Appendix 4: Technical Advice – Lake Values by Tina Bayer

Date	18 August 2025
To	Susannah Black, Principal Consents Planner, Environment Canterbury
From	Tina Bayer, Senior Scientist - Surface Water Science, Environment Canterbury
Project advice provided for	Genesis Tekapo Power Scheme Renewal
Documents referred to	1. Aquatic environmental effects, Appendix L (Cawthron 2025) 2. AEE, https://www.fasttrack.govt.nz/__data/assets/pdf_file/0017/4544/TekapoPS_Reconsenting_AEE_April_2025.pdf 3. https://lakespi.niwa.co.nz/lake/47228 4. https://www.fasttrack.govt.nz/__data/assets/pdf_file/0022/8950/Appendix-Two_-Groundwater-and-Hydrology-Discussion-26-June-2025-Record71009591.1.pdf 5. https://www.fasttrack.govt.nz/__data/assets/pdf_file/0029/8948/Appendix-Four_-Freshwater-and-Native-Fish-Discussion-30-June-2025-Record71009594.1.pdf 6. Appendix 5: s53(2)(a) Fast Track Approvals Act 2024, Technical Advice – Hydrology
Qualifications	I am a Senior Scientist – Water Quality and Ecology at the Canterbury Regional Council (CRC). I have been in this role since January 2021, prior this I worked as a Scientist in the Water Quality and Ecology team (since 2017). I have been involved in managing and reporting on CRC's lake monitoring programme since 2017. I hold an MSc in Environmental Science (2007) and a PhD in Freshwater Ecology (2013) from the University of Otago. My thesis work included investigating potential responses of Lakes Wakatipu and Wanaka to climate change. I also worked as a post-doctoral researcher at Stockholm University (Institute of Applied Environmental Research) integrating lake modelling into large scale Earth System Models and running climate change simulations.
Code of Conduct	I confirm that I have read and agree to comply with the Code of Conduct for Expert Witnesses contained in the Environment Court Practice Note 2023. This technical report has been prepared in accordance with that Code. In particular, unless I state otherwise, the opinions I express are within my area of expertise, and I have not omitted to consider material facts that might alter or detract from the opinions that I express.

Executive summary/overview

1. Current lake level variation in Lake Tekapo (Takapō) associated with the Tekapo Power Scheme (TPS) reduces aquatic plant (macrophyte) habitat substantially (estimated ca 33% on top of impact of natural level variation, see paragraph 7) and there is no mitigation proposed for this large effect and ongoing adverse effect associated with the operation of the TPS. This lack of habitat has a substantial impact on the near-shore (littoral) ecosystem that has follow-on effects on the whole lake ecosystem such as low macroinvertebrate counts and low fish productivity.
2. There is a lack of assessment of consequences of future electricity demand scenarios and future climate change scenarios on actual lake level management and flow-on effects on aquatic environment. I have concerns that the lake level of Takapō may be more variable in the future, further increasing pressure on macrophyte habitat. There is also uncertainty on how potential changes in turbidity due to climate change will interact with the effects of water level changes due to the TPS operation.
3. Solutions/mitigations to address these issues could include
    a) reduce lake level variation
    b) restrict lake level variation to match current actual operations
    c) the proposed mitigation package could consider improvements in in-lake habitat (if possible) and/or
    d) monitoring of macrophyte extent and health as well as in-lake turbidity monitoring (the second big driver of the availability of macrophyte habitat in Takapō).
4. Out of these options, only monitoring is further described below as I understand that the operating levels proposed in the application are consistent with the Waitaki Water Allocation Plan. I have suggested wording for a proposed condition to include monitoring of macrophytes and turbidity.

5. A brief overview of this advice is provided in Table 1:

Table 1: Outstanding areas of contention

Outstanding area of contention	Reason for significance	Possible solution
No mitigation proposed for current and ongoing loss of > 30% of macrophyte habitat due to TPS operation	Substantial impact on the littoral (near-shore) ecosystem that has follow-on effects on the whole lake ecosystem such as low macroinvertebrate counts and low fish productivity.	Reduce lake level variation. Explore mitigations to benefit native macrophytes. Monitoring of macrophytes and turbidity.
Uncertainty around impact of future TPS lake level operation and other projected changes on lake macrophytes: lack of assessment of consequences of future electricity demand scenarios and future climate change scenarios on actual lake level management and flow-on	In my view this lack of assessment remains a gap in understanding the full potential impact of the proposed operation. In the future, an even higher proportion of macrophyte habitat may be lost and	Establish likely variability in lake level in the future through modelling and assess the potential impact on macrophytes. Prevent any future operations that would worsen impact, e.g. restrict lake level variation to match current actual operations.

effects on aquatic environment, combined with an overreliance on presumed future increase in water clarity to lessen future impacts.	lake food webs may be further impacted.	Monitor macrophytes and turbidity.

Agreement with the Applicant

6. I have not provided further discussion for where I agree with conclusions of the Applicant.
7. While I agree with Genesis's conclusions regarding the current impact of the TPS operation on aquatic macrophytes, I do wish to make the following comments:
    a. As agreed with technical experts in Lake Water Quality, Aquatic Ecology and Native Fish Technical Discussion on 30 June 2025 and Appendix L of the substantive application current lake level variation reduces macrophyte habitat substantially: overall lake level variation reduces macrophyte habitat by >40%[1]. The TPS has increase lake level variations from an estimated natural range of 2.7m to 8.8m. If we account for the impact of natural lake level variability, the additional impact of the TPS can be currently estimated to be ca. 33% additional reduction in potential macrophyte habitat[2]. Thus, the TPS's operation significantly reduces habitat available for aquatic macrophytes because of the large lake level variation due to the power scheme operation. This lack of habitat is a substantial impact on the littoral (near-shore) ecosystem that has follow-on effects on the whole lake ecosystem such as low macroinvertebrate counts and low fish productivity. I note that a smaller lake level range, for instance 705 to 708 (compared to current range of 704.1 to 709.7 in summer) would be much closer to the natural range of the lake, and enable a healthier littoral ecosystem.

Outstanding areas of contention and significance of these

Discussions with Applicant

8. The Lake Water Quality, Aquatic Ecology and Native Fish Technical Discussion on 30 June 2025[3] forms part of my consideration.

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[1] 1. Aquatic environmental effects, Appendix L (Cawthron 2025), Table 1

[2] (habitat lost due to TPS)/(total habitat available after accounting for natural lake level variation) = (8.8m-2.7m)/(21.3m-2.7m) = 33%, at euphotic depth of 21.3m and natural variation of 2.7m and 8.8m overall lake level variation, i.e. 6.1m increase in lake level variation due to TPS. This 6.1m extra habitat loss is ca 33% of total habitat available after accounting for natural variability, and represents the TPS impact.

[3] https://www.fasttrack.govt.nz/__data/assets/pdf_file/0029/8948/Appendix-Four_-Freshwater-and-Native-Fish-Discussion-30-June-2025-Record71009594.1.pdf

Outstanding areas of contention

9. No mitigation is proposed for current and ongoing impact of loss of > 30% of macrophyte habitat due to lake level variation caused by the operation of the TPS.
10. Lack of assessment of consequences of future electricity demand scenarios and future climate change scenarios on actual lake level management and flow-on effects on aquatic environment: Mr Graham's advice (Appendix 5 to s53 Planning report) outlines concerns about the lack of assessment of projected future changes on actual TPS operation. Even if operating within currently consented limits, in response to changing conditions, actual future operations may cause lake level to vary more frequently, or for longer durations, and approach maximum or minimum levels more often compared to current operations. I am concerned that a wider range of lake level variation may potentially be used in the future and that the lake may potentially spend more time at the extreme ends of the levels, which has the potential to further reduce macrophyte habitat. The effects of changes in electricity demand and climate change on lake levels and thus macrophytes were not assessed in the assessment of aquatic effects. In my view this lack of assessment remains a gap in understanding the full potential impact of the proposed operation.
11. In my opinion there is an overreliance on presumed future increase in water clarity to lessen future impacts on lake macrophytes. The assessment of aquatic effects put a lot of emphasis on presumed increasing clarity in the lake. The assumption is that clarity increases will continue into the future and thus that future impacts of the TPS on macrophytes and the lake ecosystem will lessen over time. I caution against this assumption as there is considerable uncertainty in likely responses of large lakes in the Southern Alps to climate change. I consider there is a risk in assuming that clarity will increase in the future, as climate change will potentially lead to increased glacial melt, increased erosion and increased flood flows[4], thereby increasing turbidity inputs to the lakes[5]. The most recent (2024) LakeSPI survey in Takapō results suggest a decrease in lake macrophyte depth extent from 2017 to 2024[6]. This recent decrease suggests that there is no current clear indication that macrophyte habitat will increase over time. If there was to be a decrease in turbidity, impacts of water level variation would lessen. If there was no change in turbidity, then impacts would be as current. But if there was an increase in turbidity this would compound the effects of the water level variations due to the TPS.

Significance of these matters

12. Native macrophytes (aquatic plants) perform many important ecological functions in lakes. These include the provision of habitat and food for macroinvertebrates and fish. In the low nutrient lakes such as Takapō, the near-shore zone (littoral zone) and its

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[4] Waitaki Power Scheme - Meridian Energy Limited, e) Statement of Evidence of Dr Jennifer Purdie - Climate change Purdie 2025, https://api.ecan.govt.nz/TrimPublicAPI/documents/download/5657973

[5] Waitaki Power Scheme - Meridian Energy Limited, (k) Statement of Evidence of Dr Catherine Kilroy - Surface Water Quality, https://api.ecan.govt.nz/TrimPublicAPI/documents/download/5657979

[6] https://lakespi.niwa.co.nz/lake/47228

submerged and emergent macrophytes play a disproportionately large role in supporting the lake ecosystem (including fish). This littoral zone and its plant communities are more impacted by lake level variations than the open-water (pelagic) habitat. Water level changes may be responsible for restricting macrophyte habitat in Takapō by an estimated >40%[7] of which >30% can be attributed to the TPS operation. This loss likely translates into loss of macroinvertebrates and fish productivity. There is a potential for higher variability in lake level in the future to make these effects worse.

Solutions and/or Conditions sought

13. Table 2 provides a summary of solutions or conditions sought and reasons for these.
14. Impact on lake macrophytes could be reduced by reducing water level variation. Further degradation could be prevented by ensuring water level variation (especially length of time spend at extreme end of range) will not increase. Mitigations that enhance in-lake habitat and native macrophytes in the lake could be considered as part of the mitigation package. Monitoring could be undertaken to better understand the actual and future impacts of TPS operation on aquatic macrophytes. Out of these options, only monitoring is further described below as I understand that the operating levels proposed in the application are consistent with the Waitaki Water Allocation Plan.
15. Proposed conditions: Because lake level and water clarity are such key drivers of lake macrophyte health and thus lake ecosystem health, I suggest that they are monitored by Genesis Energy. Water level changes may be responsible for restricting macrophyte habitat by an estimated 41-86%[8]. Therefore, I suggest that Genesis funds 3 yearly surveys of the conditions of aquatic macrophytes in Takapō. I also suggest continuous turbidity and temperature measurements to monitor environmental changes that may impact macrophyte habitat and health to be able to distinguish their effects from those of the PS operations.
16. The AEE response to CRC's proposed conditions states that "The operation of the Tekapo PS does not affect turbidity, water temperature or LakeSPI." (AEE[9] page 212). However, Appendix L clearly states that "The TekPS has increased the magnitude of water level variation in Lake Tekapo, which has restricted the upper extent and productivity of macrophytes in the lake" (page 7) and "The main effect of the TekPS on Lake Tekapo is increased water level fluctuations over those naturally occurring, reducing the extent of macrophytes in the littoral zone" (page 10). Because macrophyte depth extend is one of components measured in the LakeSPI surveys, there is a direct impact of the operation of the TPS on LakeSPI results, which is, in fact, acknowledged in the assessment of aquatic effects (Appendix L).
17. The impact on lake macrophyte habitat is one of the most substantial effects of the TPS operation on the lake ecosystem, and thus a condition of monitoring lake macrophytes would in my opinion be "reasonably related to the resource consents sought" and monitoring is a condition that "directly connected" to an adverse effect of the activity on

[7] Aquatic environmental effects, Appendix L (Cawthron 2025), Table 1

[8] Aquatic environmental effects, Appendix L (Cawthron 2025), Table 1

[9] https://www.fasttrack.govt.nz/__data/assets/pdf_file/0017/4544/TekapoPS_Reconsenting_AEE_April_2025.pdf

the environment. I do not consider these conditions onerous or costly, as installation of a turbidity and temperature sensor is often required for consents involving damming and use or discharge of large volume of water and is not technically difficult nor expensive. LakeSPI surveys involve hiring a suitably qualified contractor every 3 years (or 5 if frequency is reduced) at a cost that is small compared to the scale of operations and the proposed mitigation package.

Table 2: Solutions			
Issue	**Solution**	**Condition wording**	**Consideration against FTAA**
Large reduction in aquatic plant habitat, compounded by potential changes in turbidity in future	Solution would be reduction or restrictions in lake operating range, but if that is not an option for consideration, then consider including lake littoral zone restoration in the compensation package which is currently focused on terrestrial, river and wetland mitigations, and on-going monitoring (which can help inform future lake management).	In text below table	Monitoring has relatively low cost, will not cause delay. Panel to consider whether it aligns with the FTAA's purpose.

Indicative Draft Conditions

Macrophyte monitoring – Lake Tekapo

The consent holder shall, at a frequency no less than every five years, conduct a survey of submerged aquatic plants (macrophytes) within Takapō. The survey shall:

a. Be undertaken and the numeric attribute state determined in accordance with the method described in Clayton J, and Edwards T. 2006. *LakeSPI: A method for monitoring ecological condition in New Zealand lakes. User Manual Version 2*. National Institute of Water & Atmospheric Research: Hamilton, New Zealand.
b. The consent holder shall provide a report of the findings of the survey to CRC attention: RMA Compliance and Enforcement Manager within three months of conducting the survey, specifically including but not limited to:
    a. LakeSPI Index
    b. Invasive Impact Index
    c. Native Condition Index
    d. Maximum Depth (m) of Submerged Aquatic Plants
    e. Names of native and invasive species present.

Advice note: *publication described in (a) can be found at* *https://niwa.co.nz/sites/default/files/import/attachments/lakespi_manual.pdf*

Turbidity / water clarity

The consent holder shall measure and record the level of turbidity of the water and water temperature at a frequency of every 15min. The monitoring of turbidity and temperature shall:

a. Be undertaken in accordance with the National Environmental Monitoring Standards (NEMS).
b. Use a measurement location[10] that is:
    i. downstream of any bubble interference,[11]
    ii. more than 300m away from river mouths,
    iii. more than 50m from stormwater inflows and
    iv. where the lake has at least a minimum depth (at lowest lake level) of 3m.
c. All data shall be collated and provided to CRC attention Compliance and Enforcement Manager within the Annual Report provided for in condition (x); or all data may be provided to CRC daily via telemetry.

[10] Note: Preference would be that the site location is agreed before approvals are issued, locking in a location for certainty would eliminate all of (b). Suggested location: at/near the Tekapo A intake structure.

[11] Note: Can be measured alongside water level if practical, but not inside the stilling tower.