Under the Resource Management Act 1991 (**RMA**)

In the hearing of submissions and further submissions by Meridian Energy Limited on proposed Plan Changes 28 – 30 to the Mackenzie District Plan

Meridian Energy Limited

Submitter

Mackenzie District Council

Territorial Authority

Statement of Evidence of William Veale on behalf of Meridian Energy Limited

9 May 2025

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SUMMARY OF EVIDENCE

1. Generally, my evidence addresses aspects of dam safety requirements for New Zealand dam owners and how and why the Hydro Inundation Hazard Overlay in proposed Plan Change 28 (**PC28**) was developed. It also comments on relevant submissions on PC28. The following paragraphs 2 to 17 summarise my evidence.

Regulatory Environment for Dam Safety

2. In New Zealand, design and construction of all new large dams or any alterations to existing large dams is regulated through the Building Act 2004. Post-construction dam safety is regulated by the Building (Dam Safety) Regulations 2022 (the **Dam Safety Regulations**). These regulations came into force in May 2024, with the objective of providing a nationally consistent framework for post-construction dam safety and to help ensure that dams and canals are well operated, maintained and regularly monitored, and that potential impacts of dam incidents and failures are reduced.

3. Under the Dam Safety Regulations, dams and canals over four metres in height and storing 20,000 or more cubic metres of water must undergo a Potential Impact Classification (**PIC**) to determine their requirements under the Dam Safety Regulations. The PIC of a dam or canal represents the potential impact that a hypothetical failure of the dam or canal could have on the community, critical or major infrastructure, historical or cultural places, and the natural environment.

4. Owners of Medium or High PIC dams or canals (i.e. those which have more significant dam or canal failure consequences than a Low PIC structure) are required under the Dam Safety Regulations to prepare and implement a Dam Safety Assurance Programme. This programme is required to include regular operations, inspections, maintenance, monitoring, testing, emergency preparedness and dam safety issue management to provide assurance of a dam or canal's safety.

5. In addition to the Dam Safety Regulations, the New Zealand Dam Safety Guidelines (the **Guidelines**) provide detailed recommendations and principles to help dam owners and engineers ensure the safe design, construction, and management of dams. The Guidelines represent recommended industry practice and are published by the New Zealand Society on Large Dams (**NZSOLD**) which is a technical interest group of dam engineers under Engineering New Zealand.

6. While the Dam Safety Regulations set the legal framework and minimum requirements, the Guidelines offer wider recommendations on the investigation, design, construction, commissioning, operation, maintenance, assessment, rehabilitation, and decommissioning of dams. Dam owners are recommended to use the Guidelines in conjunction with the legal requirements imposed under the Dam Safety Regulations, Building Act and other relevant legislations (e.g. Health and Safety at Work

Act, Civil Defence and Emergency Management Act, Resource Management Act) to ensure a robust dam safety management regime.

Development of the Hydro Inundation Hazard Areas

7. While the Waitaki Power Scheme dams and canals are managed as per the requirements of the Dam Safety Regulations and recommended industry practice outlined in the Guidelines, there remains a very low residual risk that a dam or canal failure could occur at any time. While the likelihood of a structural failure of a dam or canal is very low, the consequences could be serious for people, property and the environment.

8. Potential areas of inundation following a hypothetical failure of any of the large dams and canals associated with the Waitaki Power Scheme (**WPS**) are mapped in proposed Plan Change 28 to the Mackenzie District Plan and identified as the Hydro Inundation Hazard Overlay.

9. The Hydro Inundation Hazard Overlay represents areas that could be flooded in the unlikely event of failure of any of the respective dams and canals associated with the WSP, and taking account of current landforms. The flood hazard areas determined for all hypothetical canal and dam breach locations have been integrated together to produce a composite map defining the Hydro Inundation Hazard Overlay.

10. This does not imply that any of the hypothetical dam or canal embankment breaches considered would occur, or could occur at all locations simultaneously, rather the overlay defines the composite extent of potential flood inundation areas.

11. The Hydro Inundation Hazard Overlay provides Mackenzie District Council (**MDC**) and property owners with an awareness of the potential dam or canal breach flood hazard zones which would be impacted in the unlikely event of failure of any of the large dams or canals associated with the WPS. It also enables MDC to consider the appropriateness of any future development with respect to the safety of people and property, and the 'reverse sensitivity' impacts (summarised below) that developments or changes in land use might have on Meridian's existing dam and canal assets.

Reverse Sensitivity Effects

12. New developments constructed downstream of a dam or canal, and within a dam or canal breach flood inundation zone, can increase the potential consequences of a hypothetical dam or canal breach. This, in turn, may require a dam or canal to be reclassified into a higher PIC category, even if there has been no change to the size or structural elements of the dam or canal itself. This concept is referred to in the dam safety industry as "hazard creep" or "reverse sensitivity".

13. If a dam or canal is reclassified as a result of new developments constructed downstream, it may not meet the design, operation and maintenance requirements for its updated PIC category. The owner would

then need to bring the dam or canal into compliance with the Dam Safety Regulations and recommendations of the Guidelines based on the updated classification. This could require a substantial investment to be made by the owner of the dam or canal to upgrade it to meet new flood and earthquake loadings imposed by a higher PIC category. It could also result in significant operational downtime of the hydroelectric generation assets while upgrade works are implemented.

14. Even if a dam or canal already has a High PIC, there is potential for new developments which increase the number of people living or working downstream of a dam or canal (i.e. within the Hydro Inundation Hazard Overlay) to cause the performance requirements for a dam or canal to increase and thereby require the dam owner to undertake substantial investment in improvements to meet those requirements. This is because the flood and earthquake loadings which a dam should be able to safely withstand are a function of not only a dam's PIC, but also on the number of people living or working downstream of a dam or canal, and within dam or canal breach flood inundation areas.

15. As such, the Hydro Inundation Hazard Overlay, and the complementary Hydro Inundation Chapter function as an important tool to:

    a. Inform MDC and property owners of the potential dam or canal breach flood hazard zones and potential consequences associated with them; and

    b. Provide a means for minimising the potential for reverse sensitivity effects on hydroelectricity generation related assets and the consequences of those effects.

Response to Points Raised in Submissions

16. A number of points regarding the Hydro Inundation Hazard Overlay were made in submissions by the public. Comments on these points are provided in my evidence under the heading "Response to Points Raised in Submissions".

17. My response to these comments is summarised below:

    a. Removal of the Hydro Inundation Hazard Overlay, as sought by several submitters, would negate the important functions of the overlay outlined in paragraph 15 above.

    b. Provision of a quantitative estimate of the likelihood of dam or canal failure was sought by several submitters. However, such estimates are not a requirement of the Dam Safety Regulations nor of the Guidelines. The objective of the Hydro Inundation Hazard Overlay in relation to reverse sensitivity is relevant regardless of the risk or likelihood of a dam or canal failing.

    c. Several submitters consider that the more appropriate approach to mitigation of the hydro-inundation hazard is for Meridian to install 'downstream' measures that would reduce the

consequences of dam failure. However, there is no precedent, either nationally or internationally, that I am aware of regarding the construction of infrastructure downstream of an engineered dam or canal to mitigate the consequences of dam failure (e.g. stopbanks to deflect dam-break flood waters away from development). Instead, dam owners prioritise investments directly into maintaining the safety of their dam or canal assets, rather than focusing on downstream infrastructure which attempts to mitigate the consequences of dam or canal failure.

INTRODUCTION

18. My full name is William Barnabas Veale. I am a Principal Engineer at Damwatch Engineering Limited (**Damwatch**), a consulting engineering company that provides dam safety and dam engineering services.

19. I have been asked to provide evidence by Meridian Energy Limited (**Meridian**) in respect of its submissions to MDC on proposed Plan Changes 28 – 30 to the Mackenzie District Plan.

20. I confirm that I have read the following in preparing my evidence:

    a. The plan change documents prepared by Mackenzie District Council, including the s 32A report and the s 42A report prepared by Ms Megan Justice;

    b. The submissions made on the proposed plan changes related to Hydro Inundation rules and overlays; and

    c. The evidence of other witnesses appearing for Meridian.

QUALIFICATIONS AND EXPERIENCE

21. My academic qualifications and professional memberships are:

    a. Bachelor of Civil Engineering (with 1st Class Honours), University of Canterbury 2003;

    b. Master of Civil Engineering (with Distinction), University of Canterbury 2005;

    c. Chartered Professional Engineer (CPEng);

    d. Recognised Engineer (Potential Impact Classification and Dam Safety Assurance Programme);

    e. Member of Engineering New Zealand;

    f. Member of the New Zealand Society on Large Dams (an Engineering New Zealand Technical Group); and

    g. Member of the Rivers Group (an Engineering New Zealand Technical Group).

22. I have 19 years' post-graduate experience in civil and hydraulic engineering related to dams, rivers and irrigation schemes. I have specialist expertise in flood risk assessment and dam break analysis, having worked on numerous projects related to these fields.

23. I have authored or co-authored 13 technical, peer-reviewed papers related to dams, reservoirs and hydraulic engineering.

24. I was a co-author for the 2023 and 2024 updates to the New Zealand Dam Safety Guidelines, Module 2 on "Consequence Assessment and Dam Potential Impact Classification", published by the New Zealand Society on Large Dams.

25. I have been involved with the WPS since 2013, by providing advice and engineering services to Meridian and Gensis Energy Limited (**Genesis**) on the following matters:

    a. Development of dam and canal breach flood hazard areas, resulting from hypothetical failure of large dams and canals associated with the WPS.

    b. Involvement in development of the Hydroelectricity Inundation Hazard Area maps for Plan Change 13 of the Mackenzie District Plan and providing technical advice to Meridian in relation to its submissions on Plan Change 13 of the Mackenzie District Plan.

    c. Development of a technical memorandum[1] for Meridian, related to dam safety regulation in New Zealand and the Hydro Inundation Hazard Overlay included in proposed Plan Change 28. This memorandum responded to submissions requesting clarification of the technical basis for Plan Change 28, and was provided to Mackenzie District Council for use in preparation of its Section 42A report. My evidence and this memorandum should be read together.

26. I have also been involved in engineering design and construction projects related to the WPS dams and canals. These include:

    a. Design of supplementary rock rip-rap at the Pukaki Inlet Dam and Pukaki Main Dam to mitigate against shoreline erosion processes in 2013.

    b. Testing of hydraulic performance of different operation strategies for the gates associated with the Pukaki Canal Inlet Structure in 2019.

    c. Design and construction of a siphon offtake on the Pukaki Canal for irrigation purposes in 2023.

    d. Design of debris booms for intake structures on Lake Pukaki in 2021 and peer-review of debris booms designed by others in 2024.

[1] Memo prepared by Damwatch Engineering Ltd, entitled "Background on Waitaki Power Scheme and Hydro Inundation Hazards", dated 1 April 2025.

CODE OF CONDUCT

27. 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, 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

28. In my evidence I address topics regarding dam safety and the development of the Hydro Inundation Hazard Overlay included in proposed PC28, including:

    a. An outline of the regulatory and industry-standard context for dam safety in New Zealand, including dam classification and the associated maintenance, operation, surveillance and monitoring requirements;

    b. An explanation of how the dam or canal breach hazard inundation mapping which forms the basis for the Hydro Inundation Hazard Overlay in proposed PC28 has been developed, and the rationale behind the overlay;

    c. An explanation of how changes in developments within the Hydro Inundation Hazard Overlay can increase the adverse consequences of a hypothetical dam or canal failure flood, thereby causing a change in dam classification and/or the dam safety management and dam performance criteria. These have an impact on the obligations of the dam owner (i.e. 'reverse sensitivity' effects); and

    d. A response to relevant submissions on PC28.

REGULATORY ENVIRONMENT FOR DAM SAFETY

29. In recent years, there have been significant changes to the regulatory environment for dam safety in New Zealand. In May 2024, the Dam Safety Regulations came into force. Additionally, the NZSOLD updated the New Zealand Dam Safety Guidelines in December 2024 to align with the new Dam Safety Regulations.

30. Prior to introduction of the Dam Safety Regulations post-construction dam safety management in New Zealand was not regulated. Instead, dam safety management was largely guided by industry recommended practices outlined in the New Zealand Dam Safety Guidelines. These guidelines provided a basis for dam safety management, but compliance was not mandatory.

31. A summary of the Dam Safety Regulations and New Zealand Dam Safety Guidelines is outlined in the following paragraphs.

Building (Dam Safety) Regulations 2022

32. The Dam Safety Regulations are made under the Building Act 2004, and came into force on 13 May 2024. It is a legal requirement for dam owners to comply with the Dam Safety Regulations.

33. The primary objective of the Dam Safety Regulations is to provide a nationally consistent framework for dam safety to "*help ensure that classifiable dams are well operated, maintained and regularly monitored, and that potential risks of dam incidents and failures are reduced*"[2]. The introduction of the Dam Safety Regulations also means that New Zealand is now aligned with other Organisation for Economic Co-operation and Development (**OECD**) countries with regards to dam safety regulation.

34. The safety of large dams and canals in New Zealand, including those which are part of the WPS, is therefore now regulated by the Dam Safety Regulations.

35. Under the Dam Safety Regulations and the Building Act 2004, dam owners have the following obligations:

    a. Determine if their dam (or canal) is "classifiable".[3] A dam is classifiable if it is 4 metres or higher and stores 20,000 cubic metres or more of water or other fluid.[4] Dams smaller than these height and storage volume thresholds are not 'classifiable dams' and are exempt from the Dam Safety Regulations.

    b. For all classifiable dams (and canals), conduct a dam-break flood hazard and consequence assessment to determine the Potential Impact Classification (PIC). The consequence assessment determines the potential impact of a hypothetical dam failure on the community, environment, and infrastructure based on the assessed dam-break flood inundation zone. The PIC of a classifiable dam is required to be assessed as either Low, Medium, or High. The PIC must be audited and certified by a Recognised Engineer[5] before being submitted by the dam owner to the appropriate regional authority (acting as the Regulator) for approval.

    c. For dams (and canals) with a Low PIC:

        - Dams with a Low PIC have less stringent requirements under the Dam Safey Regulations than Medium or High PIC dams. Low PIC dams are only required under the Dam Safety Regulations to have their PIC status reviewed every five years to ensure the PIC remains accurate,

[2] MBIE (2024). Guide to complying with the Dam Safety Regulations. Ministry of Business, Innovation & Employment.
[3] Ss 134 and 134B of the Building Act 2004
[4] Clause 5(1) of the Dam Safety Regulations
[5] A Recognised Engineer is A Recognised Engineer must be a Chartered Professional Engineer (CPEng) who also meets the qualifications and competencies for dam safety specified in the Recognised Engineer Competency Framework (prepared by Engineering New Zealand). Recognised Engineers are registered and assessed by Engineering New Zealand.

especially if increased development has occurred downstream within the previous five years or modifications to the dam have been made.

d. For dams (and canals) with a Medium or High PIC:

- Prepare a certified Dam Safety Assurance Programme (**DSAP**). This programme is required to include regular inspections, maintenance, and monitoring to provide assurance of the dam's safety. The DSAP must be audited and certified by a Recognised Engineer and submitted by the dam owner to the appropriate regional authority for approval.
- Implement the DSAP to ensure that the dam is operated, maintained and managed safely in accordance with the procedures outlined in the DSAP.
- Prepare a certified Annual Compliance Certificate to demonstrate ongoing adherence to the requirements of the DSAP and the dam safety standards referenced in the DSAP. The Annual Compliance Certificate must be audited and certified by a Recognised Engineer.

New Zealand Dam Safety Guidelines

36. The New Zealand Dam Safety Guidelines, published by the New Zealand Society of Large Dams, complement the Dam Safety Regulations. The Guidelines were developed to provide detailed recommendations and principles to help dam owners and engineers ensure the safe design, construction, management and operation of dams, thereby minimizing the risks to people, property, and the environment which would result from a dam failure.

37. While the Dam Safety Regulations set the minimum legal requirements, the Guidelines provide detailed, industry-recommended practices for dam safety management.

38. The Guidelines were recently updated in December 2024. This update was provided to reflect the new Dam Safety Regulations, as well as advancements in technology and international best practices in dam safety since the last major update to the Guidelines in 2015. The updates to the Guidelines were authored by New Zealand dam industry experts and reviewed by national and international peer reviewers.

39. The Guidelines are structured into seven detailed modules that address specific areas of dam safety, covering aspects such as PIC assessment methods, dam design and analysis, construction and commissioning, dam safety management (including dam operation, maintenance and monitoring), emergency preparedness and life cycle management. The Guidelines are periodically updated to incorporate advances in knowledge

and technology, ensuring that dam safety practices remain current and effective.

40. Dam owners are recommended to use the Guidelines in conjunction with the legal requirements imposed under the Dam Safety Regulations and Building Act to ensure a robust dam safety management regime.

Overview of Potential Impact Classification of Dams and Canals

41. As outlined previously in paragraph 21, the Dam Safety Regulations require all "classifiable" dams and canals to be assigned a PIC of either Low, Medium or High.

42. The PIC of a dam or canal represents the potential impact that a hypothetical failure of the dam or canal could have on the community, critical or major infrastructure, historical or cultural places, and the natural environment.

43. The PIC is used to guide the necessary dam safety regulatory requirements and management practices for dam owners. The principle is that a dam or canal with a "High" or "Medium" PIC, whose failure would cause significant damage or endanger a significant number of people, should be designed, constructed, managed, operated and maintained to a proportionately higher standard than a Low PIC dam or canal whose failure would result in relatively minor damage and with little to no impact on people. Internationally, this is well-established industry practice for dam safety management.

44. It should be noted that the PIC of a dam or canal:

    a. Only considers the consequences of a hypothetical dam or canal failure, and does not consider the likelihood of that failure.

    b. Does not, in any way, provide an indication of the physical condition or structural integrity of a dam or canal.

    c. The PIC must be based on a "worst case" failure scenario, as stipulated in the Guidelines.

45. The procedures to determine the PIC of a dam or canal are outlined in both the Dam Safety Regulations and the Guidelines.

DEVELOPMENT OF THE HYDRO INUNDATION HAZARD OVERLAY

Introduction to the Hydro Inundation Hazard Overlay

46. The WPS consists of eight power stations spread between Lake Tekapo and Lake Waitaki. The WPS includes large dams and canals which contain and convey water to support hydro electricity generation for local, regional and national needs. Meridian and Genesis own and operate the hydropower generation assets and the large dams and canals associated with the WPS. Tekapo A and B Power Stations and Tekapo Canal are owned and operated

by Genesis. All other dams, canals and power stations associated with the WPS are owned and operated by Meridian.

47. While the Waitaki Power Scheme dams and canals are managed as per the requirements of the Dam Safety Regulations and recommended industry practice outlined in the New Zealand Dam Safety Guidelines (refer to Paragraphs under "Regulatory Environment for Dam Safety" heading above), there remains a very low residual risk that a dam or canal failure could occur at any time. While the likelihood of a structural failure of a dam or canal is very low, the consequences could be serious for people, property and the environment.

48. Potential areas of inundation following failure of large dams and canals associated with the Waitaki Power Scheme are mapped in proposed Plan Change 28 to the Mackenzie District Plan and identified as the Hydro Inundation Hazard Overlay.

49. The Hydro Inundation Hazard Overlay represents areas that could be flooded in the unlikely event of failure of any of the respective dams and canals associated with the WSP, and taking into account current landforms. The flood hazard areas determined for all hypothetical canal and dam breach locations have been integrated together to produce a composite map defining the Hydro Inundation Hazard Overlay.

50. This does not imply that any of the hypothetical dam or canal embankment breaches considered would occur, or could occur at all locations simultaneously, rather the zoning defines the composite extent of potential flood inundation areas.

51. The Hydro Inundation Hazard Overlay provides MDC and property owners with an awareness of the potential dam or canal breach flood hazard zones which would be impacted in the unlikely event of failure of any of the large dams or canals associated with the Waitaki Power Scheme. It also enables MDC to consider the appropriateness of any future development with respect to the safety of people and property, and the 'reverse sensitivity' impacts (also refer to discussion later under the "Background on Reverse Sensitivity Effects" heading) that developments or changes in land use might have on Meridian and Genesis Energy's existing dam and canal assets.

Development of the Hydro Inundation Hazard Overlay

52. The Hydro Inundation Hazard Overlay was originally identified between 2014 to 2016 as part of Plan Change 13 to the Mackenzie District Plan. The hazard areas included in the final, approved Plan Change 13 maps are shown on Drawings 6/3434/1/6504 Sheet No. 21 to 29 prepared by Opus International Consultants Limited (Opus - now WSP New Zealand Limited)[6], and were referred to as the Hydro-Electricity Inundation Hazard Area Maps.

[6] Opus Drawings 6/3434/1/6504 Sheet No. 21 to 29 are available online at: https://www.mackenzie.govt.nz/__data/assets/pdf_file/0020/514208/Appendix-U-Flood-Hazard-Inundation-Maps.pdf [last accessed 4th April 2024]

53. This overlay was developed using all previous dam or canal breach flood hazard information produced for Meridian Energy and Genesis Energy up to that time. The overlay included:

    a. Comprehensive dam breach flood hazard maps for a hypothetical breach of the Pukaki Dam (prepared by Works Consultancy Services in 1990);

    b. Broad scale canal breach flood hazard maps for hypothetical breaches of the Ohau A, Ohau B and Ohau C Canals (prepared by a joint Damwatch and Opus study in 2005);

    c. Detailed canal breach flood hazard maps pertaining to specific hypothetical breach scenarios for the Tekapo Canal (prepared for Genesis Energy by Opus in 2013);

    d. Detailed canal breach flood hazard maps pertaining to specific hypothetical breach scenarios for the Pukaki and Ohau Canals, and Ruataniwha Dam (prepared for Meridian Energy by Damwatch in 2013); and

    e. Detailed dam breach flood hazard maps for a hypothetical breach of the Pukaki Inlet Dam (prepared for Meridian Energy by Damwatch in 2014).

54. In general, the "comprehensive" and "detailed" dam and canal breach flood hazard maps listed above were developed from the outputs of computational hydraulic models. These models use numerical methods to analyse how water will spread over the topography downstream of the dam or canal. The ground surface topography represented in the hydraulic models is typically defined from high-resolution LiDAR (Light Detection and Ranging) derived aerial survey data.

55. The "broad scale" dam and canal breach flood hazard maps listed above were developed without the aid of a computational hydraulic model. For those maps, the dam and canal breach flood hazard areas were qualitatively defined by analysing the ground level contours downstream of the dams or canals (from the topographic information available at the time) and estimating the likely flow path of water.

56. In all cases, the dam and canal breach flood hazard maps were:

    a. Developed in accordance with the recommendations of the New Zealand Dam Safety Guidelines for dam-break flood hazard assessments.

    b. Developed assuming a hypothetical failure case where the dam or canal breach occurs over the full height of the structure and releases the contents of the impounded reservoir when the reservoir is assumed full. This is a requirement of the Dam Safety Regulations for PIC assessments.

57. The flood hazard areas defined for all hypothetical canal and dam breach locations and scenarios from the past studies listed above were integrated

together to produce the composite Hydro-Electricity Inundation Hazard Area Maps for the Mackenzie District Plan. However, the final maps introduced into the MDP through the Plan Change 13 process excluded discrete areas at the Pukaki Airport, Lyford Lane and Flanagan Lane (Annexure A). I understand this was because only the Rural Zone was within the scope of that Plan Change process.[7]

58. I understand that the Hydro Inundation Hazard Overlay included in proposed Plan Change 28 is unchanged from the version included in the final, approved Plan Change 13 maps, except that it now covers the missing areas shown in Annexure A at Pukaki Airport, Lyford Lane and Flanagan Lane.

POTENTIAL EFFECT OF DEVELOPMENTS WITHIN THE HYDRO INUNDATION HAZARD OVERLAY ON DAM AND CANAL OWNERS

Background on Reverse Sensitivity Effects

59. New developments constructed downstream of a dam or canal, and within a dam or canal breach flood inundation zone, can increase the potential consequences of a hypothetical dam or canal breach. This, in turn, may require a dam or canal to be reclassified into a higher PIC category, even if there has been no change to the size or structural elements of the dam or canal itself.

60. For example, a dam or canal that was designed and constructed as a Low PIC structure might need to be reclassified as being a Medium or High PIC structure due to new development within the downstream dam or canal breach flood inundation zone which occurs after the dam or canal was commissioned.

61. If a dam or canal is reclassified, it may not meet the design, operation and maintenance requirements for its updated PIC category. The owner would then need to bring the dam or canal into compliance with the Building (Dam Safety) Regulations 2022 and recommendations of the New Zealand Dam Safety Guidelines based on the updated classification.

62. This concept is sometimes referred to in the dam safety industry as “hazard creep” or “reverse sensitivity”. Mr Walker’s evidence will explain the operational and management implications of reverse sensitivity from a dam owner’s point of view.

Impacts on the Dam Owner

63. Changes to a higher PIC can cause the regulatory requirements for dam safety management and associated dam performance criteria to become more onerous. Raising the dam safety management requirements and dam performance criteria can have significant implications for the owner of a dam or canal.

[7] S 32 Report, at [5.6]

64. In terms of dam safety management, the biggest change in owner requirements results from a change in PIC from Low to Medium, or Low to High. Owners of Medium and High PIC dams are required to carry out more rigorous monitoring and surveillance, dam safety reviews, inspections, maintenance, testing of appurtenant structures and gates and valves, and preparation of emergency action plans and systems for identifying and managing dam safety issues. These activities are required to be incorporated in a Dam Safety Assurance Programme (DSAP) with the DSAP required to be audited annually by a Recognised Engineer. The DSAP also requires the emergency action plans to be co-ordinated with the local civil defence agencies.

65. In terms of changes to the dam performance criteria, a dam or canal must be able to safely withstand greater structural loading conditions (primarily floods and earthquakes). These loading conditions are likely to be greater than the original design load capacity and therefore significant works may be required to upgrade the dam or canal to meet the new performance criteria. This could require a substantial investment to be made by the owner of the dam or canal. It could also result in the potential for significant operational downtime of the hydroelectric generation assets while upgrade works are implemented.

66. In summary, it is important for dam owners to be aware of any proposed developments located within the dam or canal breach flood inundation zones downstream of their dams or canals. Such developments could change the consequences of a hypothetical dam or canal failure flood and may therefore have an impact on the PIC for the dam or canal.

Effect of Development on Dams and Canals with a High PIC

67. The Pukaki Airport, Lyford Lane and Flanagan Lane areas, as referred to in Annexure A, would be affected by a hypothetical breach of any of the following dams or canals associated with the WPS:

    a. Pukaki Airport: Pukaki Inlet Dam and Pukaki Canal (true left bank)

    b. Lyford Lane: Pukaki Inlet Dam and Pukaki Canal (true left bank)

    c. Flanagan Lane: Ohau Canal (true left bank)

68. The locations of the Pukaki Inlet Dam, Pukaki Canal (true left bank) and Ohau Canal (true left bank) are shown in Annexure A.

69. The Pukaki Inlet Dam, Pukaki Canal (true left bank) and Ohau Canal (true left bank) are currently High PIC structures. Additional development in the dam or canal breach inundation zones downstream of these structures would not change the PIC of these structures, as “High” is the highest PIC category.

70. However, the increased consequences of development downstream of High PIC dams and canals can still have significant reverse sensitivity effects. Large dams and canals are required to withstand extreme flood and earthquake loadings, as set out in Module 3 of the New Zealand Dam

Safety Guidelines. These performance criteria are linked not just to the PIC category but also to a life safety metric, either Population at Risk or Potential Loss of Life.

71. Population at Risk is defined in the New Zealand Dam Safety Guidelines as "*the number of people likely to be affected by an uncontrolled* release *of all or part of the stored water or other fluid due to a failure of the dam, assuming that no person takes any action to evacuate*".

72. Potential Loss of Life is defined in the New Zealand Dam Safety Guidelines as "*the number of people expected to lose their life as a result of an* uncontrolled *release of all or part of the stored water or other fluid due to a failure of the dam*".

73. While Population at Risk is an estimate of the total number of people in a dam or canal breach inundation zone, Potential Loss of Life estimates take additional factors into account such as the severity of the floodwaters (i.e. depth, velocity and time of arrival) and consideration of population density across different time scenarios (e.g. daytime versus nighttime). Any estimate of Potential Loss of Life has a high degree of uncertainty due to the variability of factors such the length of the warning time, the responsiveness of people to evacuate when warned, the presence of suitable evacuation routes, historical patterns of human activity, and the limitations of predictive life-loss models.

74. Figure 3 from the New Zealand Dam Safety Guidelines shows the recommended minimum earthquake loadings that a dam should be able to safely withstand. This figure indicates that, for a High PIC dam or canal, the Safety Evaluation Earthquake is a function of both the PIC category and the estimated Potential Loss of Life.

PIC	Incremental Potential Loss of Life	SEE
Low	0	50th Percentile of MCE ground motion, and at least a 1 in 500 AEP ground motion but need not exceed 1 in 1,000 AEP ground motion [1, 2, 4]
Medium	0	50th Percentile of MCE ground motion [1, 4] but need not exceed the 1 in 2,500 AEP ground motion
	1	84th Percentile of MCE ground motion [1, 4] but need not exceed the 1 in 2,500 AEP ground motion
High	0	84th Percentile of MCE ground motion but need not exceed the 1 in 5,000 AEP ground motion [1, 3, 4, 5]
	1	
	2 or more	84th Percentile of MCE ground motion but need not exceed the 1 in 10,000 AEP ground motion [4]

Source: New Zealand Dam Safety Guidelines, 2024

Notes: Maximum Credible Earthquake (MCE) is defined in the New Zealand Dam Safety Guidelines as "the largest reasonably conceivable earthquake magnitude that is considered possible along a recognised active fault, or fault

system, or within a geographically defined tectonic province, under the presently known or presumed tectonic framework"

Annual Exceedance Probability (AEP) is defined in the New Zealand Dam Safety Guidelines as "the estimated probability that an event of specified magnitude will be equalled or exceeded in any year."

Figure 3 – New Zealand Dam Safety Guidelines recommended minimum Seismic Evaluation Earthquake (SEE) loadings for dams and canals

75. The New Zealand Dam Safety Guidelines define the Safety Evaluation Earthquake as "t*he earthquake that would result in the most severe ground motion which a dam must be able to endure without* uncontrolled *release of the reservoir, and for which the dam, appurtenant structure and mechanical, electrical, power, control and communication equipment that fulfils a dam safety critical function should be designed or analysed*". For a High PIC dam, the Safety Evaluation Earthquake increases from an earthquake with a 1 in 5,000 Annual Exceedance Probability (**AEP**) to one with 1 in 10,000 AEP if the Potential Loss of Life increases from 0 to 1 to 2 or more.

76. If an existing dam or canal needs to be upgraded to withstand higher earthquake loadings, it may require significant design and construction works, leading to substantial costs for the dam owner. There is also potential for significant operational downtime of the hydroelectric generation assets while upgrade works are implemented.

77. The Tekapo Canal Remediation project, completed by Genesis in 2014, provides an example of design and construction works, and potential costs, associated with an upgrade of a large hydro-power canal. The Tekapo Canal is part of the Waitaki Power Scheme and located about 20 km north-west of the Pukaki Canal. In 2014, Genesis completed a $145 million upgrade (not adjusted for inflation to today's cost) of almost a third of the 25 kilometre long canal[8] to provide long term durability and a seismically resilient design[9]. The remediation works involved re-lining the canal with a geomembrane liner and strengthening of bridges crossing the canal and replacement of a 41 m high embankment at Maryburn to improve its seismic performance[9]. To enable the works to be completed, the canal needed to be out of operation (i.e. not available for hydro-electric power generation) for a period of 14 weeks[9]. This provides an example of the scale of construction works and duration of construction period associated with an upgrade of a large hydro-power canal similar to the Pukaki Canal upstream of the Pukaki Airport, Lyford Lane and Flanagan Lane areas (as shown on Annexure A).

78. Developments which increase the number of people living or working downstream of a dam or canal, and within dam or canal breach flood inundation areas, and cause the Population at Risk or Potential Loss of Life

[8] New Zealand Energy Excellence Awards website, available at: https://www.energyawards.co.nz/finalist/2014/energy-project-of-the-year/genesis-energy {last accessed 01 May 2025).

[9] Jacka, N., Dann, C & J. Eldridge (2013). Remediation of the Tekapo Canal with a geomembrane liner. Proceedings of 2013 New Zealand Society of Large Dams (NZSOLD) and the Australian National Committee on Large Dams (ANCOLD) Conference.

to increase, therefore have the potential to increase the performance requirements for a dam or canal, even if the structure already has a High PIC classification. Dam owners need to be aware of such developments as they can have significant implications for their dam safety obligations.

RESPONSE TO POINTS RAISED IN SUBMISSIONS

Removal of Hydro Inundation Hazard Overlay or Hazard Inundation Chapter

79. Several submitters have sought the removal of the Hydro Inundation Hazard Overlay and/or Hydro Inundation Chapter from the proposed Plan Change 29, or the removal of their property from the overlay[10].

80. As noted above, and discussed further in Ms Ruston's planning evidence, the Hydro Inundation Hazard Overlay, and the complementary Hydro Inundation Chapter from the Plan, function as an important tool to inform MDC and property owners of the potential dam or canal breach flood hazard zones and potential consequences associated with them. The District Plan requirements for the Hydro Inundation Hazard Overlay provide a means for minimising the potential for reverse sensitivity effects on hydroelectricity generation related assets. Removal of the Hydro Inundation Hazard Overlay would negate these benefits.

81. Exempting the three specific areas outlined on Annexure A from the Hydro Inundation Hazard Overlay would mean an inconsistent outcome with regards to the Hydro Inundation Chapter of the Plan, and one that is not supported by a difference in the inundation hazard. If these submissions were allowed, other areas within the potential dam or canal breach flood hazard zones would remain covered by the Hydro Inundation Hazard Overlay but the three specific areas identified in Annexure A would be excluded.

82. Removal of individual properties within these three areas from the Hydro Inundation Hazard Overlay would also lead to an inconsistent outcome as some properties exposed to the same potential hazard would be excluded while others would be included.

Likelihood vs consequence

83. Several submitters have called for the Plan to take a 'risk based approach', criticising the fact that the mapping shows the consequence of a dam or canal failure rather than focussing on the likelihood of the failure.[11]

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[10] High Country Properties Ltd (14.01); Mackenzie Properties Ltd (13.01); Grant and Natasha Hocken (12.01); Anthony Honeybone (08.01); Michael Beauchamp (30.01); Elizabeth Shadbolt (37.01);
[11] Anthony Honeybone (08.01); Peter Finnegan (04.01); Grant and Natasha Hocken (12.01); Mackenzie
Properties Ltd (13.01); High Country Properties Ltd (14.01); Brent Lovelock (41.01); Anna Carr (60.01); Nick Ashley (48.01); Jason Wakelin (32.01);

84. Risk is generally described as having two components, in this context the likelihood of a dam or canal failure and the consequences of that failure.

85. While the Hydro Inundation Hazard Overlay shows the consequences of a dam or canal failure, Meridian does not have quantitative estimates of the very low likelihood of failure for each dam or canal associated with the WPS (e.g. expressed in terms of an annual probability of failure). This is because, an estimate of the likelihood of a dam failure is not a requirement of the Building (Dam Safety) Regulations 2022 nor of the New Zealand Dam Safety Guidelines. Even if estimates of the likelihood of failure were available, there would be a high degree of uncertainty with those estimates.

86. Reverse sensitivity effects (as described under the "Background on Reverse Sensitivity Effects" heading above), apply regardless of the likelihood of a dam or canal failing. Accordingly, the objective of the Hydro Inundation Hazard Overlay in relation to reverse sensitivity is relevant regardless of the risk or likelihood of a dam or canal failing.

Downstream mitigation options

87. Several submitters consider that the more appropriate approach to mitigation of the hydro-inundation hazard is for Meridian to install 'downstream' measures to mitigate the risk. Examples of the measures proposed include removal of trees in or adjacent to waterways,[12] and construction of earth bunds or 'protective dams'.[13]

88. As outlined above, dam owners are required, through the Building (Dam Safety) Regulations and industry-recommended practices outlined in the New Zealand Dam Safety Guidelines, to take actions to keep their dams safe and reduce the risk of dam or canal failure. This reflects the fundamental dam safety objective stated at the start of the New Zealand Dam Safety Guidelines: "*people, property and the environment, present and future, should be protected from the harmful effects of a dam failure or an uncontrolled release of the reservoir contents*".

89. Measures must be taken by dam and canal owners to achieve an appropriate level of safety, which is commensurate with a dam or canal's PIC. These measures are prescribed in the DSAP for a Medium or High PIC dam or canal.

90. This approach means that dam owners are required to prioritise investments directly into their dam or canal assets, and asset management programmes, to ensure that the structural integrity and safety of those assets are maintained.

91. There is no precedent, either nationally or internationally, that I am aware of regarding the construction of infrastructure downstream of an engineered dam or canal to mitigate the consequences of dam failure (e.g.

[12] Alistair Shearer (53.01);
[13] John Ten Have (26.01); Elizabeth Shadbolt (37.01); Nick Ashley (48.01); Mary Murdoch (03.01); James Leslie (05.01)

stopbanks to deflect dam-break flood waters away from development). There would also be engineering challenges involved in designing such infrastructure to withstand dam-break floods, which are typically an order of magnitude more damaging than natural flood events. Further, infrastructure that is not regularly used is more likely to degrade over time, due to lack of maintenance, and potential issues which could affect its performance may not be identified and addressed. This issue would be heightened where the dam owner did not own the land where the proposed downstream structure was located.

92. For these reasons, dam owners prioritise investments directly into maintaining the safety of their dam or canal assets, rather than focusing on downstream infrastructure which attempts to mitigate the consequences of dam or canal failure.

93. Regarding the proposal to remove trees in or adjacent to waterways[14], I note that management of riparian vegetation is generally the responsibility of the regional councils and landowners. Further, removal of trees along riparian margins would have a minimal effect on the passage of a hypothetical dam-break flood due to the wide extent of resulting flood inundation. The presence of willow trees along river and stream margins is unlikely to significantly increase maximum flood levels in a dam-break flood.

Activity status for residential visitor accommodation

94. Some submitters consider that the non-complying activity status of residential visitor accommodation within the parts of the Rural Lifestyle Zone affected by the Hydro Inundation Hazard Overlay should be changed to 'permitted', subject to the property owner providing a community or emergency response plan.[15]

95. Ms Ruston will speak to the planning rationale which supports the non-complying status. However, I wish to add that a dam or canal failure could occur without much or any warning (despite active monitoring) and be fairly rapid, resulting in very dangerous flooding downstream. The potential hazard to people and property in the three areas identified on Annexure A is in the "H5" to "H6" category based on definitions provided in the 2023 New South Wales Flood Risk Management Guideline. These are the most hazardous flood hazard categories and mean that the severity of flood depths and velocities makes floodwaters unsafe for vehicles and people (inside or outside their homes). Buildings can also be considered vulnerable to failure within these categories.

96. The proximity of these areas to the upstream dams and canals also means that there would be relatively little time for warning and evacuation of residents in the unlikely event of a dam or canal failure. For example, in the case of a breach of the Pukaki Canal upstream of the Lyford Lane area, the

[14] Alistair Shearer (53.01);

[15] Springwater Trust (02.01)

canal breach floodwaters would take approximately 1 hour to arrive at the area after uncontrolled release from the canal first occurred. The peak flood discharge would occur about 1.5 hours after first release. This time frame is relatively short and may not provide sufficient time for the dissemination of warnings to potentially affected residents, and for those residents to evacuate to a safer location.

CONCLUSIONS

97. Based on my evidence, I conclude that:

a. The Waitaki Power Scheme dams and canals are managed as per the requirements of the Building (Dam Safety) Regulations 2022 and recommended industry practice outlined in the New Zealand Dam Safety Guidelines. However, there remains a very low residual risk that a dam or canal failure could occur at any time. While the likelihood of a structural failure of a dam or canal is very low, the consequences could be serious for people, property and the environment.

b. Potential areas of inundation following a hypothetical failure of any of the large dams and canals associated with the Waitaki Power Scheme are mapped in proposed Plan Change 28 to the Mackenzie District Plan and identified as the Hydro Inundation Hazard Overlay.

c. The Hydro Inundation Hazard Overlay, and the complementary Hydro Inundation Chapter from proposed Plan Change 28, function as an important tool to:

- Inform MDC and property owners of the potential dam or canal breach flood hazard zones and potential consequences associated with them.
- Provide a means for minimising the potential for reverse sensitivity effects on hydroelectricity generation related assets and the consequences of those effects.

d. A number of points regarding the Hydro Inundation Hazard Overlay were made in submissions by the public. Comments on these points are provided in my evidence under the heading “Response to Points Raised in Submissions”. My response to these comments is summarised below:

- Removal of the Hydro Inundation Hazard Overlay, as sought by several submitters, would negate the important functions of the overlay as outlined in my evidence.
- Provision of a quantitative estimate of the likelihood of dam or canal failure was sought by several submitters. Such quantitative estimates are not a requirement of the Dam Safety Regulations nor of the New Zealand Dam

Safety Guidelines. The objectives of the Hydro Inundation Hazard Overlay in relation to reverse sensitivity is relevant regardless of the risk or likelihood of a dam or canal failing.

e. Several submitters consider that the more appropriate approach to mitigation of the hydro-inundation hazard is for Meridian to install 'downstream' measures that would reduce the hazard. However, there is no precedent, either nationally or internationally, that I am aware of regarding the construction of infrastructure downstream of an engineered dam or canal to mitigate the consequences of dam failure (e.g. stopbanks to deflect dam-break flood waters away from development). Instead, dam owners prioritise investments directly into maintaining the safety of their dam or canal assets, rather than focusing on downstream infrastructure which attempts to mitigate the consequences of dam or canal failure.

William Veale

9th April 2025

ANNEXURE A

Proposed Plan Change 28 Hydro Inundation Hazard Overlay in relation to Pukaki Airport, Lyford Lane and Flanagan Lane areas