variables and will be aligned with the current Waiau Arm water quality monitoring programme in summer (i.e., Meridian's summer programme).

124. I note that submissions from the **Guardians, Waiau Working Party,** and **Waiau Fisheries and Wildlife Habitat Enhancement Trust** request or support requests for an updated and enhanced Waiau Arm water quality monitoring programme as part of the Project. Both the **Guardians** and **Waiau Working Party** express concerns regarding the trigger criteria and the decision-making framework to enable management of declining water quality or phytoplankton blooms and indicate the programme is currently under review.

125. In response, I acknowledge the detailed suggestions made in both submissions regarding possible changes and improvements that could be made to the existing programme. I confirm that the existing monitoring programme has been reviewed by

NIWA and recommendations provided to Meridian. The review was focused on existing water quality data, protocols, trigger criteria and the action management plan. I understand that Meridian intends to consider the recommendations and maintain the monitoring programme under existing consents. I also understand Meridian considers this request to be out of scope for the current application.

RESPONSE TO SECTION 42A REPORT

126. I have reviewed the section 42A Officer's Report prepared by Bianca Sullivan, resource management consultant with Environment Matters Limited, on behalf of Environment Southland, and the supporting technical report of Dr Greg Burrell.

127. I agree with Ms Sullivan (s42a report, paragraph 3.2.13) and Dr Burrell (s42s report, Appendix 3, paragraph 21) that the key adverse effect of the proposed Project is the increased turbidity and fine sediment during construction activities. As addressed in my evidence, I consider that the short-term and temporary nature of these sediment effects from construction activities (primarily the instream excavation of breakout areas) on plants and macroinvertebrates will be mitigated and managed through proposed conditions that give effect to the sediment management framework. The sediment thresholds in the framework were developed with the intention of keeping turbidity and deposited fine sediment levels within the natural range that resident fauna is adapted to (paragraph 49).

128. I note that Dr Burrell considers that the draft conditions "*give sufficient certainty that potential negative effects on water quality and aquatic ecology can be avoided, minimised or mitigated*", specifically for kākahi through the FFMP and for phytoplankton blooms through monitoring and flow releases (s42s report, Appendix 3, paragraphs 10, 24, 25). I agree with Dr Burrell and support these conditions, which I have addressed in various places in my evidence and in response to submissions.

CONCLUSIONS

129. The existing ecological value of plants and macroinvertebrates in the Project Area in the Waiau Arm and downstream in the Lower Waiau River is considered low, except for kākahi (At Risk – Declining), which is high and present in low numbers in the Waiau Arm.

130. I consider that given the magnitude and temporary nature of effects from the construction of the Project and the expected recovery of plants and macroinvertebrates following completion of the works that the direct and indirect effects of sediment on these communities will be minor, provided the Project is undertaken in accordance with and complies with the proposed sediment management framework.

131. I expect that the risks to kākahi in the Waiau Arm will be avoided, minimised and managed through appropriate measures set out in the FFMP.

132. I support the proposed phytoplankton bloom condition, which sets out monitoring and management actions (i.e., phytoplankton-specific flow releases) to address the potential increased risk of phytoplankton blooms following completion of the parallel channel. I consider this Project-specific monitoring aligns with the existing Waiau Arm water quality monitoring programme.

133. I consider that the Project will have an overall positive effect, as it will enhance flushing flow reliability, which should help reduce nuisance periphyton and improve macroinvertebrate habitat downstream of the MLC, assuming that the specified mitigation measures are implemented.

Kristy Hogsden

2 September 2024

Appendix A

Table A-1: Attribute and state (band) definitions for periphyton, phytoplankton and macroinvertebrate (MCI) variables included as attributes in the NPS-FM (2020).

Attributes are listed in the order in which they appear in the NPS-FM. Sites are classified into default or productive classes for NPS-FM based on the River Environment Classification (REC) for assessment of the periphyton attribute.[25]

NPS-FM attribute	Unit	Metric	Band A	Band B	Band C	Band D
Applicable to lakes						
Phytoplankton chlorophyll *a*	mg/m^3	annual median	≤2	>2 and ≤5	>5 and ≤12	>12
		annual maximum	≤10	>10 and ≤25	>25 and ≤60	>60
Applicable to rivers						
Periphyton chlorophyll *a*	mg/m^2	exceeded in ≤8% samples (default class) or in ≤17% samples (productive class)	≤50	>50 and ≤120	>120 and ≤200	>200
Macroinvertebrates	MCI	5-year median	≥130	≥110 and <130	≥90 and <110	<90

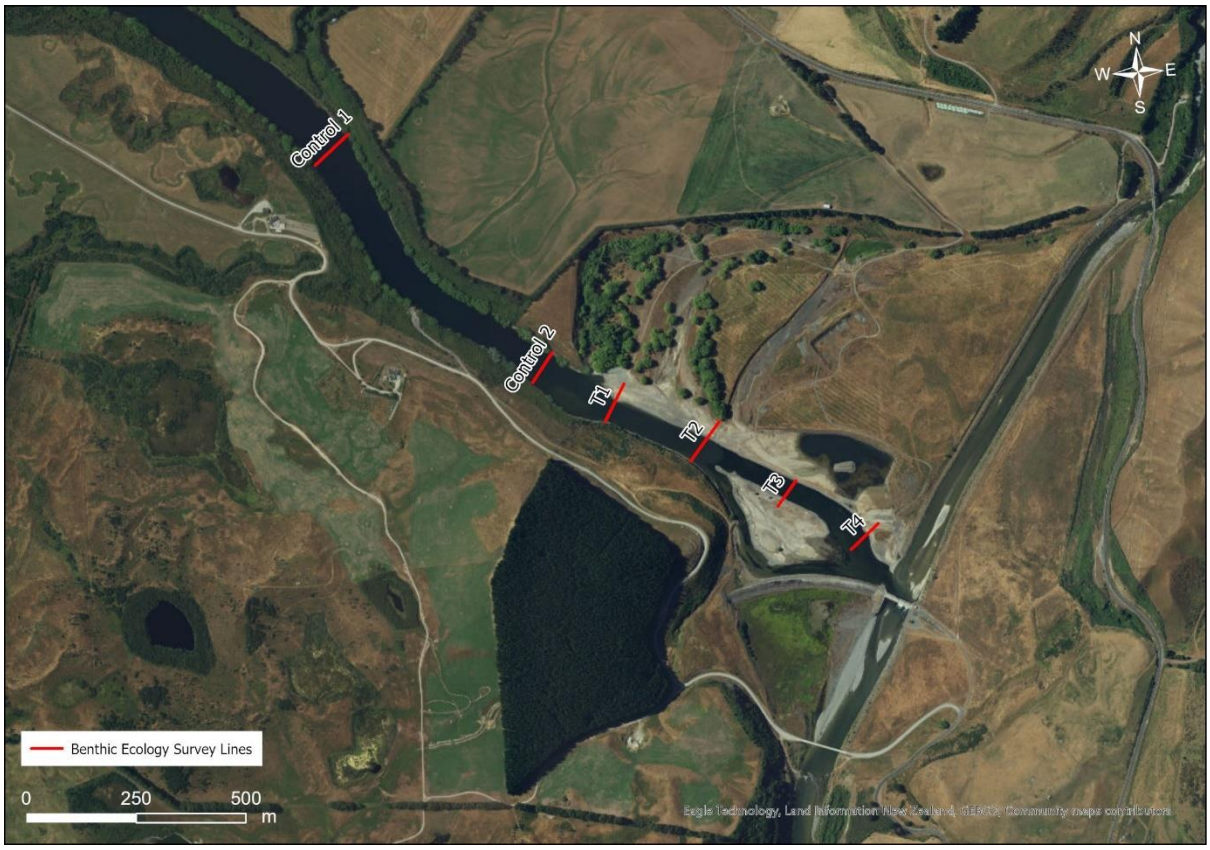
Table A-2: Trophic states listed with associated range of chlorophyll *a* concentration (following Burns et al. 2000) and the corresponding NPS-FM Band for the phytoplankton attribute (based on annual median chlorophyll *a*).

Trophic state	Chlorophyll *a* (mg/m^3)	NPS-FM Band
Ultra-microtrophic	0.13–0.33	A
Microtrophic	0.33–0.82	A
Oligotrophic	0.82–2.0	A
Mesotrophic	2.0–5.0	B
Eutrophic	5.0–12.0	C
Supertrophic	12.0—31.0	D
Hypertrophic	>31.0	D

[25] Productive sites have “dry” climate categories combined with geology categories that reflect naturally high nutrient enrichment due to the underlying catchment geology. Sites with all other REC types (not in the Productive class) are classified as default.

Appendix B

Figure B-1. Map of benthic survey transect locations in the lower Waiau Arm near the Project Area completed on 1 March 2022. Four transects (T1 to T4) were located within the proposed Project Area and two control transects were located upstream.



Appendix C

Figure C-1. Map of water quality sites currently monitored by Environment Southland (ES, yellow squares) and Meridian (MEL compliance site, blue dots) in the Waiau Arm. Note that the most downstream site (Site 1) is located approximately 2 km upstream of the Project Area.

Appendix D

Figure D-1. Relationship between chlorophyll *a* and mean water velocity averaged across the five days prior to sample collection. Combined data from the Meridian and Environment Southland monitoring sites in the Waiau Arm. The red dashed line is the 2 mg/m^3 threshold. The grey shaded areas indicate water velocity bands for which there appears to be increasing risk of exceedance of chlorophyll *a* >2 mg/m^3 (darker shading = higher risk). The black dotted line shows the best fit line (power relationship) corresponding to the equation relating chlorophyll *a* to water velocity.