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Lake Dunstan Trail Project - Geotechnical Review

Dear Sir

Further to your request we have completed a review of the provided reports, drawings and submissions relating to the geotechnical risks associated with a proposed cycle trail along Lake Dunstan and are pleased to present our observations, comments and recommendations below.

Background

WSP-Opus were instructed by CODC to complete a preliminary review of a geotechnical investigation undertaken by Geoconsulting Ltd of Queenstown and related public submissions, which were received as part of a resource consent application for the construction of a cycle trail between Bannockburn Bridge and the Clyde Dam.

The proposed cycle trail traverses the true right bank of Lake Dunstan along the Kawarau Arm and Cromwell Gorge. The proposed route of the trail crosses several well known landslip areas as well as passing through, below and over several potential rockfall sites and steep sided gulleys.

As part of the public notification process notable submissions were made regarding the perceived underestimation of Geotechnical risks associated with the construction and use of the trail.

On this basis CODC requested WSP-Opus review the Geotechnical report and the received submissions and advise council on the reports suitability and also provide council with a list of recommended conditions that may be pertinent to address any identified geotechnical risks.

It should be noted that this review has been undertaken without a site inspection. A joint inspection with CODC may be prudent in order to fully address some aspects of the geotechnical risks identified and in determining applicable consent conditions.

Geoconsulting Ltd Geotechnical Report

A Geotechnical Assessment report for the proposed Lake Dunstan cycle trail was produced by Geoconsulting Ltd in February 2018.

The report identifies a number of geotechnical hazards along the proposed route but are mainly associated with areas of potentially unstable ground, known landslides and areas of potential rockfall.

In addition, the report summarises the general geology of the route and provides generalised observations regarding slope angles.

In terms of natural hazards the report identifies the main hazards to be:

- 1) Landslides
- 2) Rockfall

Known and monitored Landslides are noted to be old features with no visible signs of activity. The report also notes that Contact Energy who monitor the slides have reported that the slides are mostly considered dormant with only minor creep to have occurred since lake filling.

The report notes that in terms of rockfall there is evidence along the route for rockfall and rockslides as well as recent collapses of rock bluff features.

The Geoconsulting report then comments on geotechnical considerations with trail construction and notes that existing tracks formed through cut and fill appear to be performing well, albeit with some areas of rockfall and minor slope failures on to the tracks.

In terms of construction of the trail the report promotes the use of cut and fill (side casting) together with minor retaining structures but does note that fill slopes are likely to be of marginal stability.

The report notes that the majority of the main landslide sites would be avoided or where the track cuts through them then the impact on the overall stability of the slide would be a "nil effect".

Overall the report concludes that the construction of a cycle trail is possible but that the bridge sites would require further investigation to ensure feasibility.

The main issue regarding safety to trail users is associated with rockfall although Geoconsulting consider the hazard to be of low to extremely low probability and *"is likely to occur during times of severe rainstorm; a time which trail users would avoid unless caught unawares. Earthquakes can also cause rockfalls but such an event is extremely rare."*

Rock scaling is recommended as a means of reducing rockfall risk prior to construction but Geoconsulting note that this does not eliminate the threat of rockfall or treat larger masses that may develop as a rockslide.

The report then recommends further input from a suitably experienced geoprofessional to bridge design, rockfall management and contractor liaison.

Submissions made on the Application

Mr Royden Thomson

As part of the public notification of the consent a detailed response was received from Mr Royden Thomson.

Mr Thomson is a reputable and well respected local geologist who has experience and knowledge of the geology and associated natural hazards of the Central Otago region.

In his submission, Mr Thomson refers to previous reports dated 19/11/13 and 24/02/18. The Geoconsulting report supplied is dated 24/02/18 however the previous 2013 report has not been supplied.

In Mr Thomson's submission he draws attention to the following key points regarding hazards and risks:

- 1) Insufficient information being supplied on construction practices and proposed structures

- 2) Rockfall hazards and Risks – requesting that more detailed information be supplied in terms of identified risk sites and review of risks posed by rockfall.
- 3) Trail Tenability – identify potential choke points in terms of natural hazard risk that could pose a risk to the viability of the trail.

In support of the submission Mr Thomson presents a report that he prepared in 2016 regarding rockfall issues associated with a known unstable rock bluff (Waenga Bend) located on the trail route.

Mr Thomsons conclusions were that a significant rockfall risk exists on parts of the trail.

Otago Regional Council (ORC)

A formal submission from ORC was not deemed necessary however observations made by ORC natural hazards team raised queries regarding the report conclusions surrounding operational management of the trail in terms of managing rockfall risk – particularly in terms of heavy rainfall events.

ORC question whether there are any proposals to close the trail during heavy rainfall events or proposals to check the trail for rockfall and damage to slopes before opening it.

WSP-OPUS comments and observations

Summary

As noted above no site inspection has been completed as part of this review and reports and submissions referenced as part of the submissions have not been supplied for review, (namely report dated 19/11/13).

In essence, the Geoconsulting report (24/2/18) provides a high level overview of the trail route and identifies a number of natural hazards that could pose a risk to the trail construction, use and maintenance.

The report concludes that a trail is feasible however further geotechnical assessment and investigation is required. We agree with this conclusion.

The report focusses on landslide and rockfall risk but does not consider other natural hazards such as debris flow, inundation, fire or storm events, (thunder plump). We consider that the key risks are associated with rockfall however other natural hazards should be considered and discounted or otherwise.

The report does not identify specific rockfall hazard sites but does identify known large scale monitored landslide sites. In terms of the landslide risk we would concur with Geoconsultings conclusions that the scale of the landslides and the potential for the trail cut to impact on the overall stability is minimal.

In terms of rockfall hazards we are however of the opinion that the information and assessment completed is insufficient in order to formulate either a quantitative or qualitative assessment of risk posed to the construction, use and maintenance of the trail. As such further work is required in order to fully assess the risks posed by rockfall and the need for specific avoidance, mitigation or protection and management of risk sites.

Rockfall Risk Assessment

The Geoconsulting assessment of risk associated with the identified rockfall hazard is not straightforward or clear. Commonly adopted qualitative methodology, in terms of assessing risks posed by rockfall, considers basic aspects of the geology, structural geology, morphology and environment combined with a detailed inspection of the rock bluff and then considers common trigger events (such as earthquake, freeze thaw, rainfall etc) in order to assess the likelihood and extent (severity) of rockfall.

Once a likelihood is determined then the potential consequence of a rockfall can be assessed. This is usually conveyed in terms of impact on construction, use and maintenance. This then enables an evaluation or assessment of the requirements for either avoidance, mitigation or developing a designed protection measure or management process to be undertaken.

Geoconsulting make reference to generalised likelihoods of occurrence in terms of frequency. Reference is made to frequency intervals as "*few and far between*" in the report but no time period is associated with this reference.

Typical risk assessment methodologies may associate the likelihood referred to ("few") as being "unlikely" or "possible". This would equate to a % occurrence of between 1% and approximately 50%, and would typically be demonstrated with evidence of rockfalls having occurred within the last 1-50yrs. This would be commensurate with the evidence of recent rockfall (within the last 5 years) and also historical evidence of rockfall since the lake was formed (at least).

It is considered probable that there are sites (as noted by Mr Thomson) that are likely to fail or produce rockfall within the next 1-50years and as such the probability of rockfall occurring is unlikely to be "rare" or non (ie <1%) and most likely sits within the unlikely to possible range (25-75%).

In addition, in terms of the frequency of rockfall this can vary from bluff to bluff or be assessed as a holistic trail appraisal. One bluff may give rise to frequent small rockfall events (high frequency low impact) whilst others give rise to infrequent but massive failures (low frequency high impact). The report does not provide any commentary as to the number of potential sites or the likely occurrence of rockfall from each nor does it consider the trail in its entirety in terms of rockfall frequency other than "few".

On this basis the level of assessment completed by Geoconsulting in terms of qualifying the likelihood of rockfall from the range of sites that are known to exist along the length of the trail is considered insufficient to enable a true assessment of the hazard.

In terms of Consequence the Geoconsulting report is also not clear. The key receptors (target populations) are not defined other than trail users or "construction" and no reference to population distribution or period of exposure is made.

The consequence of an event is assessed in terms of its severity. Consequence can be assessed in terms of financial impact, user health and safety, business interruption (loss of service), reputation and corporate objectives, with the level of severity being typically described along a scale of insignificant (resolved quickly) to catastrophic (possible fatality or complete loss of the asset).

The Geoconsulting report identifies the potential consequences of rockfall to be "quite severe on the trail formation, particularly where the trail is on a structure (bridge deck) or attached to cliff faces". Whilst in terms of personal injury it notes that the "*possibility of rockfall related injury or even fatality is considered to be very low to extremely low*". The statement is not however substantiated as it is unclear as to whether this relates to a rockfall directly impacting a trail user or a trail user hitting a fallen rock and leaving the trail as a result, leading to injury or death.

Whilst the conclusion that rockfall impacting cyclists is indeed rare it does and can occur and is more likely to occur on cycle trails and tourist tracks rather than state highways or public roads, due mainly to increased and focussed cycle traffic and also typically lower levels of rockfall preventative maintenance. Cycle trails typically being located in gorges, valleys or mountainous areas with multiple rockfall sources but have lower levels of active maintenance or protection.

As such we are unable to agree with Geoconsulting's opinion that the assessment of likelihood and consequence would result in a **low or extremely low risk to trail users**.

In addition, we do not agree with the assessment that trail use would be expected to be limited or non-existent during periods of rain storms, as noted by ORC in their submission regarding summer based flash storms. We also disagree that rockfall trigger events such as earthquakes are rare given the recent occurrence of large scale events across NZ in the last 10 years, the current predictions of a significant Alpine Fault event within the next 30-50yrs and recent earthquake related rockfalls recorded in Central Otago in the last 5 year period.

On this basis we would strongly recommend that a more detailed assessment of the key rockfall source areas be undertaken and consider the likelihood of rockfall and consequence of rockfall in order to fully assess the risks posed to the trail (including structures), trail users and future maintenance requirements as well as identifying key operational management conditions and processes (eg post storm/earthquake inspection).

Our initial assessment would suggest that rockfall risk presents an overall Medium level of risk to the trail and trail users however individual sites along its length could pose a High risk requiring further assessment and possibly intervention/avoidance. It is considered likely that rockfall risk along the length of the trail may sit in an intolerable level of risk and require localised mitigation works to reduce the perceived levels of risk.

In terms of potential mitigation works we agree that rock scaling and localised feature removal can reduce the overall risk of certain sites however it cannot remove in its entirety the risk of future rockfall. In such instances consideration will need to be given to affording other forms of protection (if economically viable) or avoidance.

In addition, consideration will need to be given to the development of a management programme for the proactive annual inspection and maintenance of key sites.

In aspects potential rockfall sites should be investigated and assessed and appropriate means of risk reduction be emplaced accordingly.

Trail Construction

In terms of trail cutting and filling, reference is made to side casting combined with minimal slope cut. This methodology is commonly adopted for cycle trail construction but can result in marginally stable slopes and also undefined settlements of the trail. The methodology is also not suited to steeper slopes where downslope and possibly upslope retaining is then required.

Cut and fill slopes are also subject to rapid erosion during storm rain events or larger landslide movements. On this basis the proposed trail construction should consider drainage as part of the construction detailing and more site specific cut/fill profiling and retaining requirements.

As noted by Geoconsulting the location of bridging structures and choice of foundation solutions will need more site specific assessment and appraisal and review in terms of potential rockfall risk.

This would imply that the proposed embankments and cut slopes will be designed and assessed for stability by a suitably qualified and experienced geo-professional.

Recommendations and Conditions

On the basis of the completed review the following recommendations are considered appropriate:

- 1) It is recommended that Geoconsulting review their risk assessment process and complete a qualitative risk assessment of critical sites in order to develop a true appraisal of rockfall risk to the trail construction (including structures), trail users, trail maintenance and operations to be established.
- 2) It is recommended that more detailed inspections and assessments of identified critical sites be undertaken to enable future maintenance and operations requirements to be better evaluated.
- 3) It is recommended that detailed site inspection/investigations are completed at the locations of proposed critical structures in order to ensure their feasibility and design.
- 4) It is recommended that the trail construction plans are compiled and reviewed in terms of potential cut/fill slope profiles and the need for retaining structures. Specific site slope stability analysis may be required to demonstrate a minimum level of acceptable stability exists.
- 5) Trail construction should account for trail surface water drainage and ensure that surface ponding does not occur.
- 6) That all proposed retaining structures and embankments or slope cuttings are assessed by a suitably qualified and experienced geo-professional for both temporary and long term stability.

We trust the above provides sufficient information for your present requirements.

We would be pleased to support Council with any further submissions if deemed necessary.

Regards

A handwritten signature in blue ink, appearing to read 'Rob Bond', is positioned above the typed name and title.

Rob Bond CPENG (Geotechnical)
Principal Geotechnical Engineer
Work Group Manager Geotechnical and Environmental