

16 July 2020

Reference No. 18107631-7405-004-LR-Rev0

Andrew Webster

Templeton Pegasus Limited
Level 28
188 Quay Street
Auckland, 1010

**WATER QUALITY INFORMATION FOR PEGASUS LAKE TO SUPPORT TEMPLETON HEARING
EVIDENCE FOR PLAN CHANGE 7 OF THE CANTERBURY LAND AND WATER REGIONAL PLAN**

Dear Andrew

In an email¹ dated 14 July 2020, Golder Associates (NZ) Limited (Golder) received a request for information from Templeton Pegasus Limited (TPL). The information request relates to comparison of historical monitoring data collected by Golder to proposed Plan Change 7 (PC7) targets.

This cover letter² has been prepared to accompany our response to the request for information. The responses provided in Attachment 2 are subject to the following limitations:

- All information provided is factual and has been referenced from technical reports previously prepared by Golder and submitted to the Canterbury Regional Council.
- Golder has not interpreted water quality data and has not commented on the likelihood of future water quality in Pegasus Lake meeting proposed PC7 targets.
- Where data sets are limited, annual averages cannot be calculated. In these instances, a direct comparison between Pegasus Lake water quality results and targets proposed under PC7 cannot be made.
- Regarding the PC7 hearing, Golder understands that our role is limited to providing factual information to TPL and does not include presenting or defending evidence.

¹ Email contained document 'Table for Golder input – Pegasus Lake water quality comparison' (Attachment 2).

² This letter is provided subject to the attached Report Limitations.

We trust the information we have provided in Attachment 2 meets your expectations. If you have any questions or comments, please contact the undersigned by email or call +64 21 393 382.

Yours sincerely

GOLDER ASSOCIATES (NZ) LIMITED



Stephanie Koviessen
Environmental Consultant



Rowan Freeman
Senior Environmental Consultant

SK/RF/jsb

Attachments: 1. Report Limitations
 2. 'Table for Golder input – Pegasus Lake water quality comparison'

[https://golderassociates.sharepoint.com/sites/31811g/deliverables/004_water quality data for tpl evidence/rev0/18107631-7405-004-lr-rev0.docx](https://golderassociates.sharepoint.com/sites/31811g/deliverables/004_water%20quality%20data%20for%20tpl%20evidence/rev0/18107631-7405-004-lr-rev0.docx)

Report Limitations

This Report/Document has been provided by Golder Associates (NZ) Limited (“Golder”) subject to the following limitations:

- i) This Report/Document has been prepared for the particular purpose outlined in Golder’s proposal and no responsibility is accepted for the use of this Report/Document, in whole or in part, in other contexts or for any other purpose.
- ii) The scope and the period of Golder’s Services are as described in Golder’s proposal, and are subject to restrictions and limitations. Golder did not perform a complete assessment of all possible conditions or circumstances that may exist at the site referenced in the Report/Document. If a service is not expressly indicated, do not assume it has been provided. If a matter is not addressed, do not assume that any determination has been made by Golder in regards to it.
- iii) Conditions may exist which were undetectable given the limited nature of the enquiry Golder was retained to undertake with respect to the site. Variations in conditions may occur between investigatory locations, and there may be special conditions pertaining to the site which have not been revealed by the investigation and which have not therefore been taken into account in the Report/Document. Accordingly, if information in addition to that contained in this report is sought, additional studies and actions may be required.
- iv) The passage of time affects the information and assessment provided in this Report/Document. Golder’s opinions are based upon information that existed at the time of the production of the Report/Document. The Services provided allowed Golder to form no more than an opinion of the actual conditions of the site at the time the site was visited and cannot be used to assess the effect of any subsequent changes in the quality of the site, or its surroundings, or any laws or regulations.
- v) Any assessments, designs and advice made in this Report/Document are based on the conditions indicated from published sources and the investigation described. No warranty is included, either express or implied, that the actual conditions will conform exactly to the assessments contained in this Report/Document.
- vi) Where data supplied by the client or other external sources, including previous site investigation data, have been used, it has been assumed that the information is correct unless otherwise stated. No responsibility is accepted by Golder for incomplete or inaccurate data supplied by others.
- vii) The Client acknowledges that Golder may have retained subconsultants affiliated with Golder to provide Services for the benefit of Golder. Golder will be fully responsible to the Client for the Services and work done by all of its subconsultants and subcontractors. The Client agrees that it will only assert claims against and seek to recover losses, damages or other liabilities from Golder and not Golder’s affiliated companies. To the maximum extent allowed by law, the Client acknowledges and agrees it will not have any legal recourse, and waives any expense, loss, claim, demand, or cause of action, against Golder’s affiliated companies, and their employees, officers and directors.
- viii) This Report/Document is provided for sole use by the Client and is confidential to it. No responsibility whatsoever for the contents of this Report/Document will be accepted to any person other than the Client. Any use which a third party makes of this Report/Document, or any reliance on or decisions to be made based on it, is the responsibility of such third parties. Golder accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this Report/Document.

Table 8-6 Water Quality Limits and Targets for Waimakariri Lakes

Parameter	PC7	NPS-FM 2014 (and proposed NPS-FM September 2019 version, unless stated)	Pegasus Lake
Total Nitrogen	<p>Annual average: 0.750 Mg/L (target)</p> <p>Actions to achieve the targets in Table 8-6 will be implemented by 1 January 2040.</p>	<p>National Bottom Line - Annual median (seasonally stratified and brackish) 750 mg/m³; annual median 800 mg/m³</p>	<p>Limitations:</p> <p>Total nitrogen (TN) is not part of the routine monitoring undertaken at Pegasus lake. TN has been included as part of the two SolarBee® assessments undertaken in 2017/2018 (Golder 2018a) and 2019/2020 (Golder 2020). TN results are limited, and data are biased towards a certain period of the year and at a very low sampling frequency. Available data is not representative of the entire year.</p> <p>What is annual average for Lake?</p> <p>The annual TN average concentration for Pegasus Lake cannot be calculated due to the limitation noted above.</p> <p>The following concentrations of TN were recorded between 2017 and 2020:</p> <ul style="list-style-type: none"> • 2019/2020 annual report (Golder 2020) - TN concentration (0.85 mg/L or 850 mg/m³). • Cyanobacteria bloom options assessment report (Golder 2018a) - TN range was 1.45 to 1.9 mg/L or 1,450 to 1,900 mg/m³. The median value 1.49 mg/L or 1,490 mg/m³ exceeded the National Bottom Line (subject to previously stated limitations). <p>Assumptions:</p> <ol style="list-style-type: none"> 1. TN results are from samples collected from the lake surface near the SolarBee® at Mid-lake.

			<p>Meet national bottom lines?</p> <p>The annual median value for TN in 2017/2018 (subject to the above limitations) does not meet the National Bottom Line.</p> <p>Likely to meet PC7?</p> <p>An annual average for TN cannot be calculated. A comparison to the proposed PC7 target cannot be made.</p>
<p>Total Phosphorous</p>	<p>Annual average: 0.05 mg/L (target)</p> <p>Actions to achieve the targets in Table 8-6 will be implemented by 1 January 2040.</p>	<p>National Bottom Line - Annual median 50 Mg/m3</p>	<p>Limitations:</p> <p>Total phosphorus (TP) is not part of the routine monitoring undertaken at Pegasus lake. TP has been included as part of the two SolarBee® assessments undertaken in 2017/2018 (Golder 2018a) and 2019/2020 (Golder 2020). TP results are limited, and data are biased towards a certain period of the year and at a very low sampling frequency. Available data is not representative of the entire year.</p> <p>What is annual average for Lake?</p> <p>The annual TP average concentration for Pegasus Lake cannot be calculated due to the limitation noted above.</p> <p>The following concentrations of TP were recorded between 2017 and 2020:</p> <ul style="list-style-type: none"> • 2019/2020 annual report (Golder 2020) – TP concentration (0.155 mg/L or 155 mg/m3). • Cyanobacteria bloom options assessment report (Golder 2018a) - TP range was 0.169 to 0.251 mg/L or 169 to 251 mg/m3. The median value 0.221 mg/L or 221 mg/m3 exceeded the National Bottom Line (subject to previously stated limitations). <p>Assumptions:</p> <ol style="list-style-type: none"> 1. TP results are from samples collected from the lake surface near the SolarBee® at Mid-lake.

			<p>Meet national bottom lines?</p> <p>The annual median value for TP in 2017/2018 (subject to the above limitations) does not meet the National Bottom Line.</p> <p>Likely to meet PC7?</p> <p>An annual average for TP cannot be calculated. A comparison to the proposed PC7 target cannot be made.</p>
<p>Ammoniacal Nitrogen</p>	<p>Annual median: 0.03 mg/L Annual maximum: 0.05 mg/L</p> <p>Based on a pH8 and temperature of 20 C</p>	<p>National Bottom Line - Annual median 1.30 mg NH4 – N/L, Annual Maximum 2.20 Mg NH4 – N/L.</p> <p>Based on a pH8 and temperature of 20 C</p>	<p>Limitations:</p> <p>Ammoniacal Nitrogen (Ammoniacal-N) is not part of the routine monitoring undertaken at Pegasus lake. Ammoniacal-N has been included as part of the two SolarBee® assessments undertaken in 2017/2018 (Golder 2018a) and 2019/2020 (Golder 2020). Ammoniacal-N results are limited, and data are biased towards a certain period of the year and at a very low sampling frequency. Available data is not representative of the entire year. Laboratory results for Ammoniacal-N have not been adjusted for a standard pH or temperature.</p> <p>What is annual medium/maximum for Lake?</p> <p>The following concentrations of Ammoniacal-N were recorded between 2017 and 2020:</p> <ul style="list-style-type: none"> • 2019/2020 annual report (Golder 2020) – Ammoniacal-N concentration (0.013 mg/L or 13 mg/m³). • Cyanobacteria bloom options assessment report (Golder 2018a) - Ammoniacal-N range was 0.001 to 0.027 mg/L or 1 to 27 mg/m³. The median value 0.004 mg/L or 4 mg/m³ was below the National Bottom Line (subject to previously stated limitations). <p>Assumptions:</p> <ol style="list-style-type: none"> 1. Ammoniacal-N results are from samples collected from the lake surface near the SolarBee® at Mid-lake.

			<p>Meet national bottom lines?</p> <p>The annual median value and annual maximum value for Ammoniacal-N in 2017/2018 (subject to the above limitations) meets the National Bottom Line.</p> <p>Likely to meet PC7?</p> <p>The annual median value and annual maximum values for Ammoniacal-N in 2017/2018 (subject to the above limitations) meets the proposed PC7 target.</p>
--	--	--	---

Table 8b Freshwater Outcomes for Waimakariri Sub-region Lakes: Artificial –Other: Lake Pegasus

Parameter	PC7	NPS-FM 2014 (and proposed NPS-FM September 2019 version, unless stated)	Pegasus Lake Annual Report 2019-2020
E. Coli	<p>Median E.coli/100ml – ≤ 130</p> <p>95th percentile E.coli/100ml – ≤ 540</p> <p>Determined from a minimum of 60 samples collected on a monthly basis over 5 years</p>	<p>New National Bottom line and table (Table 23) for primary contact sites. National bottom line of 540.</p>	<p>E. Coli monitoring is undertaken by the Waimakariri District Council (WDC). An review of E.Coli data held by the WDC should be undertaken to determine whether E. Coli parameters meet the National Bottom Line and proposed PC7 targets.</p> <p>What is median E.coli/100ml and 95th percentile for Lake?</p> <p>Meet proposed national bottom line?</p> <p>Likely to meet PC7?</p>

	Note Lake given same value in PC7 as primary recreation site in proposed NPS-FM.		
Cyanobacteria – Planktonic	<p>Cyanobacteria [either mm³/L or cells/mL – Lake SPI – Max value</p> <p>10 or 0.5 mm³/L of potentially toxic cyanobacteria</p> <p>Not likely to meet.</p>	<p>National Bottom Line: 1.8 mm³ /L biovolume equivalent of potentially toxic cyanobacteria OR 10 mm³ /L total biovolume of all cyanobacteria.</p> <p>Does not meet national bottom line.</p>	<p>ECan Report 2019-2020. On 30 December 2019 cyanobacterial biovolumes had increased to Red (>1.8mm³/L), and the lake was subsequently closed by the CDHB. Remained closed through to 23 March 2020 when inspections were halted due to Covid-19.</p> <p>Cyanobacterial biovolume concentrations recorded between 2017 and 2020 are as follows:</p> <ul style="list-style-type: none"> • 2017/2018 annual report (Golder 2018b) - maximum cyanobacterial biovolume (218.062 mm³/L) exceeded the proposed PC7 target and National Bottom Line. • 2018/2019 annual report (Golder 2019) - maximum cyanobacterial biovolume (3,794.007 mm³/L) exceeded the proposed PC7 target and National Bottom Line. • 2019/2020 annual report (Golder 2020) - maximum cyanobacterial biovolume (267.544 mm³/L) exceeded the proposed PC7 target and National Bottom Line. <p>Will not meet national bottom lines and not likely to meet PC7?</p>
Visual quality attribute: Colour	Natural colour not degraded by more than 5 Munsell Units		<p>What is Munsell units for lake?</p> <p>2019/2020 annual report (Golder 2020) - Munsell hue range (2.5GY to 5Y) meets the proposed PC7 target.</p> <p>Assumptions:</p> <ol style="list-style-type: none"> 1. One Munsell Unit has been assumed to be one quarter increment as shown on the 100-point Munsell compass (e.g., 2.5Y to 5Y or 5Y to 7.5Y, is assumed to be equal to one unit of movement).

			Likely to meet PC7?
Chlorophyll a (the green colour in algae)	<p>Maximum annual average [mg/<u>chl-a/m</u>] 5</p> <p>Annual maximum [mg/<u>chl-a/m</u>]: 25</p>	National Bottom Line - Annual median 12 Mg/m ³ ; annual maximum 60 Mg/m ³ .	<p>Limitations:</p> <p>Chlorophyll a (Chl-a) is not part of the routine monitoring undertaken at Pegasus lake. Chl-a has been included as part of the two SolarBee® assessments undertaken in 2017/2018 (Golder 2018a) and 2019/2020 (Golder 2020). Chl-a results are limited, and data are biased towards a certain period of the year and at a very low sampling frequency. Available data is not representative of the entire year.</p> <p>What is maximum annual average and annual maximum for Lake?</p> <p>The annual Chl-a average concentration for Pegasus Lake cannot be calculated due to the limitation noted above.</p> <p>The following concentrations of Chl-a were recorded between 2017 and 2020:</p> <ul style="list-style-type: none"> • 2019/2020 annual report (Golder 2020) - Chl-a concentration (0.15 mg/L or 15 mg/m³) was below the annual maximum for the National Bottom Line and proposed PC7 target (subject to the above limitations). • Cyanobacteria bloom options assessment report (Golder 2018a) - Chl-a range was 0.132 to 0.236 mg/L or 132 to 236 mg/m³ and exceeded annual maximum for the National Bottom Line and proposed PC7 target. The median value 0.231 mg/L or 231 mg/m³ exceeded the annual median for the National Bottom Line. <p>Assumptions:</p> <ol style="list-style-type: none"> 1. Chl-a results for samples collected from the lake surface near the SolarBee® at Mid-lake. 2. Units for the proposed Chl-a targets under PC7 are assumed to be mg/m³. <p>Meet national bottom line?</p>

			<p>The annual median value and annual maximum value in 2017/2018 (subject to the above limitations) do not meet the National Bottom Line.</p> <p>The annual maximum value in 2019/2020 (subject to the above limitations) meets the National Bottom Line.</p> <p>Likely to meet PC7?</p> <p>A maximum annual average for Chl-a cannot be calculated. A comparison to the proposed PC7 target cannot be made.</p> <p>The annual maximum value for Chl-a in 2017/2018 (subject to the above limitations) does not meet the proposed PC7 target.</p>
Trophic Level Index (TLI)	Maximum annual average mg/L: 4.0		<p>Limitations:</p> <p>Water quality parameters required to derive TLI (TP, TN, and Chl-a) are not part of the routine monitoring undertaken at Pegasus lake. These parameters have been included as part of the two SolarBee® assessments undertaken in 2017/2018 (Golder 2018a) and 2019/2020 (Golder 2020). These results are limited, and data are biased towards a certain period of the year and at a very low sampling frequency. Available data is not representative of the entire year.</p> <p>What is maximum annual average for Lake?</p> <p>The following TLIs for Pegasus Lake were recorded between 2017 and 2020:</p> <ul style="list-style-type: none"> • 2019/2020 annual report (Golder 2020) - TLI (>6.0, hypertrophic) exceeded the proposed PC7 target (subject to previously stated limitations). • Cyanobacteria bloom options assessment report (Golder 2018a) - TLI (>6.0, hypertrophic) exceeded the proposed PC7 target (subject to previously stated limitations). <p>Assumptions:</p>

			<p>1. The TLI values provided above are unitless. For comparative purposes, it is assumed that the proposed PC7 targets for TLI are unitless.</p> <p>Likely to meet PC7?</p>
Temperature	Temperature [Max] [C]: 19		<p>What is the Maximum temperature for Lake?</p> <p>The following maximum annual water temperatures have been recorded at Pegasus Lake between 2010 and 2020:</p> <ul style="list-style-type: none"> • 2010/2011 - 20°C • 2011/2012 – 20°C • 2012/2013 – 19.8°C • 2013/2014 – 22°C • 2014/2015 – 20°C • 2015/2016 – 20.9°C • 2016/2017 – 19.2°C • 2017/2018 – 22.8°C • 2018/2019 – 21.1°C • 2019/2020 – 22.5°C <p>Assumptions:</p> <p>1. Maximum temperatures results are collected from the lake surface at Mid-lake.</p> <p>Likely to meet PC7?</p> <p>Annual maximum temperatures recorded between 2010 and 2020 do not meet the proposed PC7 target.</p>
Dissolved oxygen (min saturation)	<p>Minimum Hypolimnion: 70 %</p> <p>Minimum Epilimnion: 90 %</p>	<p>Proposed NPS-FM; National bottom line: measured or estimated annual minimum: 0.5 mg/L</p>	<p>What is minimum Hypolimnion and Epilimnion for Lake?</p>

		<p>Mid-hypolimnetic dissolved oxygen_ Seasonally stratifying lakes</p> <p>National bottom line: 4.0 Mg/L</p>	<p>The following annual minimum concentrations of DO were recorded during the 2017/2018 (Golder 2018b), 2018/2019 (Golder 2019), and 2019/2020 (Golder 2020) annual monitoring periods:</p> <p>Mid-Hypolimnion:</p> <ul style="list-style-type: none"> • 2019/2020 – 0.0% (2.7 mg/L) • 2018/2019 – 14.1% (1.3 mg/L) • 2017/2018 – 0.0% (0.0 mg/L) <p>Epilimnion:</p> <ul style="list-style-type: none"> • 2019/2020 – 72.6% (6.7 mg/L) • 2018/2019 – 92.7% (8.7 mg/L) • 2017/2018 – 81.0% (9.2 mg/L) <p>Assumptions:</p> <ol style="list-style-type: none"> 1. Annual minimum DO results are collected from the lake surface (epilimnion) and 4.0 m below lake surface (mid-hypolimnion) at Mid-lake. 2. It is assumed that the National Bottom Line target is a minimum of 4 mg/L in the mid-hypolimnion. <p>Meet proposed national bottom lines?</p> <p>The annual minimum values for DO in the mid-hypolimnion between 2017 and 2020 do not meet the National Bottom Line.</p> <p>Likely to meet PC7?</p> <p>The annual minimum values for DO in the mid-hypolimnion between 2017 and 2020 do not meet the proposed PC7 target.</p> <p>The annual minimum value for DO in the epilimnion in 2018/2019 meet the proposed PC7 target. The annual minimum values for DO in the epilimnion in 2017/2018 and 2019/2020 do not meet the proposed PC7 target.</p>
--	--	--	--

References:

Golder 2018a. *Cyanobacteria Blooms in Pegasus Lake, Assessment of potential management options*. Report prepared by Golder Associates (NZ) Ltd, dated October 2018, reference number: 1894341-7403-002+-R-Rev2-Blooms.

Golder 2018b. *Annual Report for Water Quality in Pegasus Lake 2017 – 2018, Todd Property Pegasus Town Limited*. Report prepared by Golder Associates (NZ) Ltd, dated April 2018, reference number: 1078105033-7403-050-R-Rev0.

Golder 2019. *Annual Report for Water Quality in Pegasus Lake 2018 – 2019, Todd Property Pegasus Town Limited*. Report prepared by Golder Associates (NZ) Ltd, dated May 2019, reference number: 1078105033-7403-057-R-Rev0.

Golder 2020. *2019 – 2020 Annual Report for Water Quality in Pegasus Lake, Templeton Pegasus Limited*. Report prepared by Golder Associates (NZ) Ltd, dated July 2020, reference number: 18107631_7405-003-R-Rev0.