Alberta Transportation
Site S26 – Elkwater Slides
Highway 41:03, km 35.169, southeast of Elkwater
Site Data – Summary Binder

Section A
File Review

1 SITE LOCATION

The S26 – Elkwater Slides site (the site) is located on highway 41:03 (H41:03) at km 35.169, which is approximately 3 km southeast of the Hamlet of Elkwater, Alberta. The site is located at:

- 49°38.386’ N, 110°15.377’ W (NAD 83),
- Legal land description (LSD) NE 7-8-2 W4,
- NTS Mapsheet 72E09.

2 SITE DESCRIPTION

At the site, H41:03 is a paved two-lane highway orientated in the northwest-southeast direction. The highway is constructed on the east valley slope of an unnamed creek. Landslide movement has damaged two segments of the highway – Area A which is an approximately 600 m long section of the highway and Area B which is an approximately 250 m long section of the highway, and is about 100 m north of Area A. Numerous asphalt patches have been placed on the highway in both areas, resulting in an asphalt thickness of up to approximately 1.5 m. A shear pile wall was constructed in 2012 at Area B after a section of the highway embankment failed. The embankment failures appear to be caused by shallow localized movements.

3 CHRONOLOGICAL BACKGROUND

The table below provides a brief chronological background of the site. AMEC Infrastructure and Transportation’s (AMEC) 2007 report indicates AT investigated and assessed landslides at the site between the early 1970s and late 1980s, and monitored instrumentation and possibly installed some trench drains. Although KCB was unable to locate documentation of the trench drain construction or installation. The site was first inspected as a call-out report in March 2007, and annual site inspections began in June 2007. The site was inspected annually from 2007 to 2013, and again in 2016. KCB was not provided documentation of a site inspection in 2014 or 2015.

Klohn Crippen Berger Ltd. • Suite 301, 2627 Ellwood Drive SW • Edmonton AB T6X 0P7 • CANADA
780.444.0706 t • 780.481.2431 f • www.klohn.com

Table 1 Chronological Background of Site S15 – Crowsnest Rockfall

Date	Description
March 2007	AMEC inspected the site as a call-out request by Alberta Infrastructure and Transportation (AT). A landslide had damaged two segments of the highway. There was visible landslide terrain upslope and downslope of the highway and widespread signs of damage along two segments of H41:03. AMEC noted that many patches had previously been placed near the site, however, extensive bumps, dips, and cracking of the road surface remained. AMEC indicated the site can continue to be treated as a maintenance issue, or horizontal drains can be installed to attempt to reduce the rate and magnitude of landslide movement. There appeared to be ongoing groundwater seepage south of the site.
June 2007	An annual site inspection was completed by AMEC personnel. There were no significant changes from the March 2007 call-out inspection. New cracks and a drop of a semi-circular portion of the southbound lane was noted. AMEC also noted ongoing groundwater seepage from the cut slope above the road at the south end of the site. AMEC recommended drilling boreholes and installing piezometers and Slope Inclinometers (SIs) on both sides of the road.
June 2008	An annual site inspection was completed by AMEC and AT personnel. Around Area A, Visible landslide terrain was observed upslope and downslope of the highway, widespread signs of damage to the highway, numerous patches and overlays. A geotechnical investigation including, installing five standpipe piezometers, three SIs, one Measurand ShapeAccelArray (SAA) cable, and one rainfall gauge in Area A was completed. During the inspection, Area B had noted settlement in the southbound lane, tension cracking and damage to the road surface from landslide movement, and multiple thick overlays resulting in a reduced height of the guardrail. The headscarp of the landslide was noted to be near the centerline in Area B. Groundwater from a spring south of Area B was noted to flow north in the ditch on the upslope (east) side of Area B and percolate into the highway subgrade.
June 2009	An annual site inspection was completed by AMEC and AT personnel. The extent of damage to Area A had not changed significantly since the 2008 site inspection. The SIs installed in Area A had not recorded any slope movement, and the ditch south of Area was noted to be wet. There was localized slumping around the groundwater spring south of Area B identified in the 2008. There was additional settlement and possible retrogression of the arc shaped tension crack along an approximately 45 m long segment of the southbound lane in Area B. A small crack, that had not previously been noted, was observed in the northbound lane, which indicated possible retrogression of the instability into the northbound lane. SIs in Area B detected shallow movement within the fill. AMEC recommended adding a culvert to intercept the ground water in flowing north in the ditch and percolating into the highway subgrade.
May 2010	AT and the maintenance contractor noted that cracking at Area B had worsened since April 2010. AMEC personnel inspected the site in May. The cracking was noted to be in an arc-shape approximately 25 m long, and with a vertical displacement of about 100 mm. At the inspection, AMEC found the area had failed with a 2 to 3 m high headscarp. High groundwater following a period of high precipitation and snowmelt was thought to be the trigger of the failure. A detour lane was constructed in Area B. The maintenance contractor excavated the failed area and launched soil nails were installed. The slide mass continued to move after the repair was complete, expanding 40 m south.
June 2010	An annual site inspection was completed by AMEC and AT personnel. When the SIs were read in early June, no movement was detected. Numerous slumps in the roadway, lower embankment slope and backslope; and arc-shaped cracks in the southbound lane with vertical displacements up to 100 mm were noted in Area A. The ditch south of Area A had standing water. Several recent asphalt patches were noted within Area A. A ditch block was constructed near a 900 mm diameter culvert south of the instruments in Area A. The ditch block directs water to the culvert. An erosion channel was noted to be forming at the culvert outlet.

Date	Description
	The repairs at Area B were noted to be holding up well and the slide mass was draining freely, with no ponding water observed. The detour lane was in good condition.
June 2011	An annual site inspection was completed by AMEC and AT personnel. The ditch upslope of Area A was noted to be wet with ponded water again. Water was flowing through the culvert in this area, and there is ongoing erosion at the culvert outlet. An asphalt overlay had been placed across Area A in Fall 2010 or Spring 2011. Most of the previously observed cracks had not reformed through the new overlay. The slides in the backslope noted in 2010 had not worsened significantly. Slide movement continued, but at lower rates than in 2010. Two of three SIs were obstructed due to excessive deformation, and the third SI had not detected slope movement. The temporary repairs and detour lane constructed at Area B were noted to be in good condition. The headscarp of the May 2010 failure had retrogressed by about 1 m since the previous inspection in June 2010. The SI located a few meters upslope of the existing headscarp was found to be sheared off at a depth of 1.8 m.
June 2012	An annual site inspection was completed by AMEC and AT personnel. The ditch upslope of Area A was noted to be wet with ponded water. Several asphalt overlays had been recently placed at the areas of previously noted cracking. Some minor cracking was noted at the road edge. The backslope above the road showed continued creep movement, which has blocked the ditch at the north end of Area A. Seepage was noted from the backslope at the north end of Area A. In Area B, shear pile repair work was under construction. The shear piles were installed and most of the backfill had been placed.
Fall 2012	The shear pile repair work was completed (AMEC, 2013).
May 2013	An annual site inspection was completed by AMEC and AT personnel. The ditch upslope of Area A was wet and flowing. There were no changes from the 2012 site inspection in the erosion at the outlet of the culvert near the ditch. A recent asphalt overlay was placed at the site in the summer or fall of 2012. Several smaller landslides below the highway, that were previously noted, had well-developed scarps and flanks. There were no noted changes, since the 2012 site inspection, in the creep movement on the backslope above the road. Vegetation (grass) had started to grow downslope of the shear pile repair work in Area B. No cracks were observed on the road surface in Area B. A slight settlement of the road surface north of Area B, beyond the extent of the site was noted.
May 2016	KCB personnel read three slope inclinometers and three standpipe piezometers. KCB reported that SI12-01, which was installed at the time of the pile wall constructions in 2012, continued to move at a rate of approximately 4 mm/yr at a depth between 4 and 6 m.
June 2016	An annual site inspection was completed by KCB and AT personnel. KCB noted that landsliding is continuous over approximately 600 m from the south end to the north end of the site and in between the A and B sites previously identified. KCB noted pavement distress with cracks extending across the centerline, slope movement upslope and downslope of H41:03 at Area A and below the pile wall at Area B, erosion of the embankment slope near the culvert outlet, and wet areas on the backslopes on the east side of the H41:03 and near the stream on the west side of the H41:03. Slope movements below the pile wall had exposed the pile wall over a length of 35 m at the north limit of the wall. Voids up to 0.4 m deep have formed behind the pile wall as material is lost between the piles. KCB recommended installing a guardrail or HTCB on the west side of the highway due to the steep drop off at the edge of the pavement.

4 SITE GEOLOGY, HYDROGEOLOGY, AND GEOMORPHIC SETTING

Topographic maps from the Canada Centre for Mapping (1994) the ground surface elevation at the site ranges from approximately 1370 to 1420 m above mean sea level (a.m.s.l.). AGS (2015a) sediment thickness maps show the sediment thickness is approximately 5 to 20 m at the site, and decreases towards the north. This agrees with the AGS interactive soil maps, which indicate there is exposed bedrock near the north end of the site. At the site, AGS (2011) maps show the soil consists of preglacial fluvial deposits and Aeolian deposits. The preglacial fluvial deposits are predominantly well-sorted quartzite and chert gravel and cobbles with minor sand. The Aeolian deposits consist of unconsolidated sand, silt, and clay, that is generally less than 1.5 m thick, overlaying bedrock.

At the site, an AGS (2015b) bedrock topography map show the elevation of the bedrock is approximately 1390 m a.m.s.l., which is near the ground surface elevation. AGS (2014) bedrock geology maps of the area show the bedrock is likely part of the Ravenscrag Formation or Cypress Hills Formation. The Ravenscrag Formation consists of grey to buff mudstone and siltstone with minor fine-grained sandstone, with minor thin coal layers. It is a nonmarine formation. The Cypress Hills Formation consists of gravel and sand, locally cemented to conglomerate; mainly quartzite and sandstone clasts with minor chert and quartz components. AMEC (2007) indicated the landslide appears to consist of slumping seated in the Ravenscrag Formation bedrock underlying the valley slope.

Hydrogeological maps from AGS (2005) show there are groundwater springs near the site. This agrees with many of the site observations made. For example, in 2007, AMEC noted ongoing groundwater seepage from the cutslope above the road.

5 SITE PROBLEMS

The record of site problems is given in Table 1. AT first identified the site as having issues in the early 1970s and late 1980s. AMEC (2007) determined the main cause of the landsliding was the ongoing downcutting of the creek channel at the base of the valley. Ongoing pavement distress, cracking, and damage to the road surface at Area A are caused by shallow, localized slope movements. There is ongoing erosion at a culvert outlet south of Area A.

There was noted settlement and slope movement in the southbound lane of Area B. In 2010, the settlement and slope movement caused the road surface to fail. Repair work, consisting of a shear pile wall was completed in 2012.

At the site, H41:03 has narrow shoulders with drops of up to 0.5 m at the west edge of the pavement, where up to 1.5 m of asphalt is exposed on the shoulder. A guardrail or high tension cable barrier is required on the west side of H41:03 in Area A and areas of embankment instability.

In 2016, KCB noted the site requires some repair including extending the pile wall north, repairing the pile wall with facing to minimize material loss, constructing additional pile walls in slide areas south of the site, improving ditch drainage, regrading the highway surface to improve the smoothness, and conduct additional geotechnical investigation including boreholes and installing instrumentation to assess the depth of movement in recently active areas to help with the required design repairs.

6 PREVIOUS SITE INVESTIGATIONS

AT investigated and assessed landslides at the site between the early 1970s and late 1980s. The first noted site visit was in 2007. Annual site inspections were completed from 2007 until 2013. KCB was unable to find documentation of site inspections in 2014 and 2015. The site was inspected again in 2016.

In 2008, boreholes were drilled at the site to install instrumentation, including SIs, standpipe piezometers, and a SAA.

7 REPAIR WORK AND MITIGATIVE MEASURES IMPLEMENTED

There have been numerous asphalt overlays placed over Area A and Area B at the site. The overlays were placed to cover cracking within the asphalt. The asphalt has a thickness of up to 1.5 m, creating a steep drop at the edge of the highway that requires a guardrail.

In 2010, a section of Area B failed. Temporary repairs including repairing the slope with launched soil nails, and creating a detour lane were completed. A shear pile wall was constructed in 2012 as a permanent repair to the site.

8 MONITORING OVERVIEW

In 2008 a geotechnical investigation was undertaken in Area A that included installing five standpipe piezometers, three SIs, one SAA cable, and one rainfall gauge. The instruments were monitored by AMEC. In 2009, the SIs had not measured any slope movement. Slumps in the roadway, lower embankment slope, and backslope of Area A were detected in 2010. However, the SIs did not detect movement zones. In 2011, two of the three SIs were noted to be obstructed at approximately 2 m depth due to excessive deformation by shallow landslide movement localized around the SI locations. The third SI had not detected slope movement. The SI data has not shown any deep-seated landslide movement. In 2012, only one SI and several standpipes remained functional. The two damaged SIs were deemed to be out of service and the SAA instrument stopped reporting data in January 2012 and was assumed to be out of service. In October 2013, no movement had been detected by the remaining active SI.

In 2009, SIs in Area B detected shallow movement within the fill. A slope failure occurred in 2010 as a result of a landslide of the fill embankment along the movement planes previously measured by the SIs. High groundwater following a period of high precipitation and snowmelt is thought to have triggered the movement. SIs in the area of the movement sheared, and the SI in the northbound lane remained functional and had not detected movement. The SI located in the southbound lane a few meters upslope of the existing headscarp was found to be sheared off at a depth of 1.8 m. In 2012, an SI was installed in Area B for post-construction monitoring of the shear pile repair.

The standpipe piezometer readings show the groundwater was typically between 5 to 20 m below the ground surface at the instruments. The ground water level remained very constant from the time the standpipe piezometers were installed in 2008 to the most recent reading in 2016. The only exception is SP08-4A, where the groundwater elevation increased by approximately 10 m in 2013. The ground water at SP08-4A has remained at a constant level since the increase in 2013.

REFERENCES

Alberta Geological Survey (2005). Map 110 Hydrogeological Map, Foremost, Alberta. Retrieved from: http://ags.aer.ca/publications/MAP_110.html

Alberta Geological Survey (2011). Map 029 Surficial Geology, Foremost-Cypress Hills, Alberta (NTS 72E). Retrieved from: http://ags.aer.ca/publications/Map_029.html

Alberta Geological Survey (2014). Map 568 Bedrock Geology of the Foremost Area (NTS 72E). Retrieved from: http://ags.aer.ca/publications/MAP_568.html

Alberta Geological Survey (2015a). Map 603 Sediment Thickness of Alberta. Retrieved from: http://ags.aer.ca/publications/MAP_603.html

Alberta Geological Survey (2015b). Map 602 Bedrock Topography of Alberta. Retrieved from: http://ags.aer.ca/publications/MAP_602.html

Alberta Geological Survey (2013). GIS shapefiles of Map 601 – Surficial Geology of Alberta.

AMEC Infrastructure and Transportation (2007). Southern Region Geohazard Assessment 2007 Annual Assessment Report.

AMEC Earth & Environmental (2008). Site S26 – Elkwater, Highway 41:03.

AMEC Earth & Environmental (2009). Site S26 – Elkwater, Highway 41:03, 2009 Annual Inspection Report.

AMEC Earth & Environmental (2010). Site S26 – Elkwater, Highway 41:03, 2010 Annual Inspection Report.

AMEC Earth & Environmental (2011). Site S26 – Elkwater, Highway 41:03, 2011 Annual Inspection Report.

AMEC Earth & Environmental (2012). Site S26: Highway 41:03, Elkwater, 2012 Annual Inspection Report.

AMEC Earth & Environmental (2013). Site S26: Highway 41:03, Elkwater, 2013 Annual Inspection Report.

Canada Centre for Mapping (1994). ETopo Map, Elkwater Lake Alberta Saskatchewan, Z72E09 Edition 3 UTM Zone 12.