

Zwicky Road Landslide Site Assessment, Kaslo, BC, 18 April 2017

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April 20, 2017

On 18 April 2017, from about 1200 to 1500, Sarah Crookshanks (MFLNRO) and Peter Jordan (SNT Geotechnical Ltd.) conducted an inspection of the above landslide, accompanied by Brad Panton (MOTI), Hugh Eberle (MOTI), Nora Hannon (RDCK), and Doug Yee (Kaslo Fire Dept.). Prior to the inspection on the ground, Sarah Crookshanks and Nora Hannon conducted a helicopter reconnaissance of the landslide area to obtain an overall perspective of the area. The following is a summary of our field observations, and our conclusions regarding the hazards and risks presented by the landslide.

Based on observations by local residents of loud noises from the slope above their homes, the landslide occurred on Monday April 17, between about 0800 and 2200. According to data from the nearby Powder Creek fire weather station, the weather that day was cool with no significant rainfall. The weather during the previous month had been slightly cooler than normal, with rainfall well above normal.

On our inspection, we walked around the perimeter of the actively failing area. There was some continued movement of the landslide during our inspection, so we did not venture onto the failure surface or debris.

The landslide occurred in the lower part of a south-east facing slope between about 840 and 900 m elevation (see maps in Figures 1 and 2). It consists of two adjacent active failures, the left one (northeastern) being considerably larger. The two failures are separated by a spine of standing trees. There are several dropped blocks near the headscarp. Several tension cracks occur to the right (southwest) and upslope from the failures. The approximate dimensions of the active failure area are about 100 m (slope distance) long by about 75 m wide. The depth of failure was not determined, but is assumed to be about 2 to 4 m. The volume of the material involved in the failures is estimated, very approximately, at about 10,000 to 20,000 cubic metres. The northernmost point of the active slide area is located at approximately UTM Zone 11 5529317 N 504756 E. See photos of the landslide in Figures 3 through 7.

The slope in the failure area is somewhat irregular, with several steeper and gentler sites, and several indistinct ridges and hollows. The average slope is about 60 to 70%. The toe of the failure area is about 300 m (horizontal distance) above Zwicky Road, with an average slope of about 30%. Above the highest observed cracks is a gentler indistinct bench, with slopes of about 30% or less.

Subsurface seepage was emerging from the failure surface at several locations. No surface flow of water was observed in the vicinity of the landslide area, except for a small stream of muddy water flowing from the bottom of the landslide debris down the slope for several hundred metres.

The material involved in the landslide appears to be mainly colluvium from ancient landslide deposits. This includes fine-textured, slightly cohesive, soil which is probably of glacial till origin, and varying amounts of angular coarse fragments up to several metres in size. The coarse fragments include a variety of metasedimentary rocks, typical of the local bedrock geology. It appears that the landslide involves unconsolidated sediments, not bedrock, although we noticed what was possibly exposed bedrock at one location in the failure.

The area surrounding the landslide is covered with mature forest, and no logging has occurred in the immediate vicinity or upslope of the slide. The landslide failure straddles Crown and private land.

Based on our field observations, as well as previous site assessments higher up the mountainside and terrain mapping completed in the 1990s by Kaslo resident Bill Wells, it is our interpretation that the slope on which the present landslide occurred consists of deposits of ancient landslides. It is possible that the entire slope, which is about 1.5 km wide at its base along Zwicky Road, and about 1.5 km long, consists of one or several dormant landslides, probably involving bedrock as well as the overlying glacial till. The top of the possible landslide feature is at an elevation of about 1300 to 1500 m elevation, where some prominent escarpments can be seen along the ridge crest extending south from Mt Buchanan. In the area we inspected on April 18, no signs of recent slope movement (other than the present landslide) were observed, and several of the cracks showed a mature soil profile, indicating that little or no landslide activity has occurred for at least several centuries, and possibly not for thousands of years.

Summary of recent weather data for Kaslo

The spring of 2017 has so far been unusually wet in the West Kootenays. The following summary uses daily weather data from the Kaslo Environment Canada station for March (data presently available to April 2) and the Powder Creek fire weather station for April. Up to March 9, most precipitation fell as snow, and then after March 9 as rain.

Total precipitation:	March	189 mm	2.6 times normal
	April 1 -15	46 mm	1.5 times normal

The depth of the snow on the ground as of March 1 in Kaslo was 52 cm, which is 3 times the normal value. If the snow density is assumed to be 0.3, then the runoff or infiltration from snowmelt was approximately 150 mm, compared with the normal of about 50 mm.

Therefore, the total water input to the soil and streams over the past 5 weeks since snowmelt began, up to the day of the landslide, was roughly 390 mm, or 2.5 times normal.

It should be noted that the weather data are for the elevation of Kaslo, about 600 m. The elevation at the top of the landslide is about 900 m and the groundwater feeding the landslide area may have originated as high as 1500 m on the slope above. At these higher elevations, both the rainfall and snowpack may have been slightly higher compared to the values at Kaslo. However, the comparison of the spring 2017 rainfall and snowpack with the normal data is probably similar for the entire elevation range of the hillslope. As an interesting comparison, the total rainfall in June 2012, a record rainfall month which preceded the Johnson's Landing landslide, was 206 mm, 2.7 times normal.

Hazard and risk implications

The present landslide is in a location which is probably the site of ancient, much larger, landslide deposits. It probably occurred as a result of higher-than-normal groundwater levels, from snowmelt and unusually high rainfall in the previous month. The failures appear to be still actively moving. Based on the cracks we saw in the vicinity, it is possible that the active failure area could grow to perhaps twice its present extent. Whether this occurs will likely depend on the amount of rain in the coming weeks. There is still snow cover on the slope above about 1200 m. Once the snowmelt has finished, the slope should begin to dry out. However, based on the possibly deep landslide deposits on the slope, and the lack of surface drainage channels, it is possible that it may take several months for groundwater levels to significantly drop.

It appears from the reported long duration of the landslide activity on 18 April that it moved relatively slowly (possibly several metres per hour). However there is a possibility that if the failure continues to grow, that part of it could move more rapidly. If this were to occur, then it is possible that some debris could reach dwellings along Zwicky Road, Victoria Ave, and Charles St below the present landslide.

Conclusions and recommendations

Based on the reported landslide event of 17 April 2017, and our field inspection of 18 April 2017, we believe that the likelihood of continued landslide activity in the next week to several weeks (the hazard) is high. The likelihood that landslide debris would reach dwellings or other infrastructure at the base of the slope is low, but it is not impossible. The partial risk (which is the combination of these two factors) is therefore considered to be moderate. The values at risk which could possibly be affected include six houses, various farm buildings and other structures, the Village of Kaslo water treatment facility, and several streets including Zwicky Road.

We recommend that monitoring of the landslide continue for at least the next one to two weeks, or until the snowmelt and spring runoff period on this slope is over, and that the risk be re-evaluated during this time and as new information becomes available. This monitoring will be

composed of periodic inspections on the ground by one of the undersigned. A helicopter survey will be requested if we feel it is warranted.

It would be worthwhile to obtain LiDAR imagery for the Kaslo area. LiDAR mapping would help qualified terrain specialists to gain a better overall perspective of both the ancient and modern landslide features on the southeast slope of Mount Buchanan.

(Original Signed and Sealed by:)

Sarah Crookshanks, MFLNRO

Peter Jordan, SNT Geotechnical Ltd.

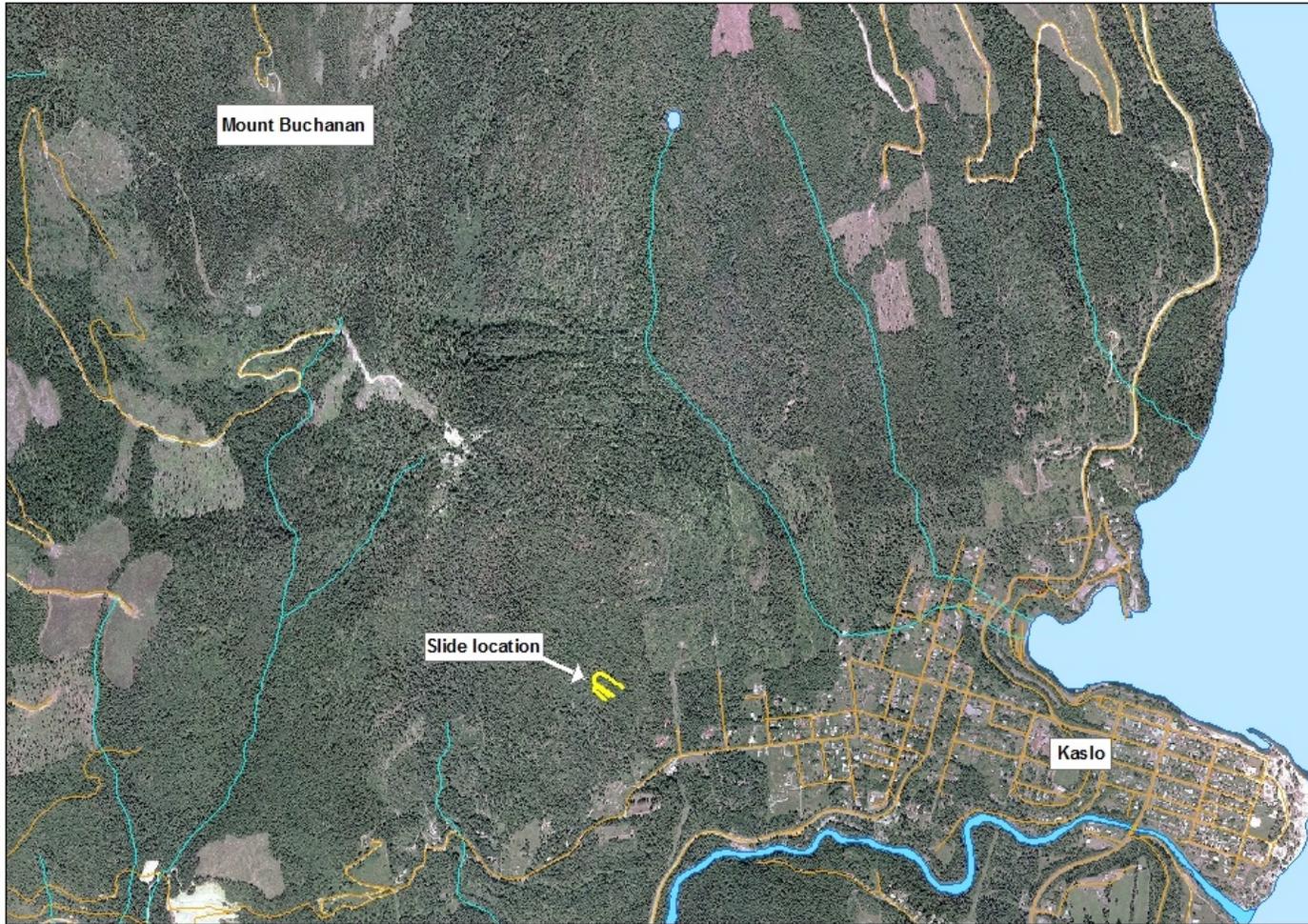


Figure 1. Location of the landslide (in yellow) in relation to Kaslo and Mount Buchanan.

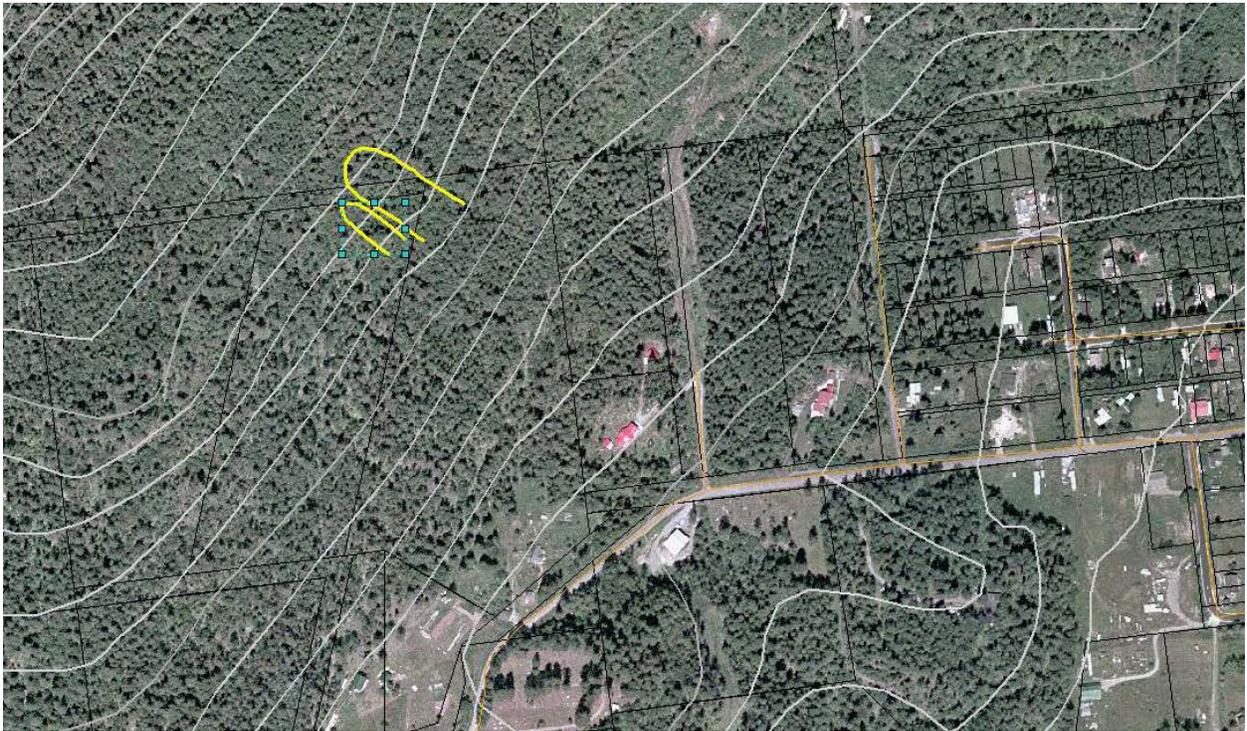


Figure 2. Location of the landslide (in yellow) above Zwicky Road in Kaslo. Contour lines are at 20 m intervals. The headscarp of the northeast slide is at approximately 890 m.



Figure 3. View of the landslide from the helicopter.



Figure 4. View across the slide from the northeast edge near the headscarp.



Figure 5. View across the slide from the southwestern edge.



Figure 6. View down the slide from above the headscarp (photo credit: Brad Pantan).



Figure 7. View across the slide path from the bottom of the northeastern edge.

Zwicky Road Landslide Site Inspection

By Sarah Crookshanks, Research Geomorphologist
Ministry of Forests, Lands, and Natural Resource Operations
and Peter Jordan, Research Geomorphologist

April 21, 2017 FOLLOW UP BY SARAH CROOKSHANKS

I performed a site visit to the Zwicky Road landslide this morning (April 21 2017) between the hours of 9:15 and 12:45 accompanied by Nora Hannon (RDCK). This email update is an addendum to the report dated April 20, 2017 that reported on the site assessment of April 18, 2017.

We observed recent signs of instability in the area that indicates that the slide is still active. Residents and the people flagging the road have reported periodic noises and crashes from the slide, which confirms these observations. During the site visit we observed/heard minor raveling and sloughing, but no bigger failures occurred during our inspection.

Additional failure(s) at the headscarp of the smaller slide to the southwest have occurred. This movement of material appears to have resulted in a small debris flow (approx. 1.5 m wide, see attached photos) that carried rocks and sediment approximately 90 m down slope. The toe of the debris flow deposits is approximately 200 m above the residences and 300 m above Zwicky Road. Some of the standing trees that separated the two slides have also fallen. The larger slide to the northeast does not appear to have changed substantially, other than a few individual trees falling down at the edge of the failure.

We observed that many of the tension cracks upslope and to the west of the failures have noticeably increased in size. We also noticed several areas where new tension cracks have formed. We flagged a dozen tension crack locations, and re-occurring photographs and measurements over the next week will allow us to determine if they are increasing in size.

The Powder Creek fire weather station across Kootenay Lake reported 5 mm of precipitation on Thursday April 20.

The people flagging the road have agreed to keep a log of any slide activity they hear, including time and duration. These observations will help determine the frequency of slide activity.

April 24, 2017 REPORT BY SARAH CROOKSHANKS

I performed a site visit to the Zwicky Road landslide this afternoon from 11:50 to 13:50 accompanied by Nora Hannon (RDCK). This email update is an addendum to my email dated April 21, 2017 and to the report dated April 20, 2017.

We observed signs of ongoing instability that indicates that at least a portion of the slide is still active. Additional failure(s) at the headscarp of the smaller slide to the southwest have occurred since the last site visit three days ago. One such failure appears to have resulted in one or several minor debris flows that have transported additional material (boulders and sediment) further down the slope. The toe of these deposits is now 150 m above several houses and 250 m above the road. One resident reported hearing large boulders crashing during the day on Sunday. Some more of the standing trees that separated the two slides near the headscarps have also fallen. During the site visit we observed and heard minor sloughing of large boulders and debris. The debris within the failure zone is highly saturated, and a significant amount of seepage is emerging from the failure surface and the toe of the slide. Approximately 600 cubic metres of unstable material is currently situated above the headscarp of the southwest slide.

The larger failure to the northeast appears to have stabilized, however, as it does not appear to have changed substantially since our initial site visit last Tuesday. The debris is not saturated and no minor sloughing was observed. The water exiting the toe of the slide is clear.

The tension cracks to the west of the failure that were flagged and photographed on April 21 2017 were re-photographed. No substantial changes to any of these tension cracks were observed.

The people flagging the road reported hearing no slide activity last night or today. I have no changes or additions to the recommendations outlined in the report dated April 20, 2107. The next site visit will likely occur either on Thursday or Friday this week.

April 28, 2017 REPORT BY SARAH CROOKSHANKS

Peter Jordan (SNT Geotechnical Ltd.) and Sarah Crookshanks (MFLNRO) performed a site visit to the Zwicky Road landslide today between the hours of 1000 and 1330 accompanied by Nora Hannon (RDCK). This update is an addendum to Sarah Crookshanks' email dated April 24, 2017 and to the report dated April 20, 2017.

Activity at the landslide headscarp is continuing, but to a lesser extent than a week ago. The landslide has grown slightly in size, but mostly due to the headscarp incorporating the strip of forest between the NE and SW parts of the slide as well as some additional small failures above the headscarp at the southwest end of the failure. There appears to be little chance of the failure enlarging much further upslope or to the SW. Residents reported hearing crashing on Wednesday, but the slide has apparently been fairly quiet for the past 24 hours.

The failures along the headscarp have resulted in the two slides merging at the headscarp. The northeast portion of the slide appears to continue to be fairly stable and it does not appear to have changed substantially since our initial site visit. Seepage emerging from the northeast portion of the slide continues to be clear. The debris on the southwest side of the failure zone is still saturated. During the site visit we did not observe or hear any active instability (sloughing, debris movement etc.). At the base of the landslide, there has been little or no recent advance of the toe of the slide. The activity below the slide has consisted of small debris flows, and discharge of muddy water, involving relatively little slide debris.

The tension cracks to the west of the failure that were flagged and photographed on April 21 2017 were re-photographed. No substantial changes to any of these tension cracks have occurred over the course of the past week.

The rainfall in the last two weeks has been close to normal, in contrast to the much higher than normal rainfall in March and early April. The forecast for the next week indicates that we will have a warmer and drier trend. Therefore it is likely that the unstable area will continue to dry out, which should result in a slowing of landslide movement.

We believe the likelihood of the slide growing substantially in area, or developing a more rapid speed of movement, is low.

We would characterize the overall landslide hazard for the foreseeable future as moderate (some continued local movement is likely, but enlargement or progression downslope is unlikely). The probability of the slide reaching houses along Zwicky Road is low. The partial risk (the combination of these two factors), therefore, would be classified as low.

We recommend that monitoring of the landslide be continued until the spring freshet period is over, or longer if any continued movement is observed. This monitoring can be done by a local, technician-level observer who is properly trained. Observations of the landslide headscarp should be made once or twice a week, or more often if renewed movement is observed.

If substantial landslide activity is heard, then residents consider evacuating the area and should report these observations to either the RDCK or to the provincial Emergency Coordination Centre (1800-663-3456).