



August 20, 2009

CG25309.B

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

Attn: Mr. Ross Dickson

**Re: Southern Region Geohazard Assessment Program
Site S32 – Bow River Upstream Of Crowfoot Ferry, Highway 56
2009 Annual Inspection Report**

This letter documents the 2009 annual site inspection of Site S32 – Bow River Upstream Of Crowfoot Ferry, along Highway 56 and approximately 4.4 km southbound from the intersection between Highway 56 and Highway 1.

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 8, 2009 by Mr. Andrew Bidwell, P.Eng. of AMEC in the company of Mr. Ross Dickson and Mr. Neil Kjelland, P.Eng. of AT.

BACKGROUND

This site was inspected for the first time under AT's Geohazard Risk Management Program in June 2008 after AT personnel noted active erosion and slope instability along the left (east) bank of the Bow River adjacent to the highway. Please refer to the report on the June 2008 inspection¹ for a description of the site layout and landslide conditions.

The assessment from the June 2008 inspection recommended:

- A hydrotechnical review of the site (airphotos, river flow data, June 2008 inspection information) to assess if the current pattern and intensity of erosion along the east bank will continue or change in the near future, and from that interpret whether or not the active landsliding will continue or possibly worsen (or become less active). Such a

¹ AMEC report "Southern Region Geohazard Assessment Program, Site S32 – Bow River Upstream Of Crowfoot Ferry, Highway 56, 2008 Annual Inspection Report", submitted to AT on September 8, 2008, AT consulting services agreement no. CE061/08, AMEC project no. CG25277.B.

review should also provide a basis to confirm the length of the highway segment that should be shifted eastward, if necessary.

- Continuation of the annual inspections in 2009 in order to check the site conditions and the position of the landslide headscarp relative to the fenceline west of the highway.

SITE OBSERVATIONS

Key observations from the June 2009 inspection were as follows:

- There has been very little change in the visual appearance of the site or the landslide conditions along the left (east) bank of the river since the June 2008 inspection. Photo S32-1 shows a general view of the landslide area.
- The minimum offset between the scarp of the landsliding and the fenceline along the west side of the road was approximately 1.6 to 1.7 m at the time of the June 2009 inspection (Photo S32-2). For comparison, the minimum offset was measured as 1.7 m in June 2008. A cross-section through the slope at this minimum offset location is shown on Figure S32-3.
- The “Ferry Crossing, 150 m” sign near the south flank of the landslide area has fallen down since the June 2008 inspection (photo ref), which indicates that the oversteepened/near-vertical crest of the east river bank slope in this area has retrogressed roughly 0.5 m in the past year. See Photos S32-3 and S32-4.
- The lateral extent of the landsliding along the left (east) river bank did not appear to have increased significantly in the past year. The downstream extent of the landsliding and bank instability is still more than 100 m away from the ferry ramp on the left bank of the river. A photo of the east ferry ramp is attached for reference (Photo S32-5).

ASSESSMENT

The site conditions have not changed significantly since the June 2008 inspection. The landsliding adjacent to the highway continues due to ongoing erosion along the east bank of the river. To date, the headscarp of the landsliding has not retrogressed across the west fenceline and into the highway right-of-way, and the June 2009 observations of the slope crest position in the landslide area as well as the oversteepened and unstable slope downstream of the south flank of the landslide area (i.e. between the landslide area and the east ramp at the ferry) show that eastwards slope crest retrogression from June 2008 to June 2009 has been in the order of 0.1 m. within the landslide area.

It remains possible that over the long term (i.e. at least several years), the oversteepened upper portion of the landslide area will retrogress back to a 15 to 20° inclination similar to the existing slope in the lower portion of the landslide area. If this happens over time, then an approximately 50 to 70 m long segment of the highway may become directly undermined by the landsliding. The risk of this occurring over the short term is judged to be low, that is it will likely not occur more rapidly than annual site inspections can provide warning of.

The landslide risk to the highway could be mitigated with one of the following strategies discussed in the 2008 annual inspection report:

- Establish erosion protection along the east bank of the river and stabilize the existing slope in the upper portion of the landslide area.
- Install a pile wall or equivalent measures to support the road surface adjacent to the landslide area.
- Eastward relocation of the highway, likely by 10 to 15 m, to a sufficient setback from the landslide area.

Significant erosion protection measures would likely be required for a river channel of this magnitude and the design of such measures would need to take into account the Crowfoot Ferry crossing a short distance downriver. Furthermore, the regulatory and environmental permitting process for significant bank protection work along the Bow River could be relatively onerous. For the likely low summer traffic counts along this segment of the highway (and presumably local traffic only during the winter months when the ferry does not operate), the most cost-effective approach may be to shift the road to the east. The site appears to be located within the Blackfoot Indian Reserve, the right-of-way acquisition aspects of which will need to be considered if contemplating shifting the highway alignment.

RISK LEVEL

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

- Probability Factor of 6 based on the active but slow rate of slope crest retrogression towards the highway. This is a reduction from the value of 9 recommended after the June 2008 inspection, based on the 0.1 m amount of slope crest retrogression at the point of minimum offset from the highway in the middle of the landslide area.
- Consequence Factor of 4 to account for the potential for at least a partial closure of the existing road could be required if an increment of landslide movement in the near-future

retrogresses eastwards through the fenceline and undermines the west shoulder of the road.

Therefore, the recommended Risk Level is 24. This is a reduction from the value of 36 recommended after the June 2008 site inspection, based on visual observations of the relatively small amount of slope crest retrogression towards the highway between 2008 and 2009 but with the long-term potential for undermining of the highway remaining.

RECOMMENDATIONS

Maintenance and Short Term Measures

The “Ferry Crossing, 150 m” sign on the east bank of the river south of the landslide area should be re-installed with a setback of approximately 3 m from the crest of the slope. The signage is likely a requirement under the Navigable Waters Protection Act.

Investigation and Long Term Measures

The hydrotechnical review of this site recommended in the 2008 annual inspection report should be performed. For reference, the scope of such a review would include:

- A review of site airphotos, available river flow data and the information from the June 2008 inspection should be performed by a hydrotechnical engineer.
- Assess if the current pattern and intensity of erosion along the east bank will continue or change in the near future, and from that interpret whether or not the active landsliding will continue or possibly worsen (or become less active).
- Such a review should also provide a basis to confirm the length of the highway segment that should be shifted eastward, if necessary.
- Such a review could also consider potential long-term issues with bank erosion/channel shifting at the ferry crossing downstream of the landslide area.

AMEC can provide a proposed scope and cost estimate for this task to AT upon request.

If the hydrotechnical review confirms that the landsliding will continue then AT should review the concept of an eastwards relocation of the highway by 10 to 15 m. The cost and issues associated with right-of-way acquisition vs. bank protection and/or slope stabilization measures to preserve the existing highway could then be considered well in advance of needing to do either.

This site should be inspected again in the future in order to check the site conditions and the position of the landslide headscarp relative to the fenceline west of the highway. As discussed on site during the June 2009 inspection, the frequency of inspections of this site could be reduced from annual to bi-annual with the timing of subsequent inspections adjusted in the future if necessary due to reduced offset of the slope crest from the edge of the highway. However, AMEC understands that AT would prefer to maintain the annual inspection frequency for this site given that it can be easily combined with the travel for the planned ongoing inspections of the S26 – Elkwater site in the Cypress Hills.

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

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Attachments: Figures S32-1 to S32-3
Photos S32-1 to S32-5