BEFORE THE ENVIRONMENT COURT AT AUCKLAND | **ENV-2020-AKL-000064**

I MUA I TE KOOTI TAIAO O AOTEAROA TĀMAKI MAKAURAU ROHE

IN THE MATTER	of an appeal under the first schedule of the Resource Management Act 1991 (**RMA**)
BETWEEN	**AWATARARIKI RESIDENTS INCORPORATED** Appellant
AND	**BAY OF PLENTY REGIONAL COUNCIL** First Respondent
AND	**WHAKATĀNE DISTRICT COUNCIL** Second Respondent and Requestor of Plan Change 17

JOINT AFFIDAVIT OF CHRISTOPER IAN MASSEY AND TIMOTHY REGINALD HOWARD DAVIES

LANDSLIDE RISK ANALYSIS AND EARLY WARNING SYSTEMS

23 November 2020

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We, Christopher Ian Massey, and Timothy Reginald Howard Davies, scientists of, Wellington and Christchurch, affirm:

1. INTRODUCTION

1.1 Our qualifications and experience are set out in the exhibits marked **A** and **B** annexed to this affidavit. We both gave evidence at the Commissioner hearing which resulted in the decisions on Plan Changes 1 and 17, which in turn are the subject of this appeal.

1.2 We have read the Expert Witness Code of Conduct set out in the Environment Court's Practice Note 2014 and we agree to comply with it. We confirm that the issues addressed in this statement of evidence are within our respective areas of expertise, except where we state we are relying on the specified evidence of another person. We have not omitted to consider material facts known to us that might alter or detract from our expressed opinion.

1.3 This affidavit addresses:

a) A summary of the results of the debris flow risk analysis for the Matatā fanhead;

b) A summary of the assessment of Early Warning Systems (**EWS**) as a response to the risk to life on the Matatā fanhead;

c) Our assessment of the efficacy of the proposed EWS to address risk during the proposed extension of the effective date of the prohibited activity rule to 31 March 2022 for 10 Clem Elliot Drive, Matatā.

2. LANDSLIDE RISK ANALYSIS

2.1 The risk from debris flow hazards to people living on Awatarariki Fan was calculated by Kevin Hind of Tonkin & Taylor (2013, 2015) following the AGS (2007c) guidelines.

2.2 The risk to people living on the Awatarariki fan from debris flow hazards has been calculated as the annual risk (likelihood) of death of a person (the consequence) from debris flows, using the annual individual fatality risk (AIFR) as the metric.

2.3 It is our opinion that the debris-flow-related risk-to-life analysis reported in Mr Hind's evidence is based on up-to-date internationally accepted methods and provides a realistic assessment of the probability of a person, if present on the Awatarariki fan, being killed by debris flows.

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2.4 The AIFR estimates produced by Tonkin & Taylor (2013, 2015) were peer reviewed by Dr McSaveney and Prof. Davies who identified an area on the fan that was considered unsuitable for residential use. This area reflected the area bound by the Tonkin & Taylor (2013, 2015) modelled AIFR contour line of 0.001% (10^{-5}), which the peer reviewers considered better reflected an actual AIFR level of 0.01% (10^{-4}). The District Council accepted the advice of Dr McSaveney and Prof. Davies. An AIFR of 0.01 % (10^{-4}) is specified in the Bay of Plenty Regional Policy Statement as High Risk and was adopted as "intolerable for existing development" by the District Council. This is also the level recommended by the Australian Geomechanics Society for contexts including slope collapse, and it roughly corresponds to the lifetime average risk faced by New Zealanders from road accidents. This is also the risk level adopted by the Canterbury Earthquake Recovery Authority and Christchurch City Council for their decision-making post 2010/11 Canterbury Earthquakes (e.g., Taig et al., 2011).

2.5 The Whalley dwelling is within the extent of the fan where the assessed AIFR is > 0.01% . The mapped > 0.01% AIFR contour, which illustrates the high-risk area with the location of the Whalley dwelling shown, is annexed to this affidavit marked "**C**". Based on this map, the Whalley dwelling is on the 0.1% AIFR line, shown on the map as the 1×10^{-3} contour.

3. EWS ASSESSMENT

3.1 Based on the information presented in our evidence before the Hearings Commissioners and the key documents we have used, or referred to, it is our opinion that a multi-staged debris flow early warning system – based on the potential design and effectiveness framework – adopting any of the scenarios discussed (in GNS, 2019), is unlikely to allow all potential people present in the hazard zone at the time that a debris flow event is initiated, to evacuate to safe areas, irrespective of where they are on the fan. Therefore, people who don't notice the alert, or do not/or cannot evacuate would continue to be exposed to the risk levels given in Tonkin & Taylor (2015), depending on their location on the fan.

3.2 The effectiveness framework (GNS, 2019) was based around nine components of an EWS system. One of these components, is called "missed alarms", which relates to an event which occurs but is missed, i.e., no warning is issued and thus no action is taken by those exposed to the hazard. The proportion of these missed

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events to the number of correctly detected events, is sometimes referred to as the probability of detection.

4. PROPOSED EWS FOR 10 CLEM ELLIOT DRIVE

4.1 The EWS proposed by the Whalleys is based on MetService weather watches or warnings. They propose to sign up to receive weather watch alert MetService emails, and they have subscribed to the following MetService lists: i) Severe Thunderstorm Watch; ii) Severe Weather Outlook; iii) Severe Thunderstorm Warning; iv) Severe Weather Warning; v) Severe Weather Watch.

4.2 The Whalleys propose to receive these watches and warnings via email and they propose to take the following actions:

a) Monitor: weekly weather forecasts via receiving weather watch alert emails sent from MetService;

b) Prepare to leave: if an Orange weather warning is received from MetService via email; and

c) Activate: evacuate their dwelling once a Red weather warning is received from MetService via email.

4.3 It us our understanding that when a red warning is issued by MetService, the occupants of the Whalley dwelling will immediately vacate the premises and relocate to their property at Rerewhakaaitu, and not return to the property until MetService has revoked the warning.

4.4 A description of the criteria used by MetService to describe severe weather watches and warnings is contained on their website[1,2]. An orange warning must meet the Severe Weather criteria, so for landslides this would relate to: i) heavy rain – defined as widespread (broad-scale) impacts over an area of at least 1000km^2, more than 50mm in six hours or more than 100mm in 24 hours; and ii) thunderstorms – affecting a localised area (small-scale) for a short period of time, or rain of 25mm/hour.

4.5 MetService will issue a Severe Weather Warning whenever there is an expectation that any of the given weather conditions (as per those listed in

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[1] https://www.metservice.com/warnings/home#weather-criteria
[2] https://about.metservice.com/assets/Watches-and-Warnings/Severe-Weather-Criteria.pdf

paragraph 4.4) will occur within the next 24 hours. However, for thunderstorm warnings these are typically only issued within 1-2 hours of the conditions occurring. Thunderstorm watches tend to be issued within 24 hours of the conditions occurring, but for the entire region.

4.6 A Red warning is issued when "an event is expected to be among the worst that we get – it will have significant impact and it is possible that a lot of people will be affected".

4.7 Severe Weather Warnings and Severe Thunderstorm Watches and Warnings respectively predict the occurrence of heavy and prolonged rain, and of short-period intense rain, in specified regions of New Zealand – refer to the evidence of Mr Blackwood for details (paragraph 3.1).

4.8 There appears to be no difference with regard to the rainfall criteria between Orange and Red Severe Weather Warnings, other than for a Red warning a larger number of people/region may be affected. They are reserved for only the most extreme weather events in New Zealand.

4.9 Based on these criteria and timelines, it is our opinion that for a single location such as the Whalley dwelling, it would be more appropriate to adopt the issuance of Severe Weather Warnings and Severe Thunderstorm Watches and Warnings (all relating to the rainfall criteria), as the trigger to evacuate the dwelling.

4.10 To evaluate the efficacy of the proposed EWS, we have assumed that the Whalleys would evacuate when MetService issue a Severe Weather Warning, a Severe Thunderstorm Watch or a Severe Thunderstorm Warning. To do this we asked the following questions:

a) How often would the Whalleys have to evacuate over the period, once the EWS is in place? This relates to the frequency of Severe Weather Warnings and Severe Thunderstorm Watches and Warnings (referred to henceforth as Warnings).

b) How much time would there be between a warning being issued and the rainfall occurring at the site, which relates to how much time the Whalleys have to respond/evacuate after a warning is issued? and

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c) Have there been any "missed alarms"? In this case we refer to actual rain amounts/intensities recorded near the site, which exceed the MetService warning thresholds, but for which no warnings were issued.

4.11 The work of Mr Blackwood (paragraph 3.7 in Mr Blackwood's affidavit for this hearing) shows that the rainfall warning criteria at two local rain gauges have been exceeded:

a) At the Tarawera at Awakaponga gauge, on 74 occasions in 31 years, being an average of 2.39 times per year, with the annual totals varying between 0 and 6 times.

b) At the Ohinekoao at Harris Saddle gauge, on 75 occasions in 20 years, being an average of 3.75 times per year, with the annual totals varying between 1 and 10 times – note the second highest total was 7 events.

4.12 Adopting the work of Mr Blackwood (paragraph 3.10 in Mr Blackwood's affidavit), the number of times the MetService rainfall threshold warning criteria in the area is likely to be exceeded between 15 December 2020 and 31 March 2022 is between 1 and 5 times.

4.13 Over the past two years there have been three occasions when rain amounts/intensities that met or exceeded the criteria for a warning, were measured at rain gauges closest to the site, but when: 1) no warning was issued (one occurrence); 2) the warning was issued after the rain was measured (one occurrence); and 3) the warning was issued minutes before the rain was measured (one occurrence). This effectively means that there would have been three missed alarms.

4.14 MetService use the probability of detection (**POD**) as one metric to estimate the performance of their heavy rain warnings. The POD is defined by MetService as the ratio of the number of times rainfall was successfully forecast to the total number of times it was observed[3]. Between 2010 and 2012 the POD ranged from 83% to 87%[4]. For 2019 the POD was 93%[5]. However, these values are estimated by MetService for the entire country and could vary from region to region.

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[3] https://blog.metservice.com/node/924
[4] https://blog.metservice.com/node/926
[5] https://about.metservice.com/assets/downloads/annualreport/MetService-Annual-Report-2019-web.pdf

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4.15 Even if a heavy rain warning were issued, it does not mean that debris flows will occur. This is also true if a heavy rain event is missed, and a warning not issued. On the three occasions listed in paragraph 4.6, the rainfall durations-intensities would have had a low probability of triggering debris flows, based on the fact that no debris-flow occurred, and based on the example rainfall-duration intensity relationship shown in GNS (2019).

4.16 In order to estimate the effectiveness of the proposed EWS in reducing risk, we would have to calculate the probability of a missed alarm occurring, coupled with the probability that the resulting rainfall would trigger a debris flow. However, in the AIFR calculation done by Mr Hind, the annual frequencies of the different volumes of debris flow events – based on the rainfall annual exceedance probabilities of the rainfall that could trigger them – are already taken into account in the risk analysis and summed to derive the estimated AIFR.

4.17 Therefore, the part of the risk equation to which the proposed EWS relates is the probability of a person being present – referred to as the temporal spatial probability ($P_{T:S}$) in AGS (2007) – should a debris flow occur. Mr Hind originally adopted a $P_{T:S}$ of 0.7 (70%) in the risk analysis, which assumes the Whalleys are present 70% of the time. If we take the mean PODs reported by MetService of between 83-93% then the risk reduction can be calculated by replacing the $P_{T:S}$ = 0.7 with the probability of a heavy rain event being missed and the Whalley's being present, which is = 100-POD, which gives 7-17%.

4.18 This simply means that there is a 7-17 % chance the Whalleys could be present during a rain event with rainfall greater than the warning threshold. Given that the annual frequencies of debris flow triggering events of different sizes are already included in the AIFR calculation, we simply substitute $P_{T:S}$ = 0.7 with 0.07 or 0.17 in the AIFR calculation (assuming the mean PODs). This means the AIFR would reduce by a factor of between 4 and 10, where 10 is an order of magnitude. Therefore, an AIFR of 10^{-3} (0.1%) would drop to 10^{-4} (0.01%) for a $P_{T:S}$ of 0.07 (7%) or 2.4×10^{-4} for a $P_{T:S}$ of 0.17 (17%).

4.19 The risk reduction afforded by the EWS, which we estimated as being up to an order of magnitude based only on the POD and the issuing of an alert, is likely to be an upper estimate of the effectiveness of the EWS. This is because we have not factored in: 1) the noticeability of the alert – will the Whalleys notice the alert; 2) their response to the alert – will they, or are they able to respond to the alert;

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and 3) the timeliness of their response – will they be able to evacuate to safety in time once an alert has been issued.

4.20 Whilst the Whalley's evacuation plan indicates that they have subscribed to MetService warning lists, they still need to notice and respond to the alerts in a timely manner.

4.21 If we assume components 5 to 9 (GNS, 2019) to do with alerting and behavioural response remain unchanged, the effectiveness of the EWS on reducing the risk would be up to a factor of 6, and so will be less than an order of magnitude.

4.22 This discussion indicates that the risk to life from debris flow hazards, even if the proposed EWS were to be in place, is unlikely to reduce the AIFR to $<10^{-4}$ (0.01%), which is the risk tolerability threshold specified in the Bay of Plenty Regional Policy Statement and adopted by Council. This is because there is a possibility that a potential debris-flow triggering rainfall event is missed and thus no warning issued, and as a result the Whalleys do not evacuate.

5. CONCLUSIONS

5.1 It is our opinion that for a single location such as the Whalley dwelling, it would be more appropriate to adopt the issuance (by MetService) of Severe Weather Warnings and Severe Thunderstorm Watches and Warnings (all relating to the rainfall criteria), as the trigger to evacuate the dwelling.

5.2 The probability of detecting and issuing a warning, or of a warning being issued in time for the Whalleys to be able to evacuate, is not 100%. The probability of detecting a heavy rain event – and thus issuing a warning – is given by MetService as being between 83 and 93%, which could be lower for this area as these figures are based on national data.

5.3 The probability that one of these missed events could be large enough to trigger a debris flow is not currently known but is likely to be relatively small.

5.4 Therefore, the probability of detecting a heavy rain event and issuing a warning is not 100%, and thus there is the possibility that a potential debris-flow-triggering rainfall event is missed and thus no warning issued, and as a result the Whalleys do not evacuate.

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5.5 The risk reduction afforded by the proposed EWS would be less than an order of magnitude. Therefore, the risk to life from debris flow hazards, even if the proposed EWS were to be in place, is unlikely to reduce the AIFR to <10^{-4} (0.01%), which is the risk tolerability threshold specified in the Bay of Plenty Regional Policy Statement and adopted by Council. Noting that the uncertainty on the risk calculations (by Mr Hind of Tonkin & Taylor (2013, 2015)) is about an order of magnitude in each direction (higher or lower).

AFFIRM at Lower Hutt)
this 3rd day of December)
2020 before me:)

(Christopher Ian Massey)

Jennifer Marjorie Woodward
A Solicitor of the High Court of New Zealand

AFFIRM at Christchurch)
this 10 day of December)
2020 before me:)

(Timothy Reginald Howard Davies)

Jon S. Harding
Scientist
CHRISTCHURCH
Justice of the Peace for New Zealand
10024

~~**A Solicitor of the High Court of New Zealand**~~
Justice of Peace, New Zealand

Exhibit "A" – Qualifications and Experience - Chris Massey

1. I hold the position of Principal Scientist at the Institute of Geological and Nuclear Sciences Limited (GNS Science). I have been a scientist at GNS Science since February 2006. My experience is in engineering geology and I have 23 years of consultancy and research experience in the investigation and analysis of complex geological and geotechnical data for landslide and slope stability including landslide monitoring, foundation design, underground/surface rock support and groundwater problems. I have applied these skills to geohazard and risk assessments, oil and gas pipelines, highway, railway, mining engineering and town planning projects in Malawi, Bhutan, Nepal, Ethiopia, Russia (Sakhalin Island), Tajikistan, Hong Kong, Australia, Europe, UK and New Zealand.

2. I hold the following qualifications:

   a. PhD (Engineering Geology) from Durham University, UK. 2010;

   b. MSc (DIC), (Engineering Geology) from Imperial College, London, UK. 1999;

   c. BSc Hons (Geology) from Leeds University, UK. 1996; and

   d. Chartered Geologist from the Geological Society of London. 2005.

3. I am also a member of New Zealand Geotechnical Society, the New Zealand Society for Earthquake Engineering and a Fellow of the Geological Society of London, UK.

4. My current responsibilities include managing many of the engineering geological consultancy projects carried out by GNS Science, the most recent being landslide and rockfall risk assessments for the Department of Conservation and Franz Josef Glacier Guides for staff and visitors to the Fox and Franz Josef Glacier Valleys.

5. I also conceived and led an assessment of the landslide hazards and route resilience of the main road and rail corridors situated on the Kaikoura coast that were badly affected by the 2016 earthquake.

This is a true copy of the exhibit marked with the letter "A" referred to in the annexed joint affidavit of CHRISTOPER IAN MASSEY affirm at Lower Hutt this 3rd day of December 2020 before me:

J Woodward

Solicitor of the High Court of New Zealand / ~~Justice of the Peace~~

This is a true copy of the exhibit marked with the letter "A" referred to in the annexed joint affidavit of TIMOTHY REGINALD HOWARD DAVIES affirm at this 10 day of December 2020 before me:

~~Solicitor of the High Court of New Zealand~~ / Justice of the Peace

Jon S. Harding
Scientist
CHRISTCHURCH
Justice of the Peace for New Zealand
10024

6. I have provided peer review services to Hastings District Council and Queenstown-Lakes District Council on several landslide risk assessments carried out for them by consultants.

7. I manage the landslide research for GNS Science, which involves setting the research strategy and goals and building relationships with other partners and collaborators in New Zealand and overseas.

8. I recently led a Ministry of Business, Innovation and Employment (MBIE) funded 4-year project investigating the impact of anthropogenic slopes in Wellington, which was completed in 2019.

9. I am currently leading a 5-year MBIE funded Endeavour Programme investigating earthquake induced landscape dynamics.

10. I am also leading GeoNet projects to establish near-real time landslide forecast tools for New Zealand. These tools would provide stakeholders with rapid advisory information on landslide locations and their severity in response to strong earthquakes and significant rain events, such as the 2016 Kaikoura Earthquake and July 2020 Northland storm.

11. I have more than 20-years' experience responding to landslide events, many of which have involved setting up landslide monitoring systems to provide hazard warning. I was involved with the 2007 Ruapehu Lahar and helped the Department of Conservation monitor the stability of the tephra dam at the crater lake, as part of the Eastern Ruapehu Lahar Warning System. I managed GNS Science's landslide response to the 2010/11 Canterbury earthquakes and the 2016 Kaikoura earthquake.

12. I have been pioneering landslide modelling and quantitative landslide risk assessment methods and practices in New Zealand since the 2010/11 Canterbury Earthquakes, and have provided expert witness advice on such matters in the Environment Court on behalf of local and central government agencies, and in particular with regards to the Port Hills, Christchurch risk analysis used by Christchurch City Council in their replacement district plan, and the Canterbury Earthquake Recovery Authority for their residential red zoning policy.

7. I have been involved in the Matatā situation since shortly after the debris-flow event of 2005.

8. In the context of comprehensive hazard and risk assessments at Franz Josef Glacier, Westland, I have also been involved in intensive community engagement processes as well as acting as a consultant for West Coast Regional Council (1997 to present).

9. I have been involved as an expert witness in Environment Court proceedings in the context of river behaviour and management on behalf of Environment Southland and Otago Regional Council, and have acted as an expert witness on river sediment behaviour for river conservation groups at hearings about the Rakaia, Waimakariri, Waitaki and Wairau rivers.

This is a true copy of the exhibit marked with the letter "C" referred to in the annexed joint affidavit of CHRISTOPER IAN MASSEY affirm at Lower Hutt this 3rd day of December 2020 before me:

Solicitor of the High Court of New Zealand / Justice of the Peace

This is a true copy of the exhibit marked with the letter "C" referred to in the annexed joint affidavit of TIMOTHY REGINALD HOWARD DAVIES affirm at this 10 day of December 2020 before me:

Solicitor of the High Court of New Zealand / Justice of the Peace

Jon S. Harding
Scientist
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