

GeoSolve Ref: 170845  
1 December 2017

Leaning Lodge Trust  
c/- Alan Thomson  
87 Norfolk St  
Saint Clair  
Dunedin 9012

Attention: Alan Thomson

## Geotechnical Assessment Leaning Lodge Hut, Rock and Pillar Range, Otago

Dear Alan,

In accordance with our Agreement dated 18/10/2017 we have undertaken an engineering geological site appraisal of the Leaning Lodge Hut and surrounding land. Our investigation has comprised a site inspection and desktop review of existing information.



*Photo 1 – Leaning Lodge Hut site.*

This work was carried out for Leaning Lodge Trust in accordance with our agreement (ref. 170845). No subsurface investigations have been carried out as part of this investigation.

## Background

We understand that geotechnical comment is required specifically to address the potential for slope instability at the Leaning Lodge Hut site, as part of a retrospective Building Consent application. We note that the main requirement is to ascertain whether occupants of the hut would be exposed to risk from any slope instability hazard that may exist.

We understand that the original Leaning Lodge Hut was replaced in 2013 with the existing hut. The existing hut occupies approximately the same building footprint as the former hut. We understand that the former hut had suffered significant deterioration and structural distress prior to its replacement, but had occupied the site since approximately 1957. We understand that the original hut was also previously relocated from a former site and comprised two joined army huts as well as a later kitchen extension that was founded on uncompacted fill.

We note that an inspection by the Department of Conservation (DOC) in 2005 observed that the old hut was of questionable construction and strength, with substandard piles. The subfloor in particular was considered to be poorly constructed and inadequately braced. Concerns were expressed in regard to seismic performance, with the conclusion was that the hut had effectively reached its retirement date and required significant remedial work.

Consequently the current hut was constructed as a replacement in 2013.

## Site Description

The existing (and former) hut site is located at an elevation of approximately 1200 m on the eastern front of the Rock and Pillar Range, on land owned by the DOC. The site is within the headwaters of Six Mile Creek and is hence topographically lower than the existing flanks of the range front. The site appears to have been selected on the basis of good shelter from prevailing winds.

The hut site occupies a minor topographical spur with minor watercourses lying approximately 50 m to the north-east and south-west. A spring-fed watercourse is located to the south and a more pronounced but ephemeral watercourse is present between the hut and the carpark.

The hut is located on a slope of approximately 20 degrees. The land upslope of the hut begins to steepen approximately 30 m from the hut and slopes at up to 30 degrees before cresting to gentle slopes approximately 50 m upslope (see Photo 1 & 2).

A pronounced steepening of slopes is noted approximately 120 m upslope of the hut and this is interpreted to be part of the headscarp area of an ancient large-scale schist landslide feature that affects most of the range-front (Photo 3).

The existing hut comprises lightweight timber frame and subfloor supported on piled timber foundations. Piles are understood to be embedded to 600 mm depth and encased in concrete footings, with robust bracing evident.

## Desk Review

We have reviewed available published geological mapping and Dunedin City Council hazard mapping.

We note that the site is located in an area underlain by Otago Schist (quartofeldspathic metamorphic bedrock).

Almost the entire south-east flank of the Rock and Pillar Range is mapped as schist landslide, based on aerial photographic interpretation (QMAP 1:250000 geological map, GNS Science 2001). We note that regional foliation of the eastern part of the range dips generally to the south or south-east as indicated on the map within an antiformal setting defined by the range.

We have reviewed a report prepared by geologists Dr Tony Reay and Chuck Landis, in 2010. This report identifies the above landslide feature and describes the area near the hut site as being formed by a series of landslides as well as headward stream erosion. The report was written when the former hut was still in place and identifies the site as being on geologically unstable ground but that the ground surface in the immediate area of the hut did not appear to be moving actively. It was considered possible that the distorted piles on the former structure were set into fill and it was noted that bracing between piles was absent. The distortion of the hut was considered to be partly attributable to poor construction. Some soil creep was also considered likely to have contributed to the damage, however this did not appear deep seated.

Hazards identified in that report included avalanche, rock avalanche from high intensity earthquakes, individual rock falls, flash floods and slumping of wet ground following heavy rain or earthquake. These hazards were not considered high risk in terms of frequency or occurrence. The authors considered that a 50 year use was likely to be possible at the site provided that foundations were well built.

No other reports or publications on the landslides are known to exist, however we note that these very large schist landslides are very common features on the ranges of Central Otago, typically involving deep-seated failure on foliation surfaces. Schist landslide debris typically consists of a chaotic mixture of clay to boulder-sized schist fragments, as well as larger blocks with more limited displacement. Our experience in similar terrain indicates that rapid failure is very unlikely in these landslides under static conditions and that the typical mode of displacement is episodic creep.



*Photo 2 – View of the hut from upslope areas above ancient headscarp. Note hummocky ancient landslide topography of the range below the hut.*



*Photo 3– Aerial photo (source Google Earth) showing inferred position of ancient schist landslide headscarp with respect to Leaning Lodge Hut (within ancient landslide terrain).*

## Site Observations and Condition Assessment

We have carried out an engineering geological appraisal of the hut site and surrounding land to check for indicators of recent landslide activity. The area of the hut shows no evidence of significant recent landslide activity. No scarps or tension cracks were observed and we note that vegetation is well established on the slopes above the hut (Photo 4) In addition, no tension cracking or other signs of recent landslide reactivation were apparent in the steeper headscarp area (Photo 5), apart from superficial near surface slip within the topsoils on the steep slope. Some accumulation of rock fragments from rockfall or rock-roll was noted below the headscarp slope.



*Photo 4– Subdued vegetated slopes behind hut, with no evidence of tension cracking or scarps.*



*Photo 5– Steeper ancient headscarp areas well upslope of the hut.*

Some areas of rock fragment accumulation was noted in ephemeral swales at higher elevation than the hut, however these areas are not directly upslope of the hut. Some occasional boulders are evident on the surface upslope, however these are generally angular fragments of tabular shape with minimal potential to present rock fall or rock-roll hazard to the hut.

The nearest lobes of active deep-seated deformation appear to be located at least 300 m downslope of the hut site based on observation of aerial photography and site observations.

No elevated groundwater conditions capable of triggering landslide activity were noted in the immediate vicinity of the hut site, based on visual observation.

We have carried out a condition assessment of the hut with emphasis on the subfloor area. The hut appears to be in excellent structural condition, however we understand that some replacement of cladding is planned and that a structural engineer will carry out more detailed assessment. We noted no evidence of sloping floors, racking damage, foundation distress or other indicators that could be related to settlement or landslide movement within the subgrade soils. We noted no significant construction issues with the piles and no significant rotation of piles (Photo 6). We understand that piles are well embedded (at least 600 mm) into the subgrade soils (inferred ancient landslide debris). Some packers (piles without embedment) are evident under the structure, however we understand that these are not formally required for structural performance of the bearers (to be confirmed by

structural inspection). We note that the piles are well braced. We note that the subfloor is anchored to the ground using chains embedded into concrete casts (to assist performance during extreme wind conditions).

We have not carried out subsurface investigations, however the structural performance of the building to date implies that the subgrade soils provide adequate bearing capacity under static conditions.



*Photo 6 – Undeformed and well braced piles.*

## Discussion

We note that the existing hut has been in place since 2013. The lack of any deformation over this period indicates it has clearly performed adequately to date despite at least two high intensity rainfall events since construction.

The lack of structural distress and the lack of evidence for recent landslide activity at the site implies that the damage to the former hut is more likely to have been the result of construction deficiencies and age-related deterioration rather than widespread progressive movement of the subgrade soils. Soil heave as a result of seasonal snow cover could also have been contributory. In particular anecdotal reports indicate that piles of the former structure were not well embedded, however the piles of the current structure are understood to be embedded to 600 mm and encased in concrete footings.

It is possible that some deeper-seated movement of the schist landslide could be occurring, however the known behaviour of these slides involves gradual episodic creep movement. Structures founded on such landslides are typically only affected by translational

movement (or rafting) with minimal distortion to the subgrade soils provided that scarps are absent. Rapid failure in schist landslides is unlikely unless considerable destabilising influences are introduced.

Based on our observations, we consider that the location of the hut presents a low risk to the public from natural hazards. This is based on the well documented slow creep behaviour of Otago's schist landslides on moderate slopes (rather than more hazardous rapid failure that is possible in other bedrock types). It is possible that some acceleration could occur during severe earthquake shaking, however this presents a low risk based on the typically long return periods of earthquake events on faults in East Otago. Localised landslip in saturated soils during storm events is also possible, however this is considered to be low risk as we note that the site has performed well despite two large storm events in 2015 and 2017. This could change in the event of change in stream flow paths, however this appears unlikely. We consider that rockfall or rock roll is unlikely to affect the hut, however longer term assurance will require regular inspection.

However some structural distortion of the building is possible over time. The construction style of the hut is ideal to enable maintenance to be readily carried out, such as periodic re-levelling or adjustment if cumulative damage does occur as a result of creep movement. There is ample working space under the building to facilitate this work if required. We suggest that regular monitoring of floor levels and condition assessment should be carried out to identify if such maintenance is required.

The hut is considered to be an important shelter in an isolated area prone to rapid changes in the weather that are potentially hazardous to people. We note that both the former and current huts have not yet presented a danger to the public despite approximately 60 years of use. Based on this precedent performance and our observations on site, we consider public use of the facility for short-term occupation to be reasonable in view of the important shelter that it provides. Relocation of the hut above the headscarp could be considered, however the assessment of low risk from landslide hazard suggests that this is unwarranted, especially in view of the additional benefits provided by the relatively sheltered current location.

We understand that a structural assessment will be carried out by a structural engineer, to comment on building code considerations.

We have not considered avalanche hazard in detail, however we note that the former hut was in place for over 50 years with no reported damage attributable to avalanche. On this basis, the risk of avalanche impact damage is considered low.

We have not carried out a hydrological study, however the location of the hut on a spur suggests that flood hazard is unlikely. We understand that there are no previous reports of flood inundation affecting the hut.

A cut-off drain could be considered upslope of the hut to provide further slope stability assurance however we note that the debris is likely to be relatively permeable and such a measure would only be required if significant focussing of upslope runoff to the foundations was noted during heavy rainfall.



## Conclusions and Recommendations

- Based on our observations, we consider that use of the hut for typical short term accommodation presents a low risk to the public from the natural hazards discussed above, provided that no destabilising influences are introduced.
- Some cumulative structural distress could occur over the medium to long-term.
- We recommend that regular monitoring of floor levels and condition assessment of the hut should be carried out to identify if any releveling work is required in response to potential landslide creep movement. Inspection every 2 years is recommended initially, however this could be reduced if no issues are evident over several inspections.
- No stormwater or other focussed water flow should be directed to the hut foundations. We recommend that consideration should be given to a deep cut-off drain upslope of the hut, however the benefits of this should be assessed with further inspection during rainfall.
- A geotechnical specialist should be contacted if any deformation of the hut or surrounding land is reported. Inspection following any strong earthquake shaking is also recommended.

This report has been prepared for the benefit of Leaning Lodge Trust with respect to the particular brief given to us and it may not be relied upon in other contexts or for any other purpose without our prior review and agreement.

Yours faithfully,



Mark Walrond

Senior Engineering Geologist