**Report on 2019 monitoring of the Johnsons Landing landslide**

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Monitoring of the potentially unstable area above the Johnsons Landing landslide continued in 2019. Stake measurements and site visits were undertaken in May and October with assistance from Murray Watt (MFLNRORD). Reflectors along the headscarp were surveyed in September by Sproulers' Enterprises Limited (SEL). No visible changes to the headscarp area were observed.

**Slope displacement measurements**

Eight measurement sites are located along the crack that bounds the top edge of the potentially unstable area (see Figure 1 for measurement site locations). One of these (Site 1) is a line of 6 metal pins, with the top pin drilled into bedrock above the crack. This site is the most reliable measurement location. The other sites consist of two or three wooden stakes driven into soil above and below the crack. The distance between the stakes is measured manually with a tape measure. Unfortunately, many of these wooden stakes have become damaged or slanted because of rockfall and snowload; therefore, the wooden stake measurements in the past few years have become less accurate or have been destroyed.

Figure 1. Measurement locations that are measured by hand are identified in yellow, and measurement sites surveyed by SEL from a base station are shown in red. The dashed line shows the approximate location of the upper crack that bounds the top edge of the potentially unstable area.

The measurement of the displacement of the upper crack over the past five years shows systematic, progressive movement at the apex of the tension crack (Figure 2) and limited or no movement towards the outer edges. This year limited or no movement was observed at all sites.

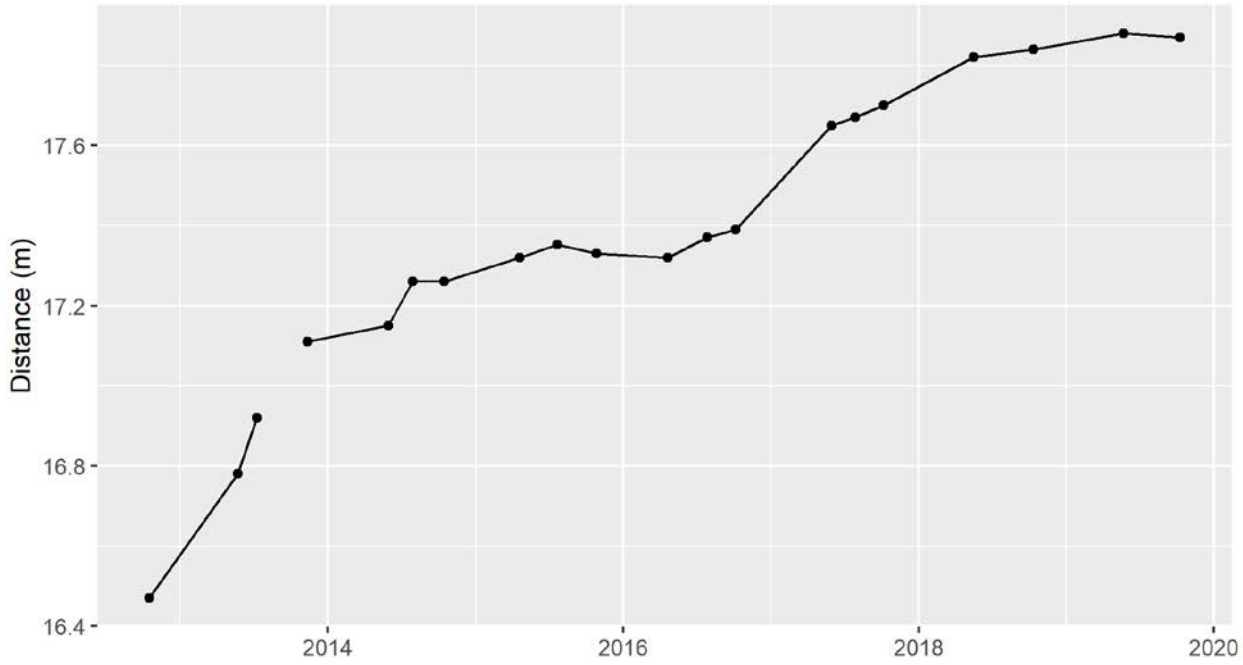


Figure 2. Cumulative downslope movement of the upper crack at Site 1 (see Figure 1 for site location). Downslope movement was measured as the distance between stakes spanning the crack.

## Weather record

Table 1 summarizes April to June rainfall over the past eight years as recorded by the Powder Creek fire weather station. Rainfall was below normal in spring 2019, mainly due to low precipitation in May and June. The snowpack at Upper Gray Creek Pass to the south of Johnsons Landing is also summarized in Table 1. In 2019 the snowpack was only 75% of average on April 1. Weather data is also summarized in Figure 3.

Table 1. Weather and snow data from 2012-2019 near Johnsons Landing.

| **Rainfall at Powder Creek (mm)** | **2012** | **2013** | **2014** | **2015** | **2016** | **2017** | **2018** | **2019** | **Normal at Kaslo** |
|---|---|---|---|---|---|---|---|---|---|
| April | 63 | 49 | 75 | 26 | 18 | 76 | 104 | 62 | 62 |
| May | 44 | 59 | 77 | 25 | 94 | 50 | 45 | 15 | 61 |
| June | 208 | 164 | 48 | 42 | 81 | 45 | 75 | 51 | 77 |
| 3-month sum | 314 | 272 | 200 | 93 | 193 | 171 | 224 | 129 | 200 |
| | | | | | | | | | |
| **Upper Gray Creek Snowpack (% of Normal)** | **2012** | **2013** | **2014** | **2015** | **2016** | **2017** | **2018** | **2019** | **Normal SWE (mm)** |
| **April 1** | 134% | 100% | 113% | 83% | 118% | 109% (est.[1]) | 127% | 75% | 722 |

[1]No data were collected April 1 2017 at the Upper Gray Creek snow course; therefore, snowpack was estimated based on comparison with the March 1 and May 1 values and the Redfish snow pillow.

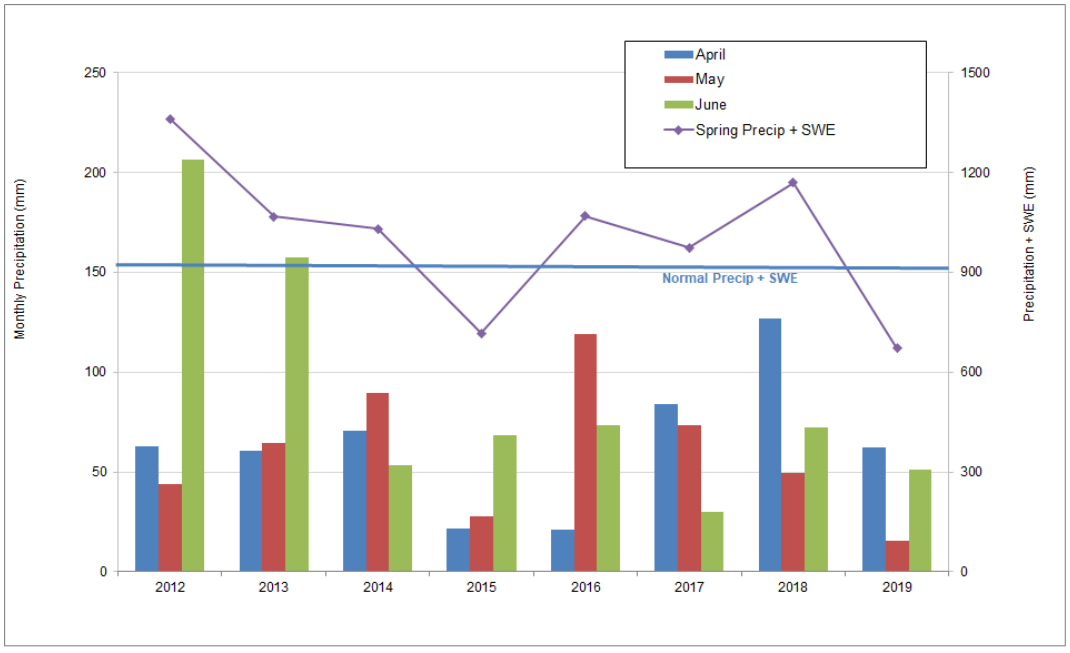


Figure 3. Record of monthly spring precipitation at the Kaslo Environment Canada station 20 km SSW of Johnsons Landing and the spring (April to June) precipitation from the Kaslo station plus the snow water equivalent (SWE) on April 1 at the Upper Gray Creek snow survey site 55 km south of Johnsons Landing.

**Survey of Reflectors at the Headscarp**

A set of reflectors were installed on the rim of the headscarp in 2014. The reflectors have been measured once a year by Sproulers' Enterprises Limited (SEL). See Figure 1 for reflector locations.

The spatial and temporal pattern of movement of the surveyed reflectors along the headscarp rim indicates that there has been some minor (11-18 cm) westerly movement of the headscarp over the past five years. This corresponds to an average annual displacement of approximately 2.2 to 3.5 cm per year, although only minimal westerly movement was detected this year. Less overall movement has been observed at MON10 (the reflector on the dropped block), and no movement (within measurement error) has been observed at MON11, which is located on stable ground outside the landslide source area.

**Conclusions and recommendations**

Given the low spring precipitation and below average snowpack, it is unsurprising that there was little movement observed at Johnsons Landing. I recommend that monitoring continue until a particularly wet spring occurs with no consequent increased displacement or until movement at the headscarp and upper crack slows to near zero for several years despite variable precipitation and snowpack levels.