BEFORE THE HEARING PANEL

IN THE MATTER of the Resource Management Act 1991

AND

IN THE MATTER of Proposed Plan Change 8 to the Operative Rotorua District Plan

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STATEMENT OF EVIDENCE OF PETER ROBERT COCHRANE
ON BEHALF OF ROTORUA LAKES COUNCIL
(Flood hazard – lakes)
Dated 13 March 2026

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INTRODUCTION

1. My full name is Peter Robert Cochrane. I am a Principal Environmental Scientist at Tonkin & Taylor Limited (T+T).

Qualifications and experience

2. I hold a Bachelors in Earth Sciences degree and a Masters in Earth Sciences degree (first class Honours) from the University of Waikato. I have over 35 years' experience in resource management science in central and local government, and in private practice.

3. I have extensive expertise in water management including:

   (a) Assessing and evaluating the effects of the operation of the lower Waikato Waipa Flood Control Scheme (including the operation of flood control gates, pump stations, lake level controls) on water levels, water flows and water quality in the Whangamarino River, Whangamarino Wetland, Lake Waikare, and Maramarua River on behalf of the Waikato Regional Council. This has been an ongoing role since 2014, building on my previous experience in understanding the effects of managed water levels in the Whangamarino Wetland on surrounding land for the Department of Conservation between 1996 and 2005.

   (b) Project Director and contributing author responsible for Hiding in Plain Sight (2018) - a national stocktake and evaluation of the flood and river management sector to understand the national state of the management of flood control, and river and drainage system management.

   (c) Senior advisory role to Te Uru Kahika on the preparation of Before the Deluge V1.0 and V2.0, which sought 30-years of co-funding of flood asset investment with stakeholders including relevant Ministers of the Crown, Treasury, Department of Internal Affairs, MBIE and LGNZ.

(d) Project Director leading initial assessments of flooding in South Dunedin and Christchurch for Suncorp. This included initial flood reconnaissance and a detailed analysis of the causes of flooding in South Dunedin in late 2024, and Christchurch in 2025. This involved understanding of magnitude of rainfall events and subsequent flooding, its effects on public and private land, damage estimates, long-term prognoses. This work included the provision of advice to the NZ Adaptation Advisory Group.

4. I was engaged by Rotorua Lakes Council (Council) to provide technical advice on flood hazard for Council's Proposed Plan Change 8 (Natural Hazards) (PC 8).

Code of conduct

5. I have read the Environment Court Code of Conduct for expert witnesses contained in the Environment Court Practice Note 2023 and agree to comply with it. I confirm that the opinions expressed in this statement are within my area of expertise except where I state that I have relied on the evidence of other persons. I have not omitted to consider materials or facts known to me that might alter or detract from the opinions I have expressed.

Scope of evidence

6. My evidence provides a summary of existing information about extreme lake levels in Lake Ōkāreka and the suitability of this information for land use planning, including a discussion of residual risk and uncertainty.

7. I also briefly comment on the relevance of lake level control to information regarding high lake levels in Lake Rotorua and the relevance of a trend of declining lake levels at Lake Tarawera to land use planning.

EXECUTIVE SUMMARY

8. I have been engaged by the Council to provide expert evidence on flood hazard in relation to PC 8, with a focus on extreme lake levels. My evidence primarily addresses Lake Ōkāreka, with brief commentary on Lake Rotorua and Lake Tarawera.

9. PC 8 proposes updated flood hazard provisions requiring new buildings to be designed for a 1% Annual Exceedance Probability (AEP) flood event, including allowances for climate change and freeboard. In implementing these provisions for lake flooding, PC 8 intends to refer to the Bay of Plenty Regional Council's (BOPRC's) *Rotorua Lakes Design Levels Technical Report 2022* (and subsequent updates) (2022 Lakes Design Report) to provide 1% AEP levels.

10. A number of submitters oppose reliance on the 2022 Lakes Design Levels Report for Lake Ōkāreka. The principal concerns raised are that the report does not adequately reflect recent outlet upgrades, does not explicitly incorporate climate change, and does not account for how the outlet might be operated during extreme events.

11. Some submitters advocate the use of a water balance model prepared to support the design of the outlet upgrade as an alternative basis for setting planning flood levels.

12. A water balance model can, in principle, be a useful tool to help understand lake level fluctuations and inform a design level to avoid flooding of land and buildings. However, the water balance developed by BOPRC was prepared specifically to inform the outlet design. It would require substantial re-working to be suitable for establishing 1% AEP design lake levels for land-use planning.

13. In my opinion, the methodology adopted in the 2022 Lakes Design Levels Report is reasonable and an appropriate way to establish a 1% AEP lake level.

14. Lake Ōkāreka is a managed lake with no natural surface outlet. Lake levels are controlled by an engineered outlet operated in accordance with resource consent conditions and guided by a Lake Level Management Plan. While this management regime seeks to maintain lake levels within a target range and avoid flooding of property, it relies on manual intervention, operator judgement, and ongoing resourcing, which introduces inherent uncertainty.

15. I consider that reliance on future outlet operation to manage flood risk is a risky proposition as there is uncertainty around the effectiveness and timeliness of operational responses, the availability of long-term funding for outlet maintenance and operation, and the ability to maintain current or higher discharge rates under future consenting regimes.

16. A freeboard allowance of +0.7 m which is recommended for Lake Ōkāreka in the 2022 Design Levels Report appropriately accounts for estimation imprecision, wind and wave effects, and tectonic influences. While climate change is not explicitly included in the freeboard, the 2022 Design Levels Report discusses the effects of climate change on lake levels and the challenges of incorporating this into its freeboard recommendations at this stage. I consider this explanation is reasonable.

17. For Lake Rotorua, existing outlet controls primarily manage low lake levels and have limited influence on extreme high lake levels. In this context, the 1% AEP lake level published in the 2022 Design Levels Report provides a suitable basis for land-use planning.

18. For Lake Tarawera, although a long-term decline in lake levels is acknowledged, further analysis is unlikely to materially alter the adopted 1% AEP planning level.

19. Overall, I conclude that the lake levels adopted by the Council for Lake Ōkāreka, Lake Rotorua and Lake Tarawera, including the application of freeboard, are reasonable and provide an appropriate basis for implementing the flood hazard provisions of PC 8.

PLAN CHANGE BACKGROUND

20. PC 8 proposes to update the rules to manage flood hazards so that they are consistent with the rest of the district. These rules would apply to new building work in areas prone to flooding in a 1% AEP[1] flood event with an allowance for climate change.

21. New buildings would need to meet minimum floor levels designed for the 1% AEP flood event with an allowance for climate change for RCP8.5 to the year 2130 (or the most recent national or regional guidance) and freeboard (Rule NH-R4(2)).

22. Resource consent and a flood risk assessment would be required for new buildings in areas where flood depths exceed 300mm in a 1% AEP flood event with allowance for climate change for RCP8.5 to the year 2130 (or the most recent national or regional guidance) (NH-R4(4)).

23. Council staff have confirmed that the BOPRC's 2022 Lakes Design Levels Report has been used to determine compliance with NH-R4(2) and whether resource consent is required under NH-R4(4) with respect to high lake levels in the Rotorua lakes.

24. To further assist with implementation, the Council also maps the levels in the 2022 Lakes Design Levels Report on its online mapping tool 'Geyserview', using a simple 'bathtub' approach.

SUBMISSIONS RELATING TO LAKE LEVELS

25. A number of submitters, including the Lake Ōkāreka Community Association and Mr Neil Oppatt, have opposed the use of the 2022 Lakes Design Levels Report for Lake Ōkāreka on the grounds that the methodology, which is based on a statistical analysis of historical high lake level data, does not take account of:

[1] Also referred to as a 100-year return period, or 100-year Annual Recurrence Interval.

(a) Improvements to the outlet from Lake Ōkāreka to Lake Tarawera constructed between 2019 and 2022; and

(b) The effects of climate change on lake levels.

26. Mr Neil Oppatt further notes that the design levels are not consistent with the reports commissioned by BOPRC to support the design of the outlet upgrade (which considered high lake levels for a range of probabilities, allowed for climate change and for outlet operation).

27. Lake Ōkāreka Community Association states that any flood assessments should not be constrained by the consented outflow from the outlet from the lake (of 500L/s) because this would fail to recognise the reality of how the system would be operated during an extreme weather event (that is, at increased outflows).

28. BOPRC, however, has maintained that the 2022 Lakes Design Levels Report remains the best available information for the purpose of implementing the flood management provisions, despite the reservations identified by submitters.

29. In BOPRC's further submission it attaches the following reports, referred to in the submission by Neil Oppatt, which it does not consider suitable for District Plan purposes:

(a) Lake Ōkāreka; Design of Pipeline Capacity; impacts on Lake Level Management, 17 November 2017 (referenced in the PDP report, dated December 2017, and titled Lake Ōkāreka Outlet Pipeline Upgrade – Options Assessment); and

(b) Lake Ōkāreka; Modelling of Lake Level Management Guideline Options, 27 July 2018.

Lake Ōkāreka

30. Lake Ōkāreka is a natural lake of volcanic origin. The lake covers an area of 3.4 km^2 and sits in a catchment of some 20 km^2.

31. It has no natural surface water outlet, with natural water losses being via seepage through the lakebed and from evaporation.

32. In response to a period of high lake levels in the early 1960s, an outlet to the Waitangi Stream (which in turn flows into Lake Tarawera) was constructed in 1965 by Rotorua County Council to better manage lake levels.

33. The maximum outflow from the outlet was subsequently set by resource consents held by BOPRC to 239 L/s, which was thought to be the capacity of the system.

34. A nominal operating range for the lake of between 353.5 and 353.9 m RL was also established through this consent.

35. Parts of the outlet were upgraded in 2015, mostly to address physical deterioration, rather than increase the outlet's hydraulic capacity.

Recent lake outlet upgrade works

36. In response to high lake levels in 2017, the BOPRC examined a range of engineering outlet options to better manage high lake levels and assessed the effect of these on the environment.

37. The assessments included an ecological assessment of the effects of erosion of the Waitangi Stream, downstream of the outlet from the lake. This assessment recommended that discharge flows from the Lake Ōkāreka outlet to the Waitangi Stream be limited to less than 500 L/s to prevent further erosion of the stream leading to loss of important habitat.

38. As a part of this work, a water balance model was used to help understand the effect of various outlet configurations on managing lake levels.

39. This work concluded that at a maximum discharge of 500 L/s, lake levels would be able to be managed within its consented target range for a 5% AEP (20-year return period) rainfall sequence (without consideration of climate change). This was used for the basis for the outlet design.

40. Currently, resource consents held by BOPRC that authorise the diversion of water from Lake Ōkāreka and its discharge to the Waitangi Stream and Lake Tarawera have conditions that restrict the discharge to less than 500 L/s and set a target lake level range of 353.5 and 353.9 m RL.

Lake level management

41. BOPRC's Lake Ōkāreka Lake Level Management Plan (Version 2.0 June 2025) sets out how BOPRC staff manage lake levels, including the outlet from the lake. The aim of the Lake Level Management Plan is to manage the lake to within its target range. To achieve this aim, the Lake Level Management Plan has four objectives, which are (in priority order):

    (a) To take action to keep the lake within the target range as much as possible.

    (b) Where this is not possible the next priority is to take action that avoids flooding damage to homes and infrastructure.

    (c) Take actions to minimise low lake levels.

    (d) Take action to minimise negative impacts on the ecology of the Waitangi Stream.

42. Operational guidelines in the Lake Level Management Plan identify various actions in response to recorded lake levels. Apart from notification procedures, the main actions are the manual adjustment of

the outlet's gate valve to control the discharge rate to certain flows depending on lake level.

43. This process involves interrogating BOPRC's Hydrotel system which records lake levels remotely, and to adjust the outlet valve depending on lake level.

44. This process is to be done daily. But this doesn't mean that the outlet valve is adjusted daily, as there will be situations where no action is needed, or when other factors (trout spawning for instance) come into play.

45. The Lake Level Management Plan makes it clear that the operators need to exercise a level of judgement to adjust flow considering factors such as the current season, periods of dry weather, weather forecasts, and whether the lake is rising or falling.

46. The processes outlined in the Lake Level Management Plan rely on a relatively high degree of operator intervention.

47. In my experience, issues like staffing shortfalls, responding to other matters in the region, or simple oversight mean that procedures are not always carried out, or carried out consistently.

48. It is also important to note that the experience of the operator is critical in anticipating conditions leading to changes in lake levels and making changes to the way the outlet is managed in a timely and effective manner.

EVALUATION OF SUBMISSIONS

49. As outlined above, the main points raised by submitters are:

    (a) The preferred use of a water balance model prepared by BOPRC to inform the design of the current outlet to set a design flood level for the lake.

(b) Concerns about the validity of using the 1% AEP level established for the lake in the 2022 Lakes Design Levels Report.

(c) Incorporation of climate change into BOPRC's 2022 Lakes Design Levels Report.

(d) Consideration of freeboard.

Water balance model to inform design lake levels

50. Some submitters have suggested that a water balance model (specifically the water balance model developed by BOPRC and used by PDP to design the outlet in 2019) would have been a more appropriate method in which to set a design lake level, than through a statistical analysis of historical lake levels.

51. I agree in general that a water balance model could be useful to help understand lake level fluctuations and might help inform a design level to avoid flooding of land and buildings.

52. There are however a range of matters that require consideration in developing a water balance:

(a) A water balance model needs to consider and resolve inflows to the lake (surface water, stormwater and overland flow, groundwater, septic tank seepage, water reticulation losses and direct precipitation) and outflows from the lake (surface water via the outlet, groundwater seepage, consumptive water abstraction, and evaporation) and their effects on the volume of water in the lake at any given time.

(b) The volume of water in the lake at any given time then needs to be converted to a corresponding water level. To do this, a relationship needs to be established between the water volumes calculated from the water balance and lake levels. This requires

information on the bathymetry of the lake and surrounding ground levels and the relationship between volume and lake level.

(c) It is unlikely that you would get a reasonable agreement between modelled and measured lake water levels at your first attempt, and the values for the various parameters used, and their relationships, would need to be adjusted in order to obtain a reasonable match.

(d) To provide predictive capability a water balance model would also need to consider how inflows and outflows would change over time.

(e) Finally, the information gathered from this would then need to be used to inform a design high water level, so that land and buildings are suitably protected from extreme events.

53. However, I would be cautious with using the water balance developed by the BOPRC in a context other than to inform the design of the outlet. I consider that it would be highly likely that the approach taken would be different if the objective of a water balance was to establish 1% AEP design lake level for Lake Ōkāreka for planning purposes.

54. Having said that, the BOPRC memo does provide estimates of lake levels for events other than 5% AEP (the selected level of service of the outlet). For example, for a projection to 2090, the 1% AEP lake level with an outlet discharge of 500 L/s is estimated at 354.11 to 354.45 m RL depending on emission pathway. This compares with the 1% AEP level design level established by BOPRC of 354.63 m RL. While both are lower numbers, when taking account error (described by BOPRC as estimate imprecision) of 0.3 m means that there is little actual difference in the resulting 1% AEP levels between different methods.

Extreme event analysis

55. Design levels for 12 Rotorua Lakes were reported in the 2022 Lakes Design Levels Report. The BOPRC also included freeboard in the derived design levels to account for imprecision in the flood estimates, wind set up, wave set up and their joint probability of occurring. The 2022 Lakes Design Levels Report also included a discussion on potential effects of climate change.

56. The lakes included those with natural outlets, controlled outlets and those with no outlet.

57. For Lake Ōkāreka the analysis included the period of time since outlet control was installed 1971 to 2020 including the maximum lake level recorded in 2017.

58. The analysis did not include the period from 2020 to its publication date and obviously did not include the period from 2022 to 2025 as its publication pre-dates this time.

59. It established a 1% AEP level of 354.628 m RL, and a level of 355.328 m RL as the 1% AEP level with freeboard (of 0.7m RL).

60. In my opinion, the approach adopted in the 2022 Lakes Design Levels Report to calculate extreme lake levels for the purpose of land use planning is reasonable.

61. Although the data upon which this analysis is based captures the high lake levels experienced in 2017, before the capacity of the outlet was increased, the results are not overly sensitive to the inclusion of this level (in the order of 0.17m increase over their previous assessment in 2010).

62. Some submitters appear to be of the view that, with the upgraded outlet, lake levels can now be effectively managed to avoid risks to development, using discharge rates above those consented.

63. In my view this is a risky proposition, as there is uncertainty around the effectiveness of future lake level management that should be factored into any decision on design levels for future development, including:

    (a) Effectiveness and timeliness of lake level management responses.

    (b) Adequate long-term funding for the operation of the outlet – noting that the upgrade works were only carried out after the 2017 event, and not pro-actively.

    (c) Certainty over whether the consent holder would be able to continue to discharge at or above the current maximum discharge rate under future consents.

Consideration of freeboard

64. The 2022 Design Levels Report provides a useful breakdown of the factors considered in recommending freeboard allowances above the 1% AEP levels calculated for Rotorua Lakes including Ōkāreka.

65. BOPRC considered the following:

    (a) Imprecision of flood estimates.

    (b) Construction tolerances.

    (c) Natural phenomena not explicitly included in flood level calculations.

    (d) Wind and wave set-up (including run-up).

    (e) Lake seiche.

    (f) Tectonics.

66. The 2022 Lakes Design Levels Report provides an assessment of the magnitude of these and the likelihood of several conditions occurring

concurrently and recommends that a freeboard of +0.7m is applied to Lake Ōkāreka.

67. My interpretation of this freeboard number is that it is a combination of imprecision of estimate (0.3m), wind and wave set up (0.3m) and tectonics (0.1m). This seems a reasonable estimate for freeboard for Lake Ōkāreka.

68. The 2022 Lakes Design Levels Report discusses uncertainties over longer timeframes including the influence of Interdecadal Pacific Oscillation and appear to have concluded that these effects are implicitly considered in the analyses carried out.

69. The 2022 Lakes Design Levels Report also considers the effects of climate change and provides semi-quantitative assessment that the effects of climate change on lake levels are likely to be around 0.5m for smaller lakes in the region.

70. However, the 2022 Lakes Design Levels Report does not include climate change in its recommended freeboard and concludes that more work needs to be done on this topic.

71. This conclusion (and the reasoning behind it) seems reasonable for the following reasons:

    (a) To account for climate change, information on future seasonal rainfall patterns would be needed, as this would influence surface water inflows and may also indirectly affect groundwater inflows (both timing and magnitude).

    (b) Climate projections for the Bay of Plenty suggest that overall, rainfall may not change significantly[2], and in the vicinity of Lake Ōkāreka there might be:

[2]Ministry for the Environment Climate Projections Map accessed 4 December 2025

(i) No change to the number of wet days per year (defined as more than >25mm of rainfall in any day) to 2100 SSP3-7.0 against a 1995-2014 baseline.

(ii) A reduction in total annual rainfall of up to 6%. Within an overall reduction in annual rainfall, the seasonal distribution of rainfall would change with spring rainfall projected to increase and all other seasons projected to decrease.

(iii) For Lake Ōkāreka a key factor influencing future high lake levels would be long periods of wet weather conditions rather than a single extreme rainfall event. So, while individual rainfall event intensities and depths may well increase with climate change, they may not greatly influence lake levels.

72. With this information in mind, the exclusion of climate change in the assessment of climate change in the BOPRC Lakes Design Levels Report is reasonable, and in any event may exert a relatively small influence on lake levels.

73. It is the BOPRC's intention to review lake levels every 10 years (with the next iteration due 2030), and to consider an alternative analytical method for Lake Ōkāreka.[3] Therefore, the concerns raised in submissions, and limitations I have outlined, will be addressed in further iterations of the BOPRC's Lakes Design Levels analyses.

OTHER SUBMISSIONS

74. In addition to the submissions relating to Lake Ōkāreka, one submission was also received from Ngāti Mākino and members of Te Uranga a Kea that concerned flooding at Lake Rotorua. The submitters noted proposed rules to fix building floor levels to a 1% AEP lake level (plus freeboard) but

[3] Ōkākera Design Levels: BOPRC memo to Rotorua Lakes Council dated 1 September 2025.

submitted that Rotorua's water levels are actively managed and wetland restoration is a priority.

75. The Lake Tarawera Ratepayers Association also questioned lake level assumptions for Lake Tarawera, stating that the historic lake levels do not account for a trend of a long-term decline in lake levels.

Lake Rotorua

76. The BOPRC Lakes Design Levels Report indicates that the outlet from Lake Rotorua through the Lake Outlet and Ohau Channel has a degree of level of control.

77. My understanding is that works to manage high levels were undertaken in 1972-73 and these resulted in a lowering of the level of Lake Rotorua by about 0.4m. In 1989, further control works were constructed through the installation of stop logs to avoid very low lake levels.

78. The "active management" described by Ngāti Mākino, I understand relates to works initially to lower levels in Lake Rotorua and then to avoid very low levels occurring in the lake. If this is the case, these works would have little influence over peak flows or have very little control over peak lake levels.

79. In this context I would regard the 1% AEP Lake Level published in the 2022 Design Levels Report for Lake Rotorua as being a more reliable means of establishing a design flood level for planning purposes.

Lake Tarawera

80. The Lake Tarawera Ratepayers Association had requested Council to engage directly with the BOPRC to update the assumptions on which the 1% AEP has been set, to better account for a long-term decline in water levels.

81. A reduction in annual maximum lake levels is evident for Lake Tarawera in the 2022 Lakes Design Levels Report, and this trend is acknowledged in the report.

82. A cursory examination of the lake level record (not just annual maxima reported in the Design Levels Report) shows similar general trend in declining water levels. However, the rate of lake level reduction appears to stabilise around mid-1990s onwards and potentially increases more recently.

83. I would certainly support ongoing dialogue with the Regional Council to better understand the drivers of lake levels for Lake Tarawera but concede that it may not result in more insight into long term trends, nor change a 1% AEP lake level as reported in the Lakes Level Design Report.

CONCLUSIONS

84. Overall, I consider that the lake levels adopted by the Council for Lake Ōkāreka (including freeboard) are reasonable and provide a suitable basis to inform the relevant rules set out in PC 8.

85. A water balance approach as favoured by some submitters could be a reasonable alternative approach. However, caution would need to be taken in using the existing water balance because the assumptions and approach were designed for its particular purpose and are highly likely to require reconsideration for use in land use planning given the complexities and uncertainties associated with a managed lake system.

86. Some submissions point out that the design flood levels calculated in the 2022 Lakes Design Levels Report are substantially higher than those used by PDP in design of the outlet (and are therefore overly conservative). However, both levels are within 180mm of one another, which are within the degree of accuracy that these methods can achieve.

87. The 2022 Lakes Design Levels Report calculated extreme lake levels based on an annual maximum water level record between 1971 and 2020, and

some submitters have made the point that there is only a very short post-construction period to determine whether the increased capacity of the outlet has been able to manage extreme lake levels.

88. This is a reasonable observation to make but this shortcoming equally applies to the water balance model promoted by some submitters, as there is less than five years' worth of lake level data available following the completion of upgrade works.

89. Furthermore, an assessment of any pre- and post-upgrade situations will be confounded by the Regional Council's management of the outlet from the Lake to meet the aims of its Management Plan.

90. Any methodology used to estimate the 1% AEP level will be subject to complexity given the uncertainties inherent in a lake subject to climate change and a management regime designed to manage the lake within a certain range.

91. A decline in annual maximum lake levels is acknowledged for Lake Tarawera in the 2022 Design Levels Report. While I would support ongoing dialogue with the Regional Council to better understand the drivers of lake levels for Lake Tarawera, it may not result in more insight into long term trends, nor change a 1% AEP lake level as reported in the Lakes Level Design Report.

Peter Robert Cochrane
Dated 13 March 2026