November 1, 2011

CG25352.200

Alberta Transportation
2nd Floor, 803 Manning Road NE
Calgary, AB T2E 7M8

Attn: Mr. Ross Dickson

Re: Southern Region Geohazard Assessment Program
Site S26 – Elkwater, Highway 41:03
2011 Annual Inspection Report

This letter documents the 2011 annual site inspection at Site S26 – Elkwater, along Highway 41:03 and approximately 3 to 4 km south of the turnoff from Highway 41 to the town of Elkwater, AB.

AMEC Environment & Infrastructure (AMEC), a division of AMEC Americas Limited, performed this inspection in partial fulfillment of the scope of work for the supply of geotechnical services for Alberta Transportation's (AT's) Southern Region (AT contract CE061/08).

The site inspection was performed on June 22, 2011 by Mr. Bryan Bale, P.Eng., and Mr. Tyler Clay, E.I.T., of AMEC in the company of Mr. Neil Kjelland, P.Eng., and Mr. Ross Dickson of AT.

BACKGROUND

A general description of the geohazard conditions at this site along with the site geological setting and chronology of previous events, investigations, monitoring and repair work were provided in a 2007 call-out site inspection report by AMEC[1] and are summarized as follows:

- The highway is constructed across the lower portion of the east valley slope of a north-draining, unnamed creek valley incised into the north slope bordering the Cypress Hills Plateau to the south.

[1]AMEC report, "Report on March 17, 2007 Call-Out Request, Highway 41:03, near Elkwater, AB", submitted to AT on October 30, 2007, AMEC File No. CG25239.D.

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- There are two segments of the highway that are being damaged by landslide movement at this site and they are referred to as Area A and Area B. Area A is near the crest of the hill and is approximately 500 m southbound from Area B. Site plans for the two areas are presented on Figures S26-1 and S26-2.

Area A

- There is visible landslide terrain upslope and downslope of the highway around Area A and widespread signs of landslide damage along this segment of the road. The landsliding consists of slumping (possibly with a translational component of movement) seated in the bedrock underlying the slope. The primary driver for the landsliding appears to be the erosion and downcutting of the creek valley over time and possibly also relatively high groundwater levels in the valley slope.

- Numerous patches and overlays have been placed over the years to maintain the road grade through Area A.

- The landsliding in Area A was investigated and assessed by AT between the early 1970's and late 1980's. There is some reference in AT's files to shallow drainage trenches having been installed, but no documentation of the construction of these trenches or any assessment of their effectiveness.

- AMEC performed a geotechnical site investigation at Area A in late May and early June 2008. The investigation included the installation of five standpipe piezometers, three slope inclinometers (SI's) and a trial installation of a Measurand ShapeAccelArray (SAA) cable adjacent to one of the SI's. These instruments have been monitored since installation, with the most recent readings from May 2011. The SAA cable is connected to datalogging and communications equipment to enable remote access to continuous data from the instrument. A rainfall gauge, also with remote data access, was also installed at the site. The instrument and weather station locations are illustrated on Figure S26-1.

- Numerous slumps affecting the roadway occurred at Area A during May and June 2010. In general, the slumps were relatively shallow (perhaps 1 to 5 m deep), and were judged to be translational or retrogressive failures of saturated surface soils. Some of the slides were linked to well-developed rotational slides on the lower slope along the creek, and likely indicate upslope retrogression of these existing slides. Figure S26-1 illustrates the locations of some of the more significant slides that were noted. The slide damage was repaired by placing asphalt overlays. Shallow slumps also formed along the backslope across the site, with tilted trees and torn vegetation mats. The slumps were estimated to be up to about 5 m deep.

- The shallow landsliding noted to have affected the road surface to date has not affected the area around the SI's or SAA cable. No movement had been detected by these instruments as of Fall 2010.

Area B

- Area B is a curved segment of the highway that is constructed on a cut and fill embankment. No past geotechnical assessments or reporting for this area were found in the file review for this site. This area was first inspected in 2007, when it was noted that the road surface had been experiencing significant settlement in recent years due to instability of the road fill and possibly underlying landslide movement, and that multiple, thick overlays had resulted in a reduction in the net height of the guardrail along the downslope side of the road.

- Several geotechnical boreholes and instrument installations were completed in Area B in 2008. Instrument monitoring had confirmed the slide mechanism causing the slow, ongoing damage to the road in 2009, but repair work was deferred with the intent of combining repair work at Area A and Area B after the depth of expected deep-seated landslide movement in Area A was hopefully confirmed by instrument monitoring through 2009 and 2010.

- A rapid slope failure occurred at Area B in late May 2010 with a headscarp matching the pattern and extent of the persistent cracking and settlement that was noted in the 2008 and 2009 inspections. The failure took the southbound (downslope) lane of the road out of service, and the road surface within the failure area settled by 3 to 4 m shortly after the initial failure. The trigger for the May 2010 failure was thought to be high groundwater levels following a period of high precipitation and spring snowmelt.

- As a temporary repair, AT's maintenance contractor excavated a portion of the failed slide mass, contracted a company to install launched soil nails, and constructed a detour lane in the upslope road ditch. AMEC provided geotechnical input to the planning and execution of the temporary repair, along with a design for the detour lane construction and alignment.

SITE OBSERVATIONS

Key observations from the June 22, 2011 inspection are summarized as follows:

Area A

- The upslope highway ditch in the area southbound (uphill) from the Area A instruments was wet with ponded water. This area has been consistently wet during past inspections, and the ditch at the culvert located near this area is often noted to be flowing. The

culvert is sufficiently sized to handle the flow, but the ditch gradient is relatively flat and water ponds in the ditch. Water was observed flowing into this area from the backslope along a newly formed channel during the inspection. Water had not been noted flowing from this area during past inspections. Erosion has been occurring at the culvert outlet, and has been noted in past inspections. At present, the erosion is relatively minor and does not present a hazard to the highway. Please refer to Photos S26-1 and S26-2.

- An overlay had been placed across the Area A site in Fall 2010 or Spring 2011, covering all areas of past cracking. Most of the previous cracking in the road surface had not reformed through the new overlay as of the June 2011 inspection, except in the area near SP 08-4 (refer to Figure S26-1). Refer to the 2010 inspection report[2] for a description of previous cracking in the area.

- Accumulated overlays have formed a steep drop-off at the downslope road shoulder. A guardrail is required according to AT's Highway Design Guidelines.

- Numerous shallow slides were noted to have formed in the backslope across much of the Area A site in 2010, most significantly near the north end of the site. The shallow slides were estimated to be up to 5 m deep. The condition of the slides had not worsened significantly as of the June 2011 inspection. The slides appeared to be only marginally stable, and will likely continue to move. Photos S26-3 to S26-5 presents several examples of these slides.

- As of the May 2011 instrument readings, SI 08-2 and 08-3 at Area A were found to be obstructed at approximately 2 m depth, apparently due to excessive deformation due to shallow landslide movement localized around the SI locations. SI 08-3 has not detected slope movement, and the SAA has not provided data of sufficient quality to confirm movement. Prior to May 2011, no movement had been detected by the SI's. The damage to these SI's indicates that shallow landslide movement, as has been observed across the site, has recently occurred at the SI locations.

- Several rotational type landslides have been noted along the lower slope below the highway during previous inspections. The slides have well developed scarps and flanks, and appear to have been formed over a period of years. In 2010, the headscarps of several of these landslides retrogressed upslope and undermined portions of the road surface, as illustrated on Figure S28-1. These slides did not intersect any of the existing SI's. The road surface was damaged by settlement and cracking, and was repaired by placing asphalt overlays. There did not appear to have been significant additional movement of these slides between the June 2010 and June 2011 inspections. Any

[2] AMEC report, "Southern Region Geohazard Assessment, "Site S26 – Elkwater, Highway 41:03 2010 Annual Inspection Report", submitted October 14, 2010.

damage that may have formed on the road surface since the June 2010 inspection was covered by the recent overlay. Refer to Photos S26-6 to S26-8.

Area B

- The temporary repairs constructed at Area B were in good condition overall. The headscarp of the May 2010 failure had retrogressed by up to 1 m into the southbound lane since June 2010, and was near the jersey barriers along the downslope edge of the remaining road surface at the time of the inspection (refer to Photo S26-10). The retrogression was due to collapse of the steep scarp face. The slide mass was draining well and the soil nails installed in the face appeared to be supporting the scarp reasonably well. The temporary detour lane was also in good condition (refer to Photo S26-9).

- SI 08-6, located in the southbound lane, a few metres upslope of the existing headscarp, was found to be sheared off at 1.8 m depth during the May 2011 instrument readings. This movement likely represents a shallow retrogression of the over-steepened headscarp into the northbound land, and indicates that the northbound lane may be damaged in the near future. The planned shear pile and granular fill replacement repair will mitigate this hazard.

ASSESSMENT

Area A

The landslide damage to the road surface in Area A worsened in early 2010, with extensive damage to the road surface from shallow, localized slides and flows. Slide movement has continued in 2011, but at apparently lower rates than in 2010. Two of the SI's have been damaged by the shallow landslide movement in 2010 and 2011 and are now out of service. These slumps appear to be retrogressive, and were noted to extend up the backslope and into the treed areas further upslope. The slumps on the lower slope continue to cause damage to the road surface and additional overlays (likely annually, at a minimum) will be required to maintain a smooth road surface.

The instrument data from the summer of 2008 onwards has not shown any deep-seated landslide movement consistent with the widespread landslide terrain on the valley slope and slickensided zones in the drill core from this area. It is possible that deep seated movement at this site may be responsive to longer-term trends in precipitation (e.g. a series of relatively wet years may lead to one or several years of deeper landslide movement). It is also possible that the site is no longer experiencing deep-seated movement, and that the damage to the road in Area A in recent years may be solely due to shallow and localized slumps such as those that occurred in April and May 2010.

The shallow slides and flows that have damaged the road surface in recent years have required extensive paving repairs to maintain a smooth road surface. Although the presence of deep-seated landsliding has not been confirmed, a repair to strengthen the road against the shallow slides would be beneficial. Such a repair would likely include replacing the road subgrade with granular fill, providing improved ditch and subsurface drainage, and shifting the road upslope away from the creek.

Area B

The temporary repair installed in the spring of 2010 has performed reasonably well, but the steep soil nailed scarp continues to retrogress and the southbound lane is at risk. A shear pile repair has been designed and tendered, with construction planned for late 2011. Therefore, the repair should be in place prior to the spring of 2012.

RISK LEVEL

The recommended Risk Level for this site, based on AT's general geohazard risk matrix, is as follows:

Area A

- Probability Factor of 13 based on active movement that is steady or increasing.
- Consequence Factor of 4 to reflect the ongoing damage to the road surface that requires maintenance work to maintain a relatively smooth running surface and the potential for a relatively large increment of landslide movement to require a partial closure of the road and/or immediate work to establish a temporary running surface through the landslide area.

Therefore the recommended Risk Level for Area A is 52, which is unchanged from 2010, and higher than the rating of 36 in 2009.

Area B

- Probability Factor of 20 to reflect the significant failure that occurred as well as the potential for the remaining lane of the road to collapse if the site is not repaired.
- Consequence Factor of 4 to reflect the partial closure of the road and required detour.

Therefore, the recommended Risk Level is 80, which is an unchanged from 2010, and greater than the rating of 52 in 2009. The Risk Level for Area B should decrease after the successful completion of the upcoming repair work.

RECOMMENDATIONS

Maintenance and Short Term Measures

- AT's maintenance contractor should continue to apply patches and overlays to Area A to maintain a suitable traffic surface in response to ongoing damage by shallow, localized slumping.

- The erosion channel forming at the culvert outlet at Area A should be protected. This could be done with armouring, erosion resistant matting, or a full culvert or flume extended to creek level.

Long Term Measures

Area A:

- The persistent damage to the road surface due to shallow, localized movements is the primary year-over-year hazard at this site. This hazard could be repaired with a combination of improved drainage, stronger road sub-grade, and shifting the road alignment. This type of repair may be required in the future, as the continued overlay type repairs will likely not be sufficient as the slides continue to develop on the lower slope. The cost of such a repair may be less than ongoing paving repairs in the long-term, and it is recommended that preliminary cost and scope for such a repair be prepared.

- Deep-seated landsliding has not been confirmed at the site since the SI's were installed in 2008, but may occur in the future. . Repairs to target the damage to the road surface, as described above, would not be sufficient to mitigate against deep-seated movement. Additional repairs could be required if deeper seated landsliding becomes active in the future.

- AMEC could prepare a design and tender for treating the shallow instabilities if requested, as the budget for this work has been provided under CE044/04.

Area B:

- A shear pile repair is planned for Fall 2011.

Monitoring

The spring/fall instrument readings and annual site inspections by AT and AMEC personnel should be continued. AMEC will continue the remote monitoring of the SAA cable and weather station in conjunction with the instrument monitoring.

CLOSURE

This report has been prepared for the exclusive use of Alberta Transportation for the specific project described herein. Any use which a third party makes of this report, or any reliance on or decisions to be made based on it are the responsibility of such third parties. AMEC Environment & Infrastructure, a division of AMEC Americas Limited, cannot accept responsibility for such damages, if any, suffered by any third party as a result of decisions made or actions based on this report. This report has been prepared in accordance with accepted geotechnical engineering practices. No other warranty, expressed or implied, is made.

We trust that this meets your needs at this time. Please contact the undersigned if you have any questions or require any further information.

Respectfully Submitted,

AMEC Environment & Infrastructure,
a division of AMEC Americas Limited

ORIGINAL SIGNED
NOVEMBER 1, 2011

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APEGGA Permit to Practice No. P-04546

Reviewed by:

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Attachments: Figure S26-1 – Area A site plan
Figure S26-2 – Area B site plan
Photos