**BEFORE THE CANTERBURY REGIONAL COUNCIL**

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| **In the matter of** | The Resource Management Act 1991 |
| **Between** | **CANTERBURY REGIONAL COUNCIL**<br>Consent Authority |
| **And** | **IRRICON RESOURCE SOLUTIONS LIMITED**<br>**VALETTA IRRIGATION LIMITED**<br><br>Submitters |

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# EVIDENCE OF KERI JOY JOHNSTON

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## Introduction

1. My name is Keri Joy Johnston. I have 11 years' experience in the field of natural resources engineering and resource management, primarily in water resources and irrigation.

2. I hold a Bachelor of Engineering in Natural Resources Engineering from the University of Canterbury. I am a Professional Member of the Institute of Professional Engineers New Zealand (MIPENZ) and a Chartered Professional Engineer (CPEng).

3. Upon completion of my degree, I worked for Meridian Energy Limited as a graduate civil engineer, based in Manapouri and Twizel, specialising in dam safety programmes required under the Building Act (2004) and NZSOLD Guidelines for a high potential impact structures.

4. After twelve months, I accepted a position with Environment Canterbury (ECan) as a Consents Investigating Officer before taking on the role of Environmental Management Systems Engineer with the River Engineering Section of ECan. During my three and a half years with ECan, I was the Consents Investigating Officer for the applications associated with the Canterbury Regional Landfill at Kate Valley, and developed environmental management systems in accordance with ISO 14001 for several units within ECan.

5. I left ECan to join RJ Hall Civil and Environmental Consulting Limited (RJH) as an Environmental Engineering Consultant. I was employed in this position for three and a half years. Work mainly involved the preparation of resource consent applications for all land and water activities, and engineering related works including dams, as well as being a contract Consents Investigating Officer for applications associated with the Central Plains Water Trust and the Ashburton Community Water Trust.

6. I am currently a director of Irricon Resource Solutions, a resource management and environmental engineering consultancy.

7. I have been involved in the design, certification and consenting of more than 80 dams in the Canterbury Region.

8. Even though this is a regional council plan hearing, I have complied with the code of conduct for expert witnesses contained in the Environment Court's Practice Note dated 31 March 2005 when preparing this evidence.

## Relief Sought

9. Irricon Resource Solutions, Valetta Irrigation Limited and Ashburton Lyndhurst Irrigation Limited all submitted on the wording of conditions 1(a) and 1(b) of Rule 5.128. The three parties sought to include the word "or" between the two conditions of the rule as follows:

*For the impounding of water outside the bed of a river or natural lake:*

*(a) the volume of water stored or impounded is less than 20,0003;OR*

*(b) the maximum depth of water is less than 3m;*

10. This aligns with the Building Act (2004) definition of a large dam, and means that if one of (a) or (b) (depth or volume) is not met, then this condition is complied with.

11. ECan has not accepted these submissions and states that:

> *"as presently worded both conditions must be satisfied in order for the impounding to qualify as a permitted activity, indicating that the permitted rules are intended to provide for relatively small dams and structures to impound water. The proposed change broadens the application of the Rule and potentially increases the scale of dams (for example an unlimited area could be impounded or a significant high dam constructed) that could be constructed as permitted activities without any assessment"*

12. This Brief of Evidence shows that ECan view is incorrect, and that the changes sought by these submitters does not broaden the application of the rule, or increase the scale of the dams that could be constructed as permitted activities.

13. In preparing this evidence, I have read:

    13.1 The Proposed Land and Water Regional Plan ("the Plan");

    13.2 S42a reports by Environment Canterbury; and

    13.3 Submissions made on the Plan.

## Evidence

### Risk of Failure

14. The risk associated with any dam structure is dam failure. A risk assessment of the effects of a dam failure requires two aspects to be addressed:

    - The probability of failure occurring;
    - The consequences of a failure occurring;
    - The Potential Impact Category (PIC) determination defined in the Building (Dam Safety) Regulations 2008; and.
    - The Potential Impact Category (PIC) in accordance with the NZSOLD Dam Safety Guidelines.

15. The Regulations require a PIC assessment based on population at risk (PAR). Environmental and economic risks are determined in parallel. Population risk is defined as the number of people likely to be affected by inundation greater than 0.5m in depth.

16. *Risk* is the product or combination of the probability of the event occurring and the magnitude of the consequences.

**Probability of Failure**

17. Under the Building Act 2004 these dams would not be classified as a "large dam". Fell (1995)[1] notes that the annual probability of failure for a homogenous earth fill dam varies between 1 in 15, 000 (AEP = ~0.00007) and 1 in 5, 000 (AEP = ~0.0002). Given the scale, of these dams, it is likely that the annual probability of failure is significantly less than 0.0002.

18. In the Canterbury Region at present, there are in excess of 300 dams of this nature. There have been no dam failures at all in this region for these dams, and given the seismic activity of the last three years, this reinforces that these dams pose little to no risk to people or the environment.

19. By way of comparison, the existing stopbank structure along the Waimakariri River (which protects Christchurch City) is likely to breach during a 1 in 450 year return period flood event[2] (AEP = ~ 0.002). Therefore, the annual probability of a dam failure is at least ten times lower than the annual probability of the existing Waimakriri Stopbank system breaching. This places the scale of this activity into perspective.

**Consequences of Failure**

20. To illustrate the fact that the adding the word "or" between clauses (a) and (b) of condition (1) of Rule 5.128 does not increase the scale of dams permitted by this rule, I have completed two dam breach assessments. The first assessment is an eight metre high dam, holding 19,999 cubic metres of water. The second assessment is a 2.99 metre high dam holding 200,000 cubic metres of water. Both of these structures would be permitted if the relief sought by these submitters is accepted.

21. In both assessments, I have used 3:1 H:V batter slopes for the upstream and downstream embankment slopes, and a crest width of three metres. By fixing these parameters, the two models are comparable.

22. A "worst case" analysis of a dam failure has been considered. This means that in the event of spillway failure, prolonged overtopping may eventually result in local erosion at a weaker or lower portion in the embankment, which has the potential to initiate a breach in the embankment. For this risk analysis, a failure initiated by overtopping at crest level was considered (i.e zero freeboard) was adopted.

23. Peak outflow from the dam if catastrophic failure were to occur has been calculated with a variety of methods including empirical equations, the results of historical failures in the USA (Von Thun and Gillette (1990), and Froelich (1995), which give appropriate cognisance to the dam type being considered here.

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[1] Fell, R (1995) Estimating the probability of failure of embankment dams under normal operating conditions and earthquake loading. NZSOLD Symposium, Christchurch

[2] Van Kalken T, Oliver T, Heslop I, Boyle T (2007) Impacts of Secondary Flood Embankments on the Waimakariri Floodplain, New Zealand. 32nd Congress of the International Association of Hydraulic Engineering & Research, Venice, Italy

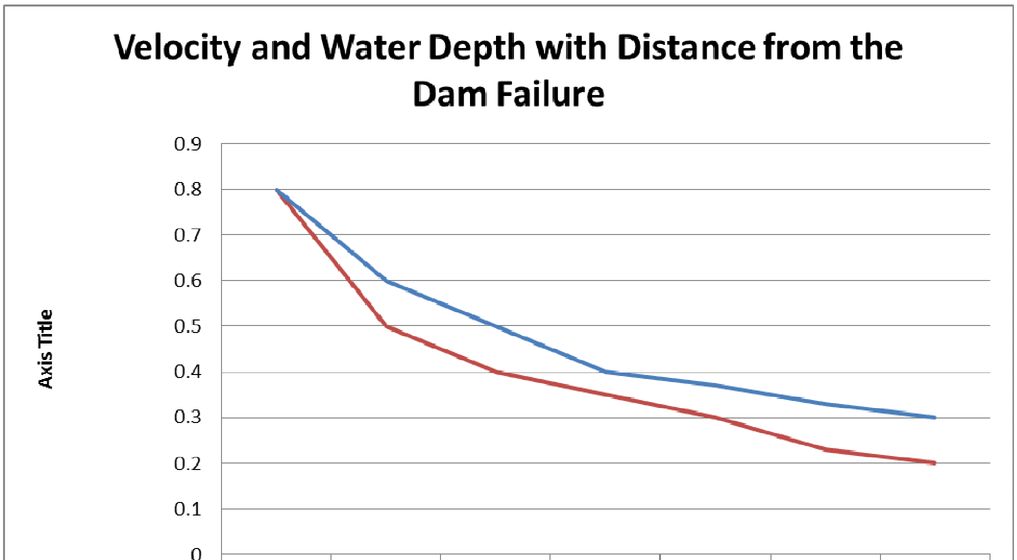
24. For Assessment One (8m high and 19,999 cubic metres stored), the dam footprint area is 0.25 hectares. So, let's assume that this dam did fail; despite the fact the probability of failure is highly unlikely.

25. The following has been calculated:

25.1 The peak outflow from this dam failure is 25 cubic metres per second, and failure would occur after 12 minutes.

25.2 The dam would be empty 15 minutes after the start of the failure.

25.3 At a distance of 500 metres from the dam failure, the resultant water depth is 0.2m, and velocity is 0.3 m/s. This is low risk even for a child standing at this distance.



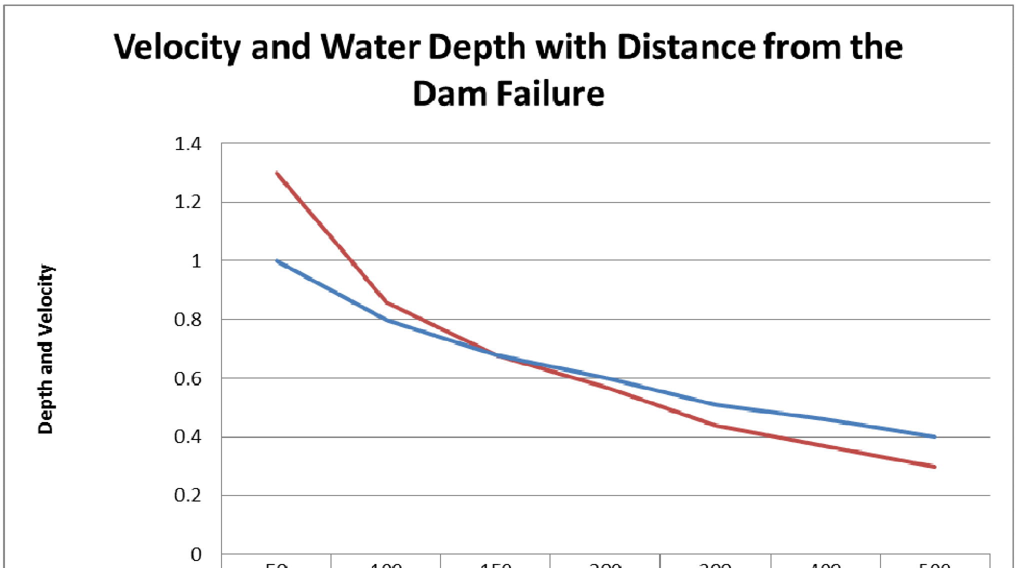

| | 50 | 100 | 150 | 200 | 300 | 400 | 500 |
|---|---|---|---|---|---|---|---|
| Depth (m) | 0.8 | 0.5 | 0.4 | 0.35 | 0.3 | 0.23 | 0.2 |
| Velocity (m/s) | 0.8 | 0.6 | 0.5 | 0.4 | 0.37 | 0.33 | 0.3 |

26. For Assessment Two (2.99m high and 200,000 cubic metres stored), the dam footprint area is 6.69 hectares. The following has been calculated:

26.1 The peak outflow from this dam failure is 58 cubic metres per second, and failure would occur after 9 minutes.

26.2 The dam would be empty 5 hours after the start of the failure.

26.3 At a distance of 500 metres from the dam failure, the resultant water depth is 0.3m, and velocity is 0.4 m/s. And again, this is low risk even for a child standing at this distance.




| | 50 | 100 | 150 | 200 | 300 | 400 | 500 |
|---|---|---|---|---|---|---|---|
| Depth (m) | 1.3 | 0.86 | 0.68 | 0.57 | 0.44 | 0.37 | 0.3 |
| Velocity (m/s) | 1 | 0.8 | 0.68 | 0.6 | 0.51 | 0.46 | 0.4 |

27. Therefore, what can be concluded from this?

28. At a distance of 500m from the dam failure, the depth and velocity very by 0.1m in the case of depth 0.1m/s in the case of velocity. In real terms, there is no measurable difference between the two assessments despite the differences in the dam heights and volume stored.

29. This reiterates that fact that the scale of a dam, and any subsequent effects of a dam failure are a function of BOTH depth and volume – not one of these parameters in isolation.

30. When the consequences are considered against the Building (Dam Safety) Regulations 2008 and the NZSOLD Dam Safety Guidelines, the PIC for these dams is considered to be LOW.

31. Coming back the point that risk is the product or combination of the probability of the event occurring and the magnitude of the consequences, given the extremely low probability of failure and the very small magnitude of the consequences, it is considered inappropriate to require such dams to obtain a resource consent.

32. It is also has to be noted that in order for these dams to be permitted, one other condition also has to be satisfied, and this is the requirement for the design and construction for dams exceeding 1,000 cubic metres to be certified by a recognised engineer. Therefore, the dams are still going designed and constructed under the supervision of an appropriately qualified and experienced person, who at the end of day, is ultimately responsible for any dam safety issues, and has to comply with a Code of Conduct and other dam safety legislation.

**Conclusions**

33. By adding the word "or" between clauses (a) and (b) of condition 1 of Rule 5.128 does not broaden the application of the rule nor potentially increases the scale of dams able to be permitted by the rule. Scale (and subsequent risk of failure and consequences of failure) are a function of BOTH depth and volume.

34. The requirement to engage the services of a recognised engineer for all dams storing more than 1,000 cubic metres means that these dams are still regulated. A recognised engineer has responsibilities under the Dam Safety Scheme (a function of the Building Act) as well as a professional code of conduct to abide by.

35. The fact that there is other regulation controlling dams, it is inappropriate for the regional council to also do so in the form of requiring a resource consent.

Keri Johnston

*(BE (hons) Natural Resources, MIPENZ, CPEng)*

Dated: 4 February 2013