24 May 2021

Brian Fitzpatrick
Queenstown Park Limited

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6-XZ226.06

Dear Brian,

Further to our updated review of natural hazards at the Queenstown Park development site we are pleased to present our supplementary assessment of landslide dam risk and flooding risk as identified by the Otago Regional Council at the mediation hearing held in Queenstown in December 2020.

Background

In 2015 WSP, previously known as Opus Consultants Ltd, conducted a Geotechnical Hazard Appraisal of the land referred to as Queenstown Station. The assessment presented a report with associated plans and drawings that identified the natural hazards associated with the property.

The 2015 report concluded that Natural Hazards were present that affected the property to greater and lesser degrees across its total coverage but that the potential impacts of such hazards were particularly limited by the topography of the site (landform) and the specific locations of the identified hazards.

The assessment concluded that by adopting simple means of mitigation along the lines of avoidance or separation (agreed set back distances) combined with soft engineering options such as planting, these would alleviate much, if not all, of the perceived risks. Where avoidance or separation could not be achieved then specific investigations and appropriate design of additional engineered solutions may be required to mitigate the risks.

In 2017 WSP prepared supporting information for Queenstown Park Limited re-zoning as part of the Stream 13 plan change hearings. This information included a review of the 2015 natural hazards report in light of a revised Queenstown Park (QP) Activity Areas plan (rural residential and rural visitor).

The information concluded that the natural hazard risks posed to the development areas were typically, and generally, low to no risk and did not require any specific mitigation.

No hazards were identified that in relation to the proposed development plan would preclude development.

In October 2020 WSP were contacted and presented a series of development proposal plans prepared by Mason & Wells (Queenstown Park Village Master Plan and Queenstown Park master planning). We were asked to review the Natural Hazard risks posed to the

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development areas, namely the QP Village area and advise on any specific mitigation requirements.

As part of the review WSP conducted a site walkover and re-inspection of the development areas and also attended a site open day, also attended by invited Stakeholders including Queenstown Lakes District Council and ORC.

As part of the 2020 review WSP reviewed the currently available information on both QLDC and ORC held databases, completed a review of recently published reports on natural hazards in Central Otago and reviewed recent aerial imagery of the site that had been undertaken since the completion of the 2015 and 2017 reports.

As with the previous assessments the risks associated with these hazards were identified to be overall no risk or low risk.

In December 2020 WSP completed a letter report identifying the critical risks posed to the proposed development areas, namely the Queenstown Village (QV) Area. Specific observations and comments were made in respect of the Alluvial fan hazards and flooding of the Kawarau river.

On 15/16 December 2020 a mediation hearing heard from the Otago Regional Council on potential concerns relating to natural hazard risk. At the hearing ORC raised the potential for large landslide dams to potentially block the Kawarau river and flood the valley back to Lake Wakatipu. ORC requested clarification on the potential impact of such an event.

Landslide dam – Kawarau River

In January 2021 ORC provided WSP with two reports relating to work completed by ORC in assessing the large landslide potential that exists above the Chard Farm area of the upper reaches of the Kawarau River valley.

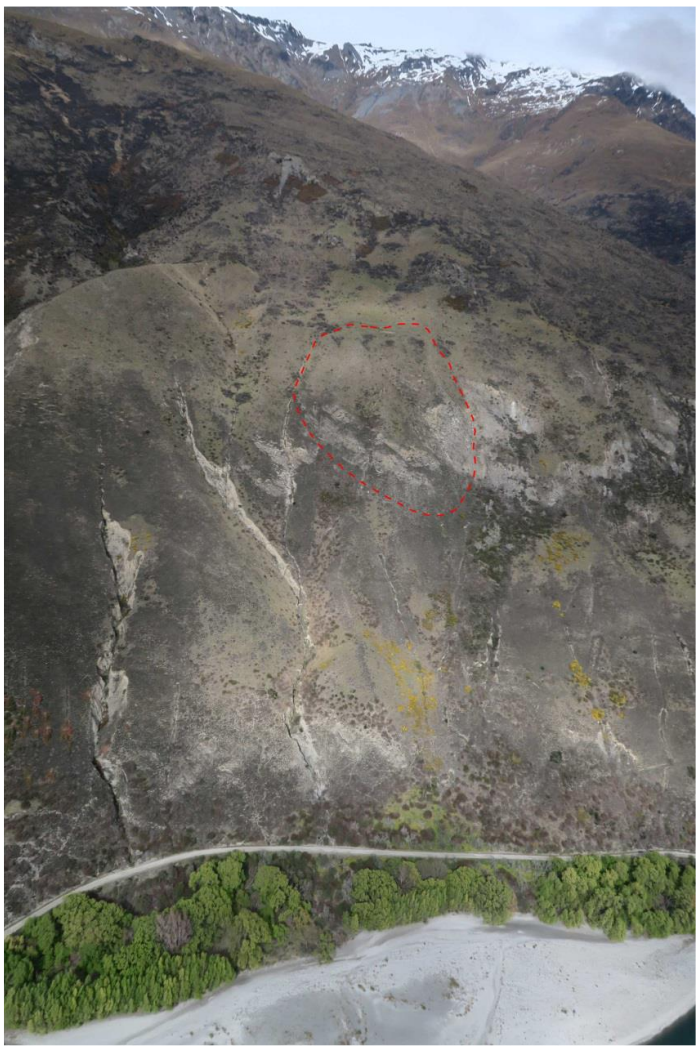
The first compiled in 1996 relates to an ORC commissioned report on the likely occurrence of a landslide dam occurring in either the Shotover or the Kawarau river valley.

The report concluded that extensive schist derived landslides were present on the slopes flanking the upper reaches of the Kawarau and lower reaches of the Shotover River and that the slides displayed varying degrees of activity.

The potential for a landslide dam to occur could however be realised at various locations but that the occurrence was far greater downstream from the Arrow River confluence with the Kawarau rather than in the upper reaches and that this was more likely associated with rockfall induced dams rather than large landslide. The probability of a large landslide dam occurring was considered much lower.

The second report was produced in October 2016 by GNS following area wide reconnaissance by ORC staff assessing large landslides in the Queenstown region. Review of lidar data indicated the presence of a large landslide in the Chard Farm area on the northern slopes of Ben Cruachen. The landslide feature was referred to as the Chard Farm Landslide.

A photo of the slide body (captured by GNS) is presented below:



Oblique aerial view of the landslide area (red dashed line), looking south, with Chard Road and the Kawarau River bed in the foreground. (Photo: S Cox/GNS Science).

Assessment of the slide feature determined that that body of the slide was circa 200m wide by as much as 200m long with a maximum volume of 1.9M m^3 and that it was a translational slide falling on shallow dipping schistosity.

Assessment by GNS on the movement history of the slide inferred that movement most likely occurred some 25+ years ago with some possible movement having occurred within the last 10 years. Movement may be ongoing or be associated with seismic / heavy rainfall events but extents of movement are uncertain.

GNS prepared some simplistic analysis on potential run out impacts of a major slide event across the Kawarau river and in mobilising the full body of the slide and determined that there was a potential, under extreme conditions, for a dam to form that could impact and at worst impede the Kawarau river and Lake Wakatipu.

The conclusion of the 2016 GNS assessment was that the slide was “recently active” and could still be “active” although insufficient work had been completed to determine rates of movement or likely triggers for further movement.

Neither GNS or ORC have completed any further work on the assessment or investigation of the Chard Farm slide since.

Kawarau River – Dam Scenario

Further to the receipt of the reports and following further assessment of the proposed development areas as part of the Queenstown Park submission we have completed some limited projections of potential flood levels assuming part/full dam scenarios of the Kawarau to determine any plausible impacts.

As part of our assessment we have considered the mean lake level for lake Wakatipu and adopted the Otago 2016 Lidar data which covers the subject site.

Our assessment shows that in respect of large landslides the potential impact on the river could be large but that the potential river level rise and impact on the development areas would be minimal (if any).

It is also considered likely that should a landslide dam occur, that could raise the river levels sufficiently high to impact on the shotover delta and Queenstown then a significant emergency response would need to be instigated to commence excavation and downcutting of the slip/dam and release the Kawarau.

Our assessment of freeboard levels and river levels suggest that the current development proposals mostly sit above the 320m asl level which also coincides with the considered dam crest height of a full dam scenario (Thompson 1996, GNS 2016). It should also be noted that our estimate of full flow conditions indicates that the river would take over two weeks to reach the 320m asl level however this level far exceeds the nominal lake level of Lake Wakatipu of 310m asl.

On this basis and given the enclosed plans and projections of conceived flood levels the impact of a landslide dam on the proposed developments would most likely be negligible.

Considerable river rise in the Kawarau would also impact on the Shotover River and more importantly Queenstown town centre (310 to 320m asl) prior to impacting the development footprints currently proposed.

On this basis the recently supplied information from ORC has supported the initial assessment of natural hazards compiled by Opus in 2015 and has provided further information in terms of the potential for the formation of a landslide dam scenario in the Kawarau river.

Our assessment of the potential impact of such a slide at the identified location within the Kawarau suggest that a significant event would need to occur to trigger the event and mobilise a full slide capable of creating a dam with a crest level above 310m asl.

Current assessments indicate that this has a low probability of occurrence and that much more detailed assessments of slide rates, flood models and lake level rise assessment would be required to fully ascertain the impact on Queenstown, the Shotover delta and the proposed development site.

In addition, it is considered likely that a lesser slide event would not necessarily dam the river but may impede its flow. This scenario would not impact the proposed development footprints.

Debris Flow – Flood levels

In addition to the assessment of a potential dam scenario in the Kawarau river we have at the request of the ORC assessed the development levels in relation to potential flood levels along the Rastus Burn and Owen Creek.

The Rastus Burn and Owen creek have both been identified as having a moderate or high risk of future debris flow and flood following heavy rainfall events or landslide events upstream of the sites. ORC expressed a concern relating to the development levels at the head of the alluvial fans and in relation to the existing stream channels during a high flow event.

As with previous assessments of this risk the development layouts have adopted a precautionary stance and have opted for avoidance rather than mitigation through design and development of flood control measures and debris flow mitigation measures. This avoidance option has taken consideration of potential flood levels and debris flow events and avoided potential flow channels and development on lower topographical levels.

In order to assist with the assessment of risk we have taken the development footprints proposed in the submission and overlaid the 2016 Lidar detail in order to compile cross sections through the Rastus Burn and Owen Creek to demonstrate the level variations and separations between the stream levels and the building footprint levels.

The enclosed cross sections typically indicate that the development areas vary from between 5m and 10m above the typical stream levels along the Rastus Burn and Owen Creek.

On this basis the development areas around the Rastus Burn and Owen Creek are considered to be at low risk from stream debris flows and storm flood events. In addition to the avoidance the proposed development will be designed such that surface water flows and storm water will be managed in order to mitigate any localised surface flooding that may occur. This aspect is however considered part of the detailed design and beyond the scope of this phase of works. Further modelling of flows and flood events could be undertaken at this stage of the development design if required.

We trust the enclosed and updated information/assessment of the potential Kawarau river dam scenario and stream bed flooding is sufficient to alleviate any further concerns that have been raised with respect to natural hazard risk at this site. However, if more detailed analysis is required then please do not hesitate to contact the undersigned.

Regards

Robert Bond
Work Group Manager Geotechnical and Environmental