MINISTRY OF BUSINESS,
INNOVATION & EMPLOYMENT
HIKINA WHAKATUTUKI

Determination 2014/047

Regarding the issuing of a section 124 Building Act Notice (relating to geotechnical hazards) on the property at 7b Hammerton Lane, Christchurch

1. The matter to be determined

1.1 This is a determination under Part 3 Subpart 1 of the Building Act 2004[1] ("the Act") made under due authorisation by me, John Gardiner, Manager Determinations and Assurance, Ministry of Business, Innovation and Employment ("the Ministry"), for and on behalf of the Chief Executive of the Ministry.

1.2 The parties to the determination are:

- Christchurch City Council, carrying out its duties and functions as a territorial authority ("the authority")
- The owners of the house K Stephens and K Setters ("the applicants") who are the applicants for this determination.

1.3 This determination arises from the decision made by the authority to issue a section 124(1)(b) notice ("the notice") in respect of this property because the authority considered that there was a risk that rocks located adjacent to the property could collapse causing death or injury to any person in the house.

1.4 The applicants dispute this finding as they consider that the assessments were incorrect, no rocks had fallen on their property, and mitigating features were not taken into account when considering the potential for future rockfall. As a result I received an application for a determination on 13 November 2012.

1.5 Therefore the matter to be determined[2] is whether the authority correctly exercised its powers in issuing a section 124(1)(b) notice. In making this decision I must consider whether the house is dangerous in terms of the Act.[3]

1.6 When considering this matter and arriving at my decision I considered all the information provided to me by the applicants and the authority. I also engaged the services of a chartered professional engineer with a specialisation in geotechnical engineering ("the first expert"), and a professional engineer with experience in the quantitative modelling of risk ("the second expert"). These experts provided advice and analysis in terms of the technical material provided.

[1] The Building Act, Building Code, compliance documents, past determinations and guidance documents issued by the Ministry are all available at www.dbh.govt.nz or by contacting the Ministry on 0800 242 243.
[2] Under sections 177(1)(a), 177(1)(b) and 177(2)(a) of the Act
[3] Under section 121(1)(d) as modified by Canterbury Earthquake (Building Act) Order 2011 cl7

2. Context

2.1 This determination relates to a property located on Canterbury's Port Hills, an area already at risk of rockfall which experienced significant damage as a result of the 22 February 2011 earthquake and subsequent aftershocks. The area is now understood to lie over an earthquake faultline.

2.2 This property is one of a number in the Port Hills with notices applied under the definition of 'dangerous building' that was modified by the Canterbury Earthquake (Building Act) Order 2010[4] ("the 2010 Order"). This Order was superseded by the Canterbury Earthquake (Building Act) Order 2011 on 17 September 2011 ("the Order"), which in turn was superseded by the Canterbury Earthquake (Building Act) Order 2013 on 17 September 2013 which has further extended the application of these notices.

2.3 I have appended a description of the Port Hills and associated rockfall hazards, as well as background to the issue of section 124 notices in the Port Hills including the evolving decision-making process for their issue, as this information provides significant context to the determination.

3. The property

3.1 The site and house

3.1.1 The site is in the Heathcote Valley near the lower end of Hammerton Lane, which zigzags up the hill to near the Heathcote Quarry. Vegetation above the site has been variously described by the Port Hills Geotechnical Group[5] (PHGG) as "sparsely forested" and "dense vegetation and scrub upslope".

3.1.2 The house was built in 2001 and is a standard NZ 3604[6] construction. It is on a floating concrete slab and has a masonry base. It is cut into a bench of land and has a steeply sloping lawn behind, retained near the house with a small retaining wall. There is an exposed deck at the front (downslope) of the dwelling.

3.2 Rock sources

3.2.1 The property lies below a continuous rocky outcrop, with a maximum observed boulder size of 8.4 m^3. The rockfall source has been described by PHGG as having dilated rock masses, partially scaled for lifelines and with some unstable fallen or displaced blocks. My expert undertook a site visit and made the following observations:

- A 10m by 20m wide Heathcote Quarry bench is located approximately 100m to 120m upslope from the dwelling. Maps 2 and 4 of the PHGG memorandum dated 3 April 2013 indicate that this bench extends a distance of approximately 150m along the hillside above Hammerton Lane and that the quarry face is up to approximately 12m high.
- Several discontinuous rock outcrops are evident on the hillside above the old Heathcote Quarry that appear to have provided a source of fallen rocks, in addition to the rock face in the Heathcote Quarry as indicated on map 2 of the PHGG memo.

[4] Canterbury Earthquake (Building Order) 2010 cl7
[5] A consortium of geotechnical engineers contracted by Christchurch City Council
[6] New Zealand Standard 3604: Timber framed buildings

- An approximately 2m high wire cable and mesh fence is located along at least part of the downhill edge of the Heathcote Quarry bench. The fence showed some damage, which may have been caused by the rockfall. Assuming this to be the case, then the fence does not appear to have been effective to-date in arresting the falling boulders.

3.2.2 To date, no rocks have reached the house or landed on the property.

4. Assessments of this property

4.1 On 11 July 2011 a notice issued under section 124(1)(b) was affixed to the building on this property by the authority. This notice said it was a dangerous building under s121 and section 124 of the Act due to risk from rockfall and/or other hazards. I assume that this coincided with the expiration of a Civil Defence-affixed red placard.

4.2 On 7 September 2011, this was replaced by another notice. Both this notice and the earlier notice relied on the definition of dangerous building as modified by the 2010 Order (refer paragraph 2.2).

4.3 On 27 October 2011 a further notice was affixed to this property by the authority. This notice said it was a dangerous building under section 121 and section 124 of the Act and the Order, due to risk from rockfall, cliff collapse and/or other hazards.

4.4 On 30 November 2011, PHGG completed an assessment of the property using the process that I describe in the Appendix, paragraph A4.3.1 to A4.3.2. This review concluded:

- rocks reached or passed (but did not hit) the house
- there were obvious sources for further rockfall
- there was no effective natural or man-made protection.

4.5 On 31 January 2012, PHGG completed a geotechnical hazard verification report. This included a photograph identifying four houses in the vicinity of this property it said were struck by falling rocks. This report stated

> Rock fall occurred during the 22 February 2011 and 13 June 2011 aftershocks
>
> Unstable boulders and bluffs have been observed above the property
>
> Potential source rock exists upslope from the dwelling
>
> There is a gap between houses located upslope from the dwelling; the upslope houses provide only partial protection.

4.6 On 8 March 2012, PHGG undertook a site assessment at the property. This assessment was part of the suburb-wide field testing of GNS Science's[7] rockfall risk model. As noted in the Appendix, paragraph A3.4.5, such assessments were carried out at all Port Hill properties and were not section 124 assessments. This assessment concluded:

- the GNS $Risk_{LOL}$ ("loss of life") at the dwelling was between 10^{-2} and 10^{-3}
- boulders did not pass or land within 10 m of the house
- the measured "F"[8] angle at the dwelling was 30.5°

[7] GNS Science is a New Zealand Government owned research institute that specialises in earth, geoscience and isotope research and consultancy

[8] F angle, or Fahrboeschung angle: the angle formed between the horizontal and a line drawn from the actual rockfall source location to the stopping point for a given boulder or to a particular given point on the slope below the source.

- the measured "S"[9] angle at the dwelling was ≈25° and the GNS map "S" angle at the dwelling was 25.5°
- the rockfall source did not vary significantly from the suburb average and there were no significant topographic features influencing risk to the dwelling
- the site risk was therefore considered to be the same as the GNS suburb-scale value
- a section 124 notice was required.

4.7 On 4 July 2012, the authority wrote to the applicant to say that as a result of the announcements taken on tolerable life-risk on 29 June 2012 by the Canterbury Earthquake Recovery Authority (CERA) for various properties, including the subject property, the notice still remained in place. It said that further geotechnical investigation was needed before a robust decision could be made 'for those properties' and that completing this work was a high priority for CERA and for the authority.

4.8 The authority sent a further letter to the applicants on 17 August 2012 to say that there had been no change in the CERA zoning of their property and, as the geotechnical hazards remained, the section 124(1)(b) notice would continue.

4.9 On 3 April 2013 and as a result of this determination application, PHGG completed a further review of the notice on this property using the process described in the Appendix, paragraphs A4.6.1 to A4.6.7. The results of this review were provided to the applicants and to me (dated 8 April 2013).

4.10 The review noted that the property was in the GNS risk zone (Scenario C, year 1) of greater than 10^{-3} and CERA zoning model of 10^{-3} to 10^{-4}. Its key outcomes were:

> No *Fallen* [PHGG's italics] boulders have been observed to have landed on the property or impacted the dwelling
>
> Upslope (approx 25 m) dwellings to the north east and south east have been impacted/near impacted by *Fallen* boulders
>
> Unstable and non-mitigated rockmass exists upslope of the dwelling
>
> There are no upslope structures immediately in the fall line that provide any significant degree of protection from rockfall
>
> Boulder trajectories from numerical rockfall modelling (RocFall) indicate that impacts on the dwelling at 7b Hammerton Lane are considered possible
>
> The inclusion of vegetation (Tables 1 and 2) greatly reduces but does not eliminate the potential for rockfall reaching the dwelling.

4.11 PHGG's checklist with this review noted that earlier 2D rockfall modelling "from ground truthing of GNS model; bare slope model" did not show a section intercepting the dwelling, but that the model rockfall runout predicted by this model did not match the field evidence. It said that the 3D Hy-stone model (bare slope) intercepted the dwelling, but it was unclear if the quarry (the Heathcote quarry above the property) was included.

4.12 New 2D rockfall modelling was carried out for this review along nine section lines (profiles) which PHGG said were defined on the basis of the field inspection and

[9] S angle, or shadow angle: the angle between the horizontal and a line drawn from the base of the rockfall source to the stopping point for a given boulder or to a particular given point on the slope below the source.

data review. It provided results for what it said was the most critical section (model Section 12a, based on profile 5-HammertonLane-012).

4.13 PHGG said the suburb-specific 95th percentile rockfall block size determined from the CCC fallen rock database was 1.6 m^3. However, it said the site-specific 95th percentile rockfall block size determined from the CCC fallen rock database was 2.5 m^3 and this was the boulder size used in the analysis.

4.14 The 95% total kinetic energy at the dwelling was then given as 246 kJ (bare slope, no mitigation) and 183 kJ (vegetated slope, no mitigation) for Section 12a, each with a bounce height of 0.3 m. PHGG noted that the bounce heights given were "above ground level" and that, where the dwelling was cut into the slope, the effective bounce height was considerably higher.

4.15 The authority's conclusion

4.15.1 In April 2013, the authority concluded on the basis of this review that the notice should remain in force.

4.15.2 While the authority's letter does not specifically make reference to constructing a rock protection structure (RPS) I assume that it accepts the PHGG opinion and recommendation in this regard, namely:

> … that the section 124 notice should remain on this dwelling until such time as properly designed, constructed and approved rockfall protection works have been implemented.
>
> Appropriate independent calculations and requisite engineering sign-off in accordance with the CCC IDS RPS Technical Guideline must be provided to allow design review.

5. Section 183 decision for section 124 notice to remain in force

5.1 Pursuant to s183 of the Act, the authority's decision to issue a notice in respect of this property was suspended when the applicant applied for the determination. However, that provision also gives me the power to direct otherwise.

5.2 On 1 November 2012, the authority requested that I make a direction in respect of this property that the notice should remain. On 13 November 2012 I issued an interim direction that the notice should remain in force until the final determination was made.

5.3 On 3 December 2012, the authority requested that I make a final direction on this matter. The authority noted that the property had been red-zoned by the Minister, although it said it was understood that a final review of the Port Hills zoning decisions was underway. I have made no further direction on this matter.

6. The applicants' views

6.1 The applicants consider the notice should be removed for the following reasons:

- The verification of geotechnical hazard report of 31 January 2012 was incorrect: there was no rock fall above their property as a result of the 13 June 2011 aftershock, and the assessor did not take into account the large flat area provided by the Heathcote quarry 'on average 10m >20m wide and about 100m long' or the zigzag road above their property which also had a number of flat areas.

- The map associated with the same report identified four neighbouring properties that were struck by rocks. However, the applicants said that one of these was 146m from their own property, the rock at 21 Hammerton Lane was a landscaped rock placed by the owner, and the rock that hit 9 Hammerton Lane was dislodged by Geovert. (I assume this last reference to be to the rock remediation work undertaken by this engineering and construction company above Hammerton Lane in mid-2011 on behalf of the authority).
- The applicants said that the section 124 (geo) notice assessment (flowchart completed 30 November 2011) was completed incorrectly as rocks did not reach or pass the house (the assessor ticked "yes"), and they also argued that the flat areas from the Heathcote Quarry, the road behind the property and partially covered tree area upslope were not taken into account when the assessor determined that there was no effective natural or man-made protection.
- They also supplied maps of rock source areas and predicted rock falls with passing transits, maximum heights and maximum kinetic energies that they said were at the minimum end of the scale.
- After thousands of aftershocks, there were still no rocks on their property.

7. Discussion in relation to the first draft determination

7.1 In order to arrive at a view of whether this house is dangerous in terms of the Act and whether the authority correctly exercised its powers in issuing the notice, I considered:

- the meaning of a dangerous building, and
- whether a risk existed at this property.

7.2 Meaning of dangerous building

7.2.1 The relevant sections of the Act are

- section 121 Meaning of dangerous building, and
- section 124 Powers of territorial authorities in respect of dangerous, earthquake-prone or insanitary buildings.

7.2.2 The relevant clauses of the Order are:

- clause 7 Modification of meaning of dangerous building and extent to which territorial authority can apply modified provision
- clause 9 Modification of powers of territorial authorities in respect of dangerous, earthquake-prone, or insanitary buildings under section 124 of Act

7.2.3 The section 124 "rockfall" notice was issued under section 124(1)(b), which provides:

> **124 Powers of territorial authorities in respect of dangerous, earthquake-prone, or insanitary buildings**
>
> (1) if a territorial authority is satisfied that a building is dangerous, earthquake-prone, or insanitary, the territorial authority may– …
>
> (b) attach in a prominent place on, or adjacent to, the building a notice that warns people not to approach the building; …

7.2.4 The authority issued the notice based on the definition of dangerous building as modified by clause 7 of the Order, which provides:

> **121 Meaning of dangerous building**
>
> (1) a building is dangerous for the purposes of this Act if, – …
>
> (d) there is a risk that adjacent, adjoining, or nearby buildings or land could collapse (including collapse by way of rock fall, landslip, cliff collapse, or subsidence) or otherwise cause injury or death to any person in the building

7.2.5 The expanded definition establishes a very low threshold before a building will be considered dangerous. In respect of the rockfall risk at this property, the only requirement is that 'there is a risk' that adjacent land could collapse by way of rockfall and cause injury or death to any person in the building.

7.2.6 A 'risk' that something could happen is simply a possibility of that event happening. This is in contrast to the definition of a dangerous building in s121(a) where a building must be 'likely', in the ordinary course of events, to cause injury or death.

7.2.7 The modified definition also requires that the risk of injury or death must be "to any person in the building". This means that rocks (or other defined hazard) must reach the building itself, not just the property boundary, with sufficient force to injure the occupants. I note further that the term "building" is defined in s8 of the Act and includes the house, any decks connected to it, and any outbuildings on the property.

7.3 Whether there is a "risk"

7.3.1 To arrive at my decision on whether or not the house was a dangerous building under the Act I considered whether "there was a risk".

7.3.2 In particular I considered whether there was

- a credible risk of a triggering event that would generate a rock fall
- a source of rocks above the property
- a risk that rocks from these sources would reach the building
- a risk that they would do so with sufficient kinetic energy to injure an occupant, and
- sufficient mitigation that would offset this risk.

7.3.3 In considering each of these points, I drew on expert advice (as described in paragraph 1.6).

7.4 Triggering events that will generate rockfall

7.4.1 A seismic event is in part described by the resulting peak ground acceleration (PGA). This is a measure of earthquake acceleration on the ground and it is described in terms of the gravitational constant, "g".[10]

7.4.2 In order for a seismic event to be likely to generate a hazardous rockfall a minimum PGA is required. The GNS Science pilot study includes frequency data (per annum) at which different PGA values are exceeded. I note that there are also non-earthquake mechanisms that could release boulders (refer Appendix paragraph A1.3) and this

[10] For example, a PGA of 2 g is acceleration twice that of gravity.

would mean that the exceedance rate for all events is slightly higher than that described in the GNS Science pilot study.

7.4.3 On the basis of the GNS data, I accepted that there was a risk that a triggering event could occur that would result in hazardous rockfall.

7.5 Rockfall source

7.5.1 PHGG has identified rockfall sources above the property, as described in paragraph 3.2.1. As shown in Map 2 accompanying the PHGG reassessment of 3 April 2013, a number of boulders have been dislodged and fallen in the area below these bluffs.

7.5.2 On the basis of this information, I concluded that this area provided a source of hazardous rocks.

7.6 Rockfall pathways & rockfall energy

7.6.1 I then considered whether there was sufficient evidence to allow me to conclude that rocks could reach the building with sufficient energy to cause injury to the buildings' occupants. My expert reviewed the rockfall models that contributed to and underpinned the authority's decision as well as other information relevant to this property.

7.6.2 My expert advised that the output from the 3D Hy-Stone rockfall modelling had been utilised by PHGG in its assessment of this property. However, since the Hy-Stone model has not been calibrated against actual boulder roll paths I concluded that little weight should be given to the Hy-Stone output shown on Map 3 of the PHGG memorandum.

7.6.3 As noted in paragraph 4.12, PHGG carried out 2D rockfall analyses and provided the results for the most critical section (Section 12a, which is based on Profile 5-Hammerton Lane-012).

7.6.4 I accept that estimating the site specific size of the 95th percentile sized boulder is difficult and more properly should be stated as a range. In the case of this dwelling, the authority concluded that the 95th percentile boulder could lie in the range of 1.1m^3 to 2.7m^3.

7.6.5 I have adopted the threshold of 25kJ as being a sufficient level of energy to trigger the placing of this notice based on advice from the authority. On 4 March 2013, the authority emailed me and explained that in its view any boulder that reached the dwelling would be required to have a residual energy value of about 25 kJ or greater in order to be able to penetrate the rear wall or roof and enter the dwelling:

> …[PHGG] has developed its analysis slightly – if the modelling indicates that a boulder will pass or reach the dwelling with sufficient total kinetic energy to damage the building, then this is considered to meet the "there is a risk" test and a section 124 notice would be recommended (or, more commonly, a recommendation to keep a section 124 notice on a building will be made).
>
> and:
>
> …if a boulder has less than 50 kJ of energy it is judged unlikely to be able to pass completely through a dwelling. A single skin outer wall obviously has less stopping capacity and the energy is judged as in the region of, or greater than, 25 kJ at the dwelling to be capable of penetrating the wall and entering the house.

7.6.6 PHGG provided 2D modelling for a 2.5m^3 boulder and used this sized boulder for their modelling. Their results indicated that the energy of the boulder at the rear of the dwelling greatly exceeded this 25kJ threshold.

7.6.7 I asked my experts to consider the likely energy for the lesser 1.1m^3 boulder at the rear of the dwelling. Their advice was that for a partially vegetated slope the energy of the smaller boulder would be proportionately less but still significantly greater than the 25 kJ threshold.

7.6.8 I therefore accepted there is a risk that rocks could reach or pass the building and that they would do so with sufficient energy to penetrate the exterior cladding.

7.7 Mitigating factors

7.7.1 PHGG's assessments considered the mitigating effects of features above the site such as vegetation and topographic channelling. The 2D rockfall modelling (refer paragraph 7.6.6) took these features into account and I accept were adequately considered.

7.7.2 In considering the vegetation above the dwelling, I accepted the RocFall output which showed that it was insufficient to stop boulders reaching the dwelling. As PHGG stated in its key outcomes:

> The inclusion of vegetation (Tables 1 and 2) greatly reduces but does not eliminate the potential for rockfall reaching the dwelling at No. 7b Hammerton Lane.

7.7.3 Therefore, based on the information provided, I accepted that while there is some mitigation arising from the vegetation above the site it is not adequate to eliminate the risk.

8. The first draft determination

8.1 I issued a draft of my decision to the parties on 15th July 2013. I concluded that the authority had established that the dwelling was dangerous and accordingly confirmed their decision.

8.2 The authority accepted the draft, but the owners requested a hearing.

9. Hearing and site visit

9.1 A hearing was held on 30th September 2013 and as a result of this hearing I visited the site on the 11th December 2013 with my expert and a referee engaged by the Chief Executive under section 187(2) of the Act. Also in attendance were the owner, the owner's supporter, and a representative of PHGG.

9.2 Site visit

9.2.1 Whilst I had accepted the authority's conclusions I acknowledged the owners' frustrations in that no rocks had fallen on their property during the many aftershocks experienced since the February and June 2011 events.

9.2.2 My expert observed a boulder, approximately 1m^3 in size, inside the neighbouring dwelling to the north (7 Hammerton Lane). We were advised that the boulder had rolled over the 2.4m high pole retaining wall located along the uphill (eastern) edge of the property and rolled onto and through the north eastern corner of the corrugated steel roof. Map B10 of Appendix C of the GNS Pilot Study Report indicates that 7 and 7B Hammerton Lane are located on the same shadow angle (25°). Consequently my expert concluded that a boulder could reach the dwelling at 7B Hammerton Lane. This conclusion is consistent with the RocFall output for Section 12a appended to the PHGG memorandum.

9.2.4 Other boulders were also noted during the site visit as follows:

- Three boulders, all less than 0.1m3, at the hairpin bend directly uphill from 7 Hammerton Lane. Map B10 indicates that these boulders reached the 26° shadow angle
- A single boulder, approximately 0.8m3 immediately to the north of the dwelling at 19 Hammerton (28° shadow angle).

9.2.5 As a result of the site visit I accept the authority's conclusions in respect of the presence of hazardous rocks and boulders. I was also able to draw some conclusions as to a cost effective and appropriate means for mitigating risk, which I discuss in section 13).

10. The second draft determination

10.1 The second draft determination was issued to parties on 30 January 2014.

10.2 The second draft determination concluded that the authority had exercised its powers correctly in issuing a notice.

10.3 The authority accepted the draft determination on 18 February 2014 although it requested that I delete or modify a paragraph relating to the suitability of a quarry bench located above the house as a location of rockfall protection. Accordingly I deleted that paragraph as I accepted the analysis of the authority.

10.4 The owners responded to the draft on 17 August 2014 expressing disappointment at the process which will see them "forced out of our home!"

11. Discussion

11.1 In reviewing my earlier decision as to whether there is a "risk" I applied the same framework as described in paragraph 7.3.2.

11.2 Despite the site visit and considering the owners' views and that of the owners' support person, my view has remained unchanged with that articulated in paragraphs 7.4.3, 7.5.2, 7.6.8 and 7.7.3.

12. Conclusion

12.1 Exercise of powers

12.1.1 In considering whether or not the authority exercised its powers correctly I have considered its process in terms of whether the process was carried out in accordance with the requirements of the Act.

12.1.2 I note that the Act does not prescribe the process to be undertaken when deciding whether or not a building is dangerous. I accept that the authority has established a process for this purpose and in respect of this property it followed that process.

12.1.3 Accordingly I conclude that the authority correctly exercised its powers in issuing the s124 notice.

12.2 Issue of the s 124 notice

12.2.1 Based on my review of the information provided to me and on the advice provided by my experts, I accept the authority's view that this property contains a dangerous building as defined by the Act and the notice should remain in force.

13. Addressing the risk

13.1 The information provided in this section is not part of the matter to be considered for the determination and is offered to assist both parties to agree to a way forward.

13.2 A section 124 notice requires a building owner to remove/reduce the danger (s124(1)(c)(i). This can be achieved by either

- reducing the threat posed by the hazard, or
- undertaking work to the building so that it is able to manage the threat posed by the risk.

13.3 Whilst my expert agrees with PHGG that protective works are likely to be viable, in this case he does not consider that these works could be situated within the owners boundaries. The reason for this is that

- the section to the rear of the house is triangular and only extends the length of the house immediately behind the house
- rockfall fences undergo large plastic (downslope) deformations, in the order of 4-5m when arresting a boulder. This means that a rockfence would need to be at least 5m away from the rear of the dwelling, which would mean a rockfall fence would have to extend onto the roadway
- upslope cables normally extend a horizontal distance equivalent to the height of the fence, which would extend onto the roadway
- similarly the footprint of the bund would be greater than that available within the site, for instance a 2m high bund is typically 2.8m wide at the base.

13.4 However my expert advises me that the quarry bench situated above this and the other properties in Hammerton Lane, should be sufficiently wide to enable rockfall protection to be constructed at this point.

13.5 Similarly, my experts have concluded that it is not feasible to undertake building work on the property that would reduce the risk. The reason for this being that the deflection resulting from the impact of a boulder would far exceed that able to be managed by a house designed within the scope of NZS3604 or a specifically designed barrier for the same purpose.

14. Decision

14.1 In accordance with section 188 of the Act, I hereby determine that the authority correctly exercised its powers in issuing the section 124 notice under s121 of the Act and accordingly I confirm the authority's decisions to issue and to refuse to withdraw the section 124 notice.

Signed for and on behalf of the Chief Executive of the Ministry of Business, Innovation and Employment on 29 September 2014.

John Gardiner
Manager Determinations and Assurance

Appendix

A1. The Port Hills and associated rockfall hazards

A1.1 The Port Hills are the northern part of the eroded and now extinct Lyttelton basalt volcano, which comprises five overlapping volcanic cones. The hills extend from the southeast edge of Christchurch's main urban area to Lyttelton Harbour and from Godley Head in the east to Governors Bay in the west. They range up to about 500m high and include steep coastal cliffs.

A1.2 The rock forming the hillside slopes and bluffs comprise strong jointed volcanic lava flows. These are composed of basalt and trachyte interbedded with softer breccia (scoria), agglomerate (volcanic gravel), ash and buried soil layers and cut by intruded dykes. The volcanic rocks are generally mantled with loess soils (windblown sand and silt). These are typically about 1m thick but can reach up to 5m thick in places.

A1.3 From time to time, the jointed rock masses release boulders that roll and bounce downhill and then accumulate as talus or scree at the toe of the slopes. Potential triggers for releasing these boulders include earthquake shaking and a variety of non-earthquake mechanisms such as prolonged heavy rainstorms, shrinkage of soil beneath detached boulders during dry periods, and frosts.

A1.4 As well as potentially triggering a boulder release, earthquake shaking can also fracture and loosen the jointed rock masses, making them more susceptible to future rockfalls.

A2. Events relating to the issue of section 124 notices in the Port Hills

A2.1 The magnitude 7.1 earthquake of 4 September 2010 resulted in significant damage to buildings in the Canterbury region. As a result, a Civil Defence emergency was declared. The Canterbury Earthquake (Building Act) Order 2010 ("the 2010 Order") was passed to enable the region's territorial authorities to respond appropriately, and this came into force on 16 September 2010.

A2.2 The 2010 Order expanded the definition of dangerous building to include:

> **7 Modification of meaning of dangerous building and extent to which territorial authority can apply modified provisions**
>
> (1) Section 121(1) of the Act is modified by adding...
>
> (d) there is a risk that other property could collapse or otherwise cause injury or death to any person in the building.

A2.3 On 22 February 2011 the Canterbury region suffered a major aftershock on the Port Hills. As a result of this event, Civil Defence applied red placards to approximately 500 properties including the house that is the subject of this determination. These placards were issued under part 5 of the Civil Defence Emergency Management Act 2002.

A2.4 On 19 April 2011, the Canterbury Earthquake Recovery Act 2011 came into force and provided the power to extend these placards[11] for a further 12 weeks.

A2.5 The 2010 Order deemed a red placard to be a notice under section 124(1)(b) of the Act[12]. Therefore, when the red placards expired in July 2011, the authority was required to formally serve section 124 notices.

A2.6 In mid 2011, the authority established the Port Hills Geotechnical Group (PHGG), a consortium of specialist engineers, to assess those properties bearing Civil Defence red placards and to recommend whether (or not) a section 124 notice should be served.

A2.7 The PHGG has continued to review properties on behalf of the authority with regard to issuing, retaining or removing section 124 notices in view of the definition of dangerous building contained in the Canterbury Earthquake (Building Act) Order 2011 ("the Order"). This superseded the 2010 Order referred to in paragraph A2.1 and took effect on 17 September 2011. The 2011 Order further modified the definition of dangerous building:

> **7 Modification of meaning of dangerous building and extent to which territorial authority can apply modified provisions**
>
> (1) Section 121(1) of the Act is modified by adding...
>
> (d) there is a risk that adjacent, adjoining, or nearby buildings or land could collapse (including collapse by way of rock fall, landslip, cliff collapse, or subsidence) or otherwise cause injury or death to any person in the building

A2.8 I note that should the 2011 Order was superseded by the Canterbury Earthquake (Building Act) Order 2013 on 17 September 2013. The general effect of which provides for the continuance of certain notices that were due to expire on the close of 16 September 2013 with the expiry of the Canterbury Earthquake (Building Act) Order 2011. The notices are continued until the expiry of the Canterbury Earthquake Recovery Act 2011 on 18 April 2016, unless they are lifted earlier. The notices continued by this order are those given in reliance on the extended definition of dangerous building in the 2011 order include prohibited access notices that were attached on, or adjacent to, a building by the Christchurch City Council under section 124(1)(b) of the Building Act 2004.

A3. Suburb-wide geotechnical assessments

A3.1 The earthquake and aftershocks of 2010 and 2011 revealed a hitherto unknown earthquake fault in the Port Hills region. This has heightened the awareness of the level of rockfall risk in the area.

A3.2 A considerable amount of geotechnical assessment has been now undertaken to assess that risk. Work has been commissioned by the authority to help with its assessment of risks from rockfall, cliff collapse and related hazards in the area. Work has also been commissioned by the Canterbury Earthquake Recovery Authority (CERA) to inform its land zoning decisions across all affected regions, including the Port Hills.

[11] Under s85
[12] cl8(2)

A3.3 As I consider that this work has influenced some of the decision-making relating to the maintenance of notices issued under section 124 on this and other Port Hills properties, I now describe these assessments.

A3.4 Assessments for the authority

A3.4.1 As a result of the February 2011 aftershock, the authority commissioned GNS Science in mid 2011 to undertake a comprehensive assessment of the life-safety risk in the Port Hills from rock fall.

A3.4.2 GNS Science's risk model identified areas of different Annual Individual Fatality Risk (AIFR) within the Port Hills.

A3.4.3 GNS Science's Port Hills rockfall risk assessments were derived from three independent components:

- the behaviour of people (where and how they lived relative to the Port Hills)
- the nature of the surroundings relative to where people live (where boulders could fall from, the number of boulders available to fall and the paths they could follow), and
- the frequency and magnitude of rockfall triggers such as earthquakes, rain and human disturbance.

A3.4.4 I understand that GNS Science combined the frequencies, probabilities and consequences of these to estimate the different AIFR areas. However, GNS Science noted that this assessment was based on limited data that was subject to uncertainties and therefore had to be generalised as average values.

A3.4.5 This model was further calibrated for GNS Science by PHGG between February and May 2012. PHGG assessed each Port Hills property against the model to calibrate the risk contour maps (it termed this field testing work "ground-truthing"). The finalised model and associated research was made public in September 2012.

A3.5 Assessments for CERA

A3.5.1 At a similar time, the Government recognised that there was land in the Canterbury region that may no longer be able to be built on and wanted to provide options for residents. Accordingly, CERA also commissioned geotechnical and life risk modelling research from GNS Science and others, including 3D rock fall modelling. I understand from the authority that this modelling was not independent but a rerun of the modelling GNS Science had previously carried out for the authority, but with different parameters. This research was used as a basis for CERA's land zoning decisions, in what it deemed to be red zones, since property owners in those zones would become eligible for a Crown purchase offer.

A3.5.2 In late 2012 CERA announced its decisions relating to red zones in the Port Hills. It said red zoned properties were those:

- affected by cliff collapse and with immediate risks to life, or
- where land remediation was not considered viable and infrastructure would be difficult and costly to maintain, or

- affected by rock roll and where the risk to life was considered unacceptable or was unlikely to reach an acceptable level in a reasonable timeframe, or
- where protective works to mitigate the life safety risk were not considered practicable.

A3.6 The section 124 notices and CERA's zoning process

A3.6.1 There is potential for confusion in the understanding of the CERA zoning process and the authority's decisions to issue section 124 notices; both can have significant impact on the living choices of building owners. Both decisions have drawn on similar data and investigative reports, which makes sense given the technical challenges of assessing the increased risk of rockfall and the limited resources of both CERA and the authority. However, it is important to keep in mind that the authority, unlike CERA, must comply with specific statutory requirements before issuing a notice.

A3.6.2 The notices issued by the authority make use of significant powers intended to ensure that a minimum standard of safety is maintained for all buildings and that people's health and safety is not placed at risk by buildings that are dangerous, earthquake-prone or insanitary.

A3.6.3 The powers provided for under section 124 can have a very severe outcome as they can prevent a person from accessing their own home. Accordingly, the authority is required to provide a clear articulation of when these powers will be exercised and appropriate evidence in support of any specific decision to issue a notice.

A3.6.4 While the GNS Science methodology was initially commissioned by the authority, it is a suburb-scale tool which the authority advises me was not applied directly to its decisions to issue or retain section 124 notices relating to rockroll in the Port Hills. The methodology was subsequently applied by CERA, although using a different set of initial assumptions.

A4. The authority's process in respect of section 124 notices in the Port Hills

A4.1 The authority has acknowledged that the decision-making process relating to the application or removal of notices on this and other Port Hills properties has been an evolutionary process. Based on the documentation provided to me in the context of this and similar determinations, I describe this process as I understand it:

- first, by focussing on the authority's decision making criteria (paragraphs 4.2 to 4.2.3), and
- second, by summarising the types of assessment carried out, in chronological order (paragraphs 4.3 to 4.6.7).

A4.2 The authority's decision making criteria

A4.2.1 The authority has applied criteria related to:

- whether the building had actually been hit by a boulder or rock
- whether a boulder or rock had landed at or passed the building

- whether there was a rockfall source and how that source compared to the suburb average
- whether any topographic or other mitigation features influenced the risk to the dwelling
- how the site compared with the GNS Science' suburb-scale risk assessment, and
- whether the F angle[13] was less than the GNS shadow angle[14].

A4.2.2 Latterly, additional criteria have been specified. These are as follows:

- whether a boulder or rock will pass or reach the building with sufficient energy to damage the building, with sufficient energy now being specified as 'in the region of, or greater than 25 kJ at the dwelling' for an external wall of the type described within NZS 3604, and
- where any interceptors (e.g. a rock protection structure or vegetation) were present, the mitigation effect of those interceptors being limited to 50 kJ unless those interceptors have mitigation effects certified as otherwise.

A4.2.3 The authority has advised me that the energy capacity attributed to a NZS 3604 type external wall (25 kJ) was established as a result of discussion with its engineers and then cross checked by 'basic back calculation' of the energy levels of rocks reaching, impacting or penetrating some of the dwellings directly affected by rocks in Morgans Valley and Sumner.

A4.2.4 The authority advised that it had allocated an energy capacity of 50 kJ to rock protection structures constructed before the 2010/2011 earthquake sequence that had 'typically been installed across the Port Hills, generally comprised of chain-link fence or double-twist mesh' because the performance of these structures was highly dependent on the mode of travel of the boulder, type of construction and quality of workmanship, and that:

> After considering supplier product information, anecdotal evidence, and some limited back analyses, the indication is that these rudimentary structures generally have rockfall stopping capacities no greater than 50kJ.

A4.3 Assessments from mid 2011

A4.3.1 From mid 2011, PHGG assessed all properties for section 124 notices on behalf of the authority. I refer to any house that had a red placard from this time as having a notice. The authority said these notices were placed and reviewed on the basis of site-specific conditions and observations and that PHGG considered topography, vegetation, actual boulder locations in relation to houses, upslope houses and potential rock sources for future boulders. In a letter to me of 26 November 2012, the authority advised that:

> In the expert opinion of the PHGG consultants, where a s124 notice has been issued, the level of risk is very high or extreme.

[13] F angle, or Fahrboeschung angle: the angle formed between the horizontal and a line drawn from the actual rockfall source location to the stopping point for a given boulder or to a particular given point on the slope below the source.

[14] S angle, or shadow angle: the angle between the horizontal and a line drawn from the base of the rockfall source to the stopping point for a given boulder or to a particular given point on the slope below the source.

A4.3.2 This assessment process included a flowchart and considered:

- whether rocks fell on this or an adjacent property and, if so, whether they reached or passed the house and whether the house was hit by rocks
- if the slope below the source was steep enough for boulders to roll
- whether there were obvious sources for further rockfall, and
- if there was effective man-made or natural protection such as rock fences, houses, bund or trees.

A4.4 Assessments from mid-2012

A4.4.1 PHGG continued its assessments for the authority from mid-2012 using a revised flow chart that represented its process.

A4.4.2 At this time the process considered

- whether a boulder had passed within 10m of the house
- if the F angle was less that the GNS shadow angle
- whether the rock fall source varied significantly from the suburb average
- whether topographic features influenced the risk to the dwelling
- whether there were any other known mass movement issues that could increase the risk to the dwelling, and
- whether the risk at the site was the same, less or greater than the GNS suburb-scale value.

A4.4.3 The authority said the GNS Science modelling information was used for context. However, from the documentation, it appears that it used the GNS Science model as a filter as the decision-making process did not allow for an existing notice to be lifted unless the AIFR[15] at the property (as assessed by the model) was less than 1×10^{-6}.

A4.5 Assessments from late 2012

A4.5.1 CERA made several zoning announcements for the Port Hills during 2012, and these triggered further assessments. Properties with existing notices that were zoned red were sent letters by the authority saying that the section 124 notice would continue. I also note that the assessment template changed around that time to reflect CERA's adaptation of the GNS Science life safety risk model. From then on, the decision-making process did not allow for an existing notice to be lifted unless the AIFR at the property was less than 1×10^{-4} as assessed by the GNS Science model for the authority and by CERA's own modelling.

A4.5.2 The authority has recently advised me that it also completed 2D rock fall energy modelling for approximately 130 properties at this time. These properties were those where:

[15] Annual individual fatality risk, which is used in the GNS work for the authority and CERA to express the probability (likelihood) that a particular person occupying a dwelling will be killed by an event such as rockfall in any one year. This risk is expressed as logarithmic numbers such as 10 (-4) (10 to the power of minus 4) per year.

> ...the s124 notice was uplifted following the zoning announcement by CERA in June 2012, but where the [authority] subsequently decided a review was needed to verify the decisions that had been made.

A4.6 Assessments from early 2013

A4.6.1 Where a determination application had been made, a complete reassessment of the rockfall risk for the property was undertaken by PHGG. The review included completion of a two-page checklist, an office review of existing data, further field testing and 2D rockfall modelling.

A4.6.2 I understand that the rockfall model has been calibrated against actual, observed roll/bounce trails of boulders that fell during the Canterbury earthquake sequence. The rockfall model also takes into account the topography, geomorphology, vegetative cover and other barriers along any particular rock-roll path that has been selected.

A4.6.3 I note that in the accompanying memoranda to the authority for all reassessments of this type that I have seen, PHGG says the criteria used to determine whether or not a dwelling was in a location such that it was exposed to a 'clear and present danger' include, but are not limited to, whether (in recent earthquake events)

- rocks fell on this or an adjacent property
- rocks reached or passed the dwelling
- the dwelling was hit by rocks
- the slope above the dwelling was steep enough for rocks to roll down it
- there were obvious sources for further rockfall, and
- the rocks could reach the dwelling with sufficient energy to penetrate the exterior cladding (of the dwelling), and
- there was effective natural or man-made protection for the dwelling.

A4.6.4 In order to undertake the 2D Rock fall modelling and arrive at a calculated potential energy, a 95th percentile boulder size was calculated and the 95th percentile energy value of that boulder at the dwelling was recorded. I understand from PHGG that for many properties the site specific 95th percentile rock was assumed to be the same as the suburb wide 95th percentile boulder size.

A4.6.5 I note further that the review checklist provides for consideration of rockfall mitigation measures, but only if these are approved or consented by the authority:

> Non [authority] approved engineering mitigation works cannot be used to change the risk.

A4.6.6 The checklist also gives PHGG three options for its recommendations to the authority:

- Retain the notice on the property.
- Retain the notice but reassess this once approved rockfall protection measures have been installed.
- Remove the notice.

A4.6.7 The authority has advised that, except for one additional property, this complete reassessment has been limited to:

(a) properties with existing section 124 notices where a determination application had been made; and

(b) properties that are exposed to increased risk of rock fall due to the demolition of an upslope dwelling that currently provides protection and which may need a section 124 notice to be applied.

The reason given for limiting this reassessment was because of the time and cost associated with the reassessment work.