September 8, 2008

CG25277.B

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
2008 Annual Inspection Report

This letter documents the 2008 annual site inspection of 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 Earth & Environmental (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 20, 2008 by Mr. Andrew Bidwell, P.Eng. and Mr. Bryan Bale of AMEC in the company of Mr. Ross Dickson and Mr. Roger Skirrow 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 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.

- 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. The site airphoto (Figure S26-1, attached) illustrates the relative locations of Areas A and B.

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- 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 has been 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 details on the construction of these trenches or their effectiveness.

- AMEC performed a geotechnical site investigation 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. 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 S26-2. The depth of the SI's is shown on the cross-section on Figure S26-3.

- Area B is a curved segment of the highway that appears to have been benched into the valley slope. No past documentation for this area was found in the file review for this site. This segment of the highway has been experiencing significant settlement in recent years which has necessitated multiple, thick overlays and reduced the net height of the guardrail along the downslope side of the road.

- The damage to the road surface in Area B looks like it is being caused by landslide movement with a headscarp around the centerline of the highway, but possibly extending further upslope.

SITE OBSERVATIONS

- The extent and magnitude of the damage to the road surface in Area A had not changed significantly since the 2007 inspection, nor since observations during the late May and early June 2008 borehole drilling and instrument installations. Photos S26-1 and S26-2 show views of the damage to the road in this area. The position of cracks in the road surface is shown on Figure S26-2.

- The upslope highway ditch to the south of the Area A instruments, i.e. uphill from Area A, was noted again to be swampy and it appears that the 900 mm diameter culvert near Sta. 1+330 (see Figure S26-2) carries a lot of drainage from the swampy area.

- A groundwater spring was noted in a shallow slumping area in the cut slope immediately above the upslope highway ditch and approximately 50 to 70 m south of the south end of the Area B guardrail. The water from this spring flows northwards along the upslope highway ditch and appeared to percolate into the highway subgrade around or slightly upslope of the segment of damaged road in Area B.

- Significant settlement was noted along an approximately 45 m long segment of the southbound lane (on the downslope side of the highway) in Area B. The tension cracking around the perimeter of the damaged area was in an arc-shaped pattern and encroached approximately 1 m across the centerline and into the northbound lane. Photos S26-3 to S26-5 show the damaged area as it appeared in early August 2008 after patching in late July 2008. Figure S26-4 shows a schematic site plan of the site features and damage to the road surface at Area B.

- The guardrail along the settlement area in Area B was relatively low, apparently due to multiple overlays to the road surface without raising the guardrail. Photo S26-6 shows some timber lagging that had been installed between the guardrail posts during previous patching and overlays. The lagging was bulging in several locations at the time of the site inspection.

Other notes:

- As of the August 7, 2008 readings, no slope movement has been detected measured at the SI's or the SAA cable (relative to the June 7, 2008 baseline readings). The weather station that was installed in early June 2008 has been recording precipitation data since that time.

- AT personnel have reported that additional, significant settlement of the road surface occurred in Area B during July 2008 and that subsequent patching of that area has brought the total amount of asphalt placed in Area B over the years to in the order of

1.5 m. AMEC and AT personnel performed a call-out site inspection of Area B on August 11, 2008 to review the Area B site conditions at that time and discuss a path forward for short-term mitigative measures followed by a site investigation to provide information for the design of a longer-term repair. Please refer to the report on the August 11, 2008 inspection[1] for more details.

ASSESSMENT

There does not appear to be significantly more landslide damage to the road surface in Area A since the 2007 inspection. As of late August, the SI's and SAA cable that were installed in late May and early June have not yet shown any landslide movement. It is possible that the landslide movement in Area A is seasonal. Overall, it is still considered most likely that over the long term it will be more cost-effective to try to reduce the landslide movement damage to the road in Area A than to continue to treat it as a maintenance item. When the instruments are able to confirm the depth of landslide movement, AMEC will prepare a list of repair options for AT's consideration.

The more recent damage to the road surface in Area B appears to be the result of relatively active landslide movement. This damage is somewhat manageable as a maintenance issue, however the accumulated thickness of the asphalt is understood to be significant and continued placement of overlays not likely sustainable for too much longer. AMEC has recommended a site investigation to confirm the depth and extent of landslide movement in Area B and to provide a basis for repair design. Please refer to the Recommendations section for further information.

RISK LEVEL

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

<u>Area A</u>

- Probability Factor of 9 based on the inferred active movement (not yet confirmed by the SI's installed in late May/early June 2008) but with the uncertainty regarding the rate of movement at this time. This is a reduction from the value of 13 recommended after the 2007 inspection when it was assumed the there was ongoing movement at a high rate, based on the visual observations to that time.

[1] "Report on August 11, 2008 Site Inspection, Site S26 – Highway 41:03, Elkwater "Area B", South Of Elkwater, Alberta", submitted to AT on August 29, 2008, AMEC project no. CG25277.D.

- 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 (however low) 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 36, which is a reduction from the value of 52 recommended after the 2007 inspection. This reduction is due to the reduction in the Probability Factor, which may be adjusted again after the depth and rate of landslide movement has been confirmed by future instrument data.

Area B

The recommended Risk Level for Area B is taken from the report on the August 11, 2008 call-out site inspection of Area B:

- Probability Factor of 13 to reflect the active movement damaging the road, with an inferred high and at least steady rate of movement based on the ongoing damage and prompt cracking after the late July 2008 overlay.

- Consequence Factor of 4 to reflect the ongoing damage to the road surface that requires significant maintenance work and the potential (albeit possibly low) for a relatively large increment of movement to require a partial closure of the road and/or immediate work to establish a temporary running surface extending into the upslope ditch.

Therefore, the recommended Risk Level is 52.

RECOMMENDATIONS

Maintenance and Short Term Measures

- AT's maintenance contractor should continue to apply patches and overlays to both Areas A and B as required to maintain a suitable traffic surface. This should be treated as an ongoing maintenance issue.

- Add a culvert to intercept the ditch flow from the groundwater spring noted in the slope above the highway and roughly 50 to 70 m south of southernmost end of the Area B guardrail. This new culvert would intercept this water before it flows into Area B and possibly contributes to the ongoing damage to the road surface.

- Borehole drilling and instrument installations in Area B. This work is planned for mid-September 2008. Please refer to the "Investigation" section below for further details.

Long Term Measures

Area A:

- Continue monitoring the instruments in order to confirm the depth and rate of landslide movement, and from that determine suitable repair methods.

- Repair options for Area A will likely consist of subsurface drainage – either horizontal drains with entry points on the slope below the highway or deep trench trains excavated and backfilled with single-pass deep trenching equipment.

- AMEC will continue the remote monitoring of the SAA cable during the fall and winter of 2008, and the next set of SI readings is planned for the spring of 2009 unless the SAA cable shows movement beforehand.

Area B:

- Repair work to mitigate the ongoing damage to the road surface. A suitable repair option needs to be determined and then repair design completed. Please refer to the "Investigation" section below for further details.

- Repair options for Area B may include one or a combination of the following:
    - More culverts and generally improved surface and subsurface drainage. Perhaps including horizontal drains drilled downwards from entry points in the upslope ditch and with exit/discharge points on the slope face below the road.
    - A pile wall to support the damaged segment of the road.
    - Realignment – shifting the road upslope.
    - Grade lowering and/or use of lightweight fill for the road section to reduce the load on top of the apparent landslide area.

Also, the annual site inspections by AT and AMEC personnel should also be continued.

Investigation

Area A:

- No further investigation work for Area A is recommended at this time.

Area B:

- Borehole drilling and instrument installations are recommended for Area B to confirm the soil and bedrock conditions as well investigate the movement depth and mechanism for the apparent landslide damage in this area.

- Please refer to AMEC's August 22, 2008 proposed scope and estimated costs for the recommended site investigation. The proposed scope includes the installation of three SI's, one settlement gauge, two piezometers and a site survey.

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 Earth & Environmental, 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 Earth & Environmental,
a division of AMEC Americas Limited

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APEGGA Permit to Practice No. P-04546

Reviewed by:

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Attachments: Figure S26-1 – airphoto site plan
Figure S26-2 – Area A site plan
Figure S26-3 – Area A typical cross-section
Figure S26-4 – Area B schematic site plan
Figure S26-5 – Area B schematic cross-section