Budge Road Landslide Jackson
Extensometer installation report 23-27 April 2014 with data to 20 May

Four extensometers were installed across fissures at the head of the Budge Road landslide on the East Gros Ventre Butte, Jackson, Wyoming 23-26 April 2014. Each extensometer consisted of a flexible carbon-fiber rod length-standard anchored down-hill and a dual sensitivity displacement sensor in a steel enclosure fastened up-hill. Where possible the rods were buried within ½" PVC conduit to reduce exposure to thermal variations. Two instruments cross the headscarp (1 &3) and a third(#2) crosses a graben system that forms a lateral spread below the head scarp with 3-5 m of extension at the time of installation. A fourth extensometer monitors two minor fissures above the head scarp. The first three extensometers have a range of 16 feet, the fourth 4 feet.

Figure 1 View north of the toe of the Budge Road slide showing the location of the extensometers at the head scarp. 2000 tons of dirt and gravel were placed on the toe of the slide 23-26 April by engineers of Landslide Technology to increase friction near the base of the slide. The slide has a concave slump surface emerging 10-20 m in front of the old Budge quarry scarp (Figure 2). The tarmac has been thrust and crumpled approximately 12 feet to the south.

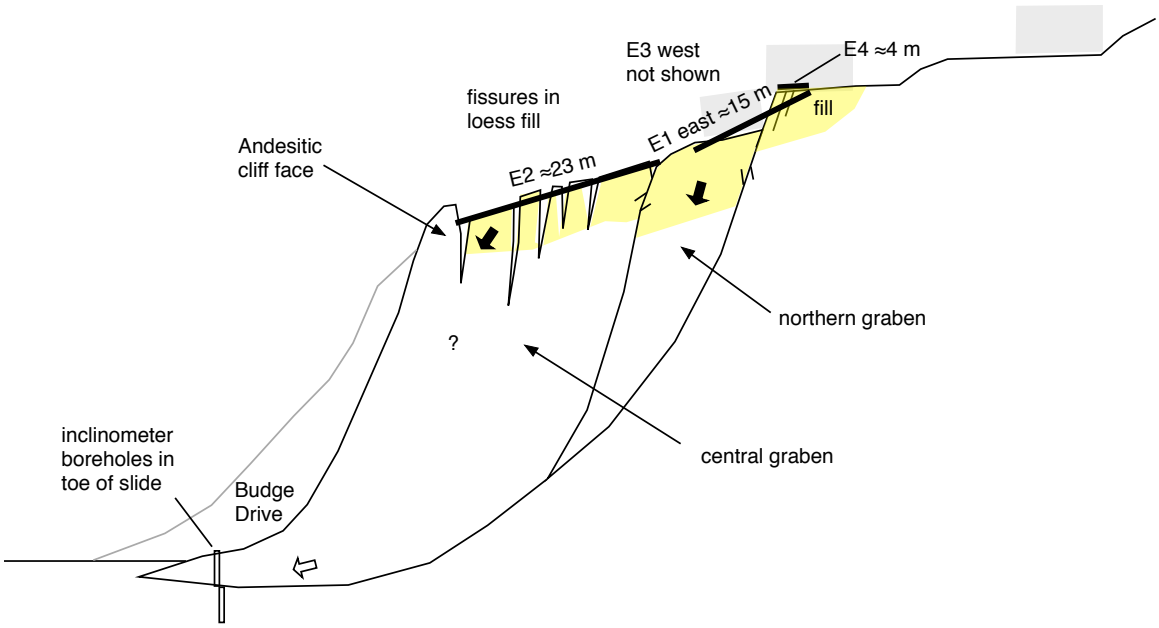

Figure 2 Sketch through the Budge slide showing approximate arrangement of extensometers and inclinometers monitoring slide stability.

Figure 3 Arrangement of extensometers across head scarp fissures. East Gros Ventre Butte, Jackson. The northern slump block which has severed the house has thrust beneath the fissured central graben block immediately to its south monitored by instrument #2 (green trace in Figure 4).

Brief History of slide

During house construction a large amount of fill was placed over the head of the current slump to provide a flat garden area south of the house. At least two inclinometers holes to monitor hill-slope stability were installed that are now severed.

Dec 2013 – crack noted by resident near head-scarp
4 April – significant movement on slump surface noted
9 April 2014 – crack widens, concave slump initiated. 42 homes and 60 residents evacuated.
12 April – water pump at base of slide had been pushed 5 m south on toe of slump
14 April – remedial measures approved ($700k) to load toe of slide
18 April – significant acceleration of slide –house destroyed. Slip 2-3 cm/day after slump.
23 April – Extensometers installed- rate measured initially 7 mm/day
23-25 April - toe of slide loaded with 2000 tons of soil and gravel. Borehole inclinometers installed by Landslide Technology.
26-27 April Head scarp extension slows to 3-5 mm/day
20 May this summary report

Extensometers

The extensometers consist of a stranded stainless- steel wire attached to the end of a rigid, carbon fiber rod. Inside the sensor unit the wire is held in 3 lbs of tension by a constant-tension spring-motor. The wire, when pulled by the rod causes two precision wheels to rotate. One is attached to a continuous-rotation angular Hall-effect transducer to provide a precision of 0.05 mm over a range of 30 cm, and the other to a ten-turn potentiometer that provides an absolute indication of large extension (up to 3 m) should this occur. The two sensors are calibrated individually. An Onset data logger records temperature, the two displacements and battery voltage. The range of the 30 cm continuous-rotation sensor is limited by the constant tension spring motor to 5.5 m. Should further extension be required a 5 m extension link can be inserted between the rod and the extensometer unit.

The distal mount to extensometer E2 which was connected initially to a steel anchor fixed to a steel restraining net, was replaced 2 May with a simple rod anchor resulting in an approximate offset of 66 mm which has been removed from the data.

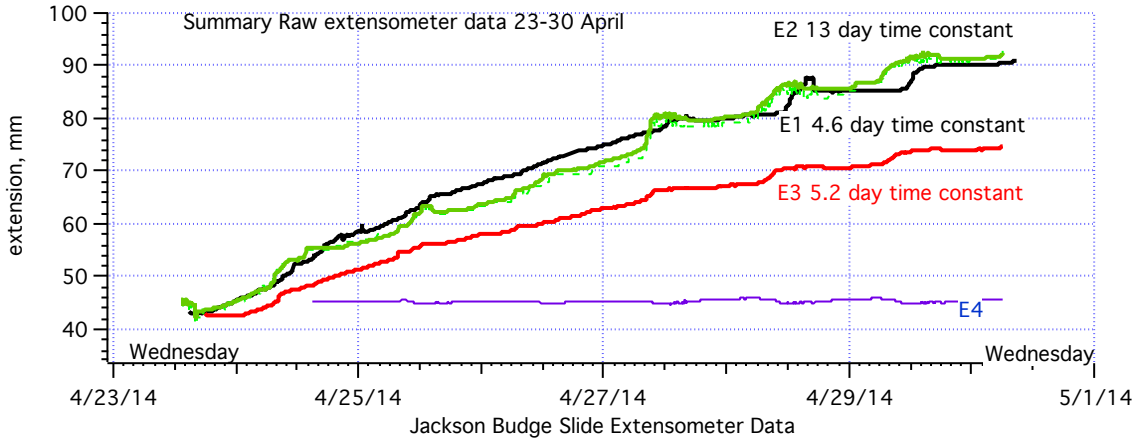

Figure 4 Summary of data acquired in first week of operation. Short period perturbations of the data are caused largely be temperature changes in the air to which the graphite rods are exposed. The details at each site are shown in Figure 5. Exponential time constants fit to longer spans of data average at 6-7 days for each instrument (Figure 6).

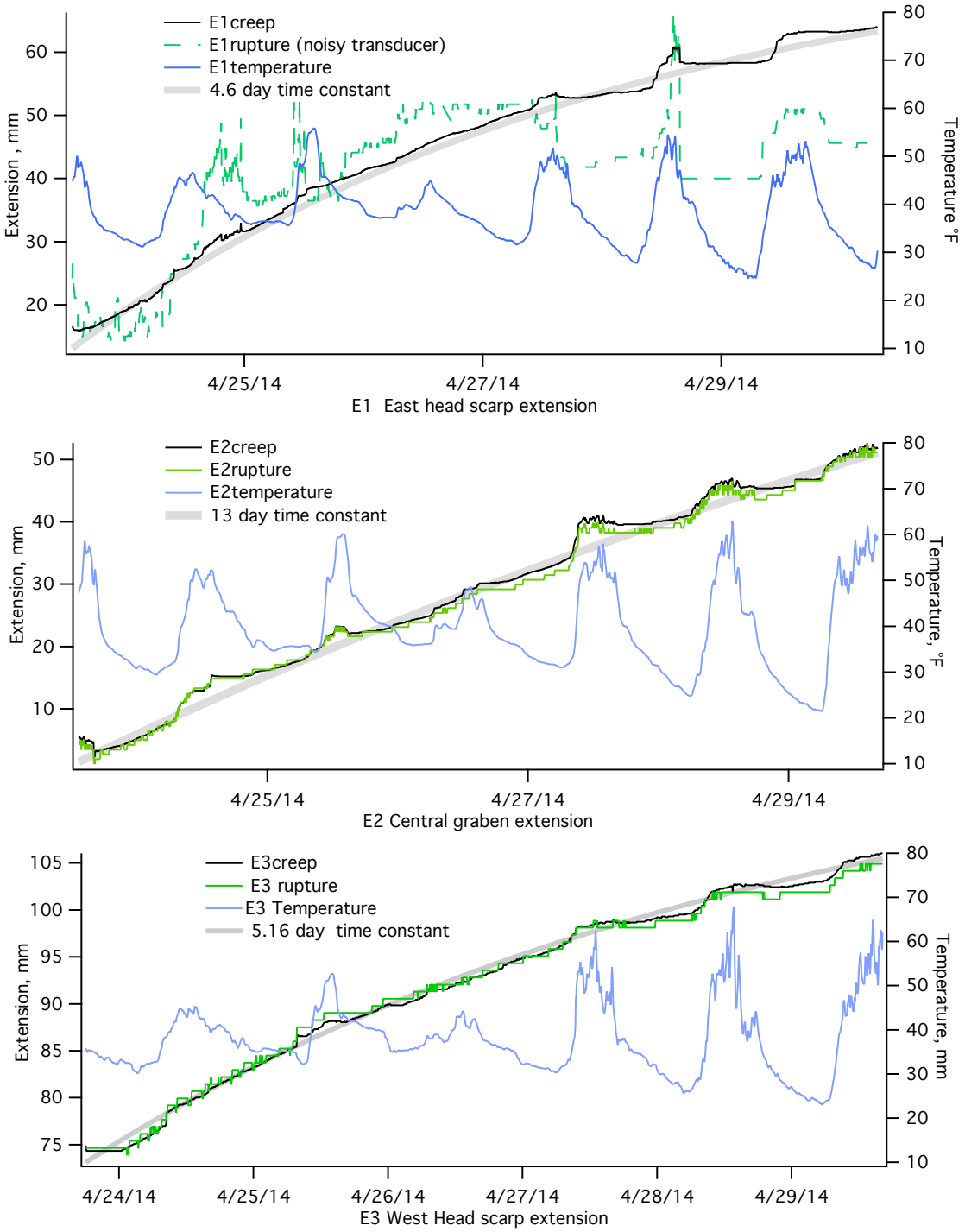

Figure 5 Data recorded 23-30 April 2014. Extensometer #1 across the east head-scarp was the first to be installed (black) and is currently the only one to be telemetered. Head scarp extension was initially 10-14 mm/day. Noise on the traces is caused by temperature and by people walking on the buried rods. The thick grey trace in each plot illustrates least-squares fit to the temperature compensated data (see Figure 6).

Data Processing and predictions

Because the graphite rods lie partly above the surface they are sensitive to air temperature variations. Using the temperature measured in the sensor boxes as a proxy for air temperature a regression between detrended extension and temperature for extensometer E1 yielded coefficient of 0.09 mm/°C for E1, 1.5 mm/°C for E2 and 0.55mm/°C for E3.

Synthetic exponential fits to these temperature-corrected data 23 April-20 May are used to forecast trends anticipated on these data **to 20 June** using double-exponential fits.

The toe of the slide is expected to slip a further inch and the two headscarp measurements are expected to open and slump a further 1-1.5 inches, consistent with a slowing in slump rotation measured by the toe inclinometer.

By summing E1 and E2 extensometer data it is possible to estimate that the front edge of the slide will separate from the hill by a further 4 inches. The hillside above the headscarp is apparently stable near where we are measuring it (West of the damaged house).

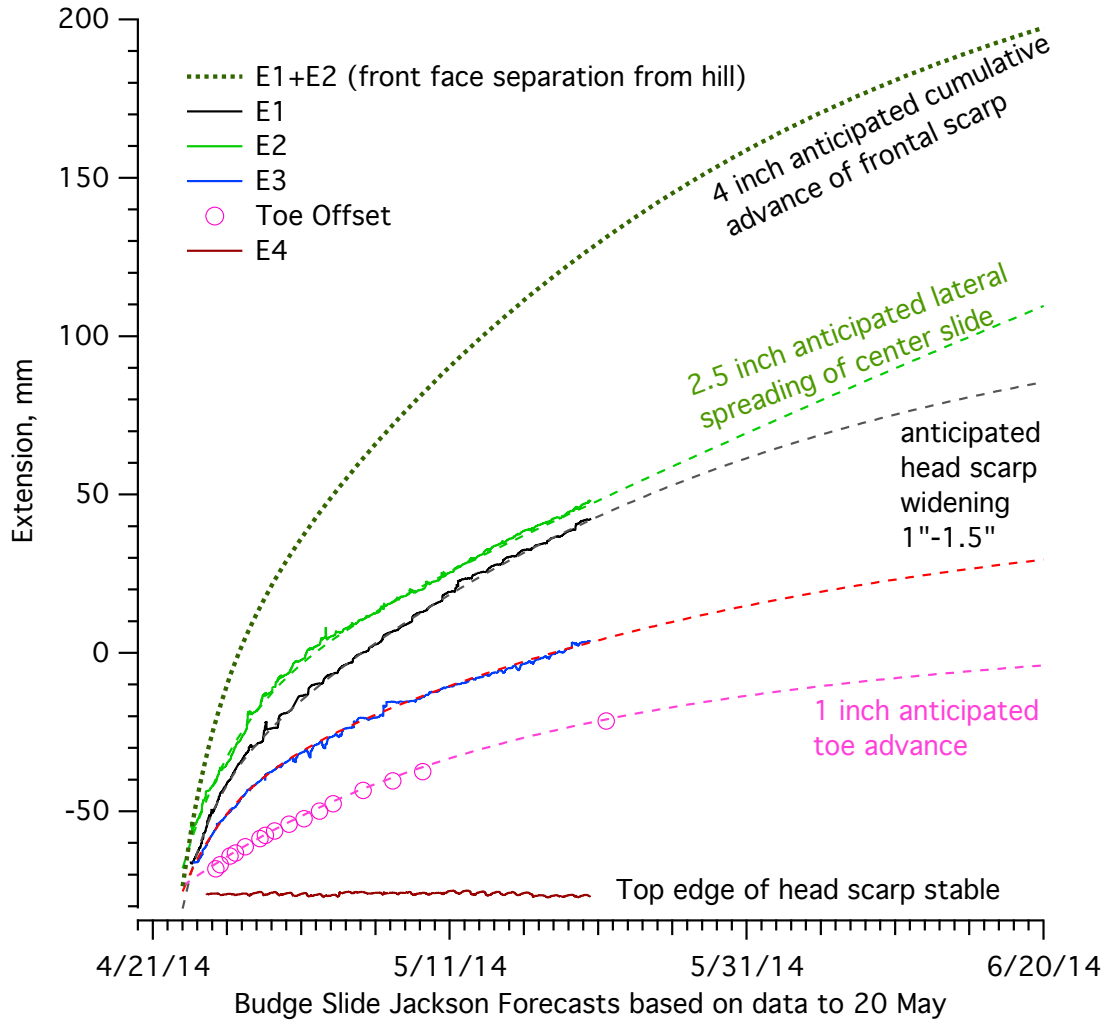

Figure 7 Double exponential fits to a month of temperature compensated extensometer and inclinometer data are used to forecast future slip to June 20. The anticipated advance of the front face of the slide above the Walgreen building is roughly 1 inch per week, a halving of its average rate for the previous month. This represents a steepening of the front face at a rate of ≈¾"/week.