December 2013

CG25399

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

Attention: Mr. Ross Dickson

Dear Ross:

Re: Southern Region Geohazard Assessment
2013 Annual Inspection Report
Site S4: Highway 2:08, Willow Creek

This report documents the 2013 annual site inspection of Site S4 – Willow Creek, along Highway 2:08, south of Claresholm, Alberta and approximately 4.7 km north of the Highway 2 bridge over the Oldman River. This site is located on a segment of the west slope of the Willow Creek valley where the slope crest has been retrogressing westwards towards the highway in recent years.

AMEC Environment and 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 CON0013506).

The site inspection was performed on May 28, 2013 by Bryan Bale, P.Eng., Hugh Wang, P.Eng., and Tyler Clay, E.I.T., of AMEC; and Roger Skirrow, P.Eng., and Ross Dickson of AT during the 2013 Annual Tour.

1.0 SUMMARY

The site condition is relatively unchanged from the 2012 inspection. Stability of the repaired area is improving. The risk level has decreased to 10 from the 2012 Risk Level of 12. The slope crest will likely continue to retrogress and will require a guardrail. A deep drainage trench may help to slow this retrogression. Additional investigation will be required to design such a trench. AT should evaluate if additional mitigation is warranted and initiate the additional investigation accordingly. The site should be inspected next in 2014.

2.0 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

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provided in the Geotechnical File Review (Section A of the site binder) and summarized in the annual inspection reports up to 2007[1].

The landsliding at this site has been monitored by AT and their consultants since 1993. This site has been under greater scrutiny since the summer of 2005 when a relatively large increment of slope crest retrogression towards the highway occurred.

A repair was performed in late 2008 and consisted of:

- Construction of longitudinal peak stone toe protection (LPSTP) and vanes along the right creek bank along with bioengineering treatments to reduce creek erosion along the toe of the slope in the landslide area.
- Slope regrading and the installation of launched soil nails to stabilize the segment of the slope crest that had retrogressed towards the highway and west of the fenceline.
- Trial applications of numerous bioengineering and erosion control treatments on the exposed soils on the slope in the landslide area as part of a field workshop hosted by AT.

Please refer to Figures S4-1 and S4-2, attached, which are adapted from the as-constructed drawings for the 2008 repair and show the type and locations of the various repair measures at this site.

3.0 SITE OBSERVATIONS

Key observations from the May 2013 inspection were as follows:

- In general, the rate of retrogression of the headscarp towards the highway appeared lower or similar to recent years. Reference stakes were placed along the slope crest at 1 m offsets for comparison during future inspections.
- There was continued retrogression of the headscarp to the south of soil nail repair area. The reference stakes installed during the 2012 inspection at the slope crest 60 to 70 m south of the soil nail area were within the slide mass. The crest was coincident with the old slope inclinometers (SIs) in the area and was offset approximately 20 m from the edge of the pavement (Refer to Photo S4-1).
- The upper slide mass and headscarp at the 2008 soil nail area appeared similar to 2012 conditions. Retrogression rates in this area appeared to have decreased based on intact reference stakes. Vegetation growth was still disturbed from soil flows and erosion. Refer to Photo S4-2.

[1] AMEC Earth & Environmental, 2007. *Southern Region Geohazard Assessment, Annual Assessment Report, 2007*, Project Number CG25263, Report submitted to AT on November 6, 2007.

- At the area of closest encroachment to the highway (at the soil nail area), the slide scarp was offset from the paved surface by 13.5 m. The overall slide mass below the scarp was sloping at 15 degrees. This offset is unchanged from the 2012 inspection; however, there were tension cracks observed up 1.0 m from crest.

- Seepage was observed within the exposed headscarp, approximately 1 m below the crest at the soil nail area (refer to Photo S4-3) and 3 m below the crest in the headscarp area to the south. The soil was wet but there was no observable flow. The conditions were similar to the observations from previous years.

- There was a 1 to 2 m deep translational slide in the main gully at the south end of the site along the north side of the upper side-slope. The slide mass had diverted water flow within the invert of the gully but did not block flow (refer to Photo S4-4).

- Shallow flow-type slides were observed at the south end of the site near the main gully. The steepest and highest sections of the headscarp in the area appeared to be stable.

- The lower slopes of the slide mass were in good condition with no significant post-repair landslide damage or bank erosion noted, similar to the 2012 conditions (refer to Photo S4-5). Vegetation was well established. The lower half of the slope appeared mostly stable; however, cracks and a probable slide toe bulge were noted 10 to 15 m from the bank in an area approximately 50 m south of the soil nail area.

- The river was turbid and at a fairly high level during the inspection; however, there was no active erosion observed along the banks.

- The bank engineering works appeared to be in similar condition as was observed during the 2012 inspection and were functioning as designed. The vanes appeared to be diminished due to erosion as expected and had extensive sediment infilling between them. The LPSTP appeared to be intact (refer to Photo S4-5). The alignment of the river bank appeared to be unchanged from the as-built survey.

- In general, the stability of the site appeared to be improved as compared to the 2012 and preceding inspection observations.

4.0 ASSESSMENT

The 2012 assessment for this site remains valid and is summarized as follows:

Highway and Upper Slide Area

- Groundwater seepage observed since 2010, appears to be a key factor in the ongoing slope instabilities causing shallow earth flows at the upper slope and block toppling along the crest. The persistence and severity of groundwater seepage likely varies year-to-year, based upon the amount and intensity of precipitation. The soil nails are

ineffective for the shallow earth flow failures that have occurred in the area where they were installed.

- Ongoing slope crest retrogression is expected across the upper slope until the slope achieves a long-term stable configuration. As the slope crest continues to retrogress, the overall slope angle, free-standing height of the crest and size of crest retrogression increments are all expected to decrease. The observations in 2012 and 2013 support this concept of increasing long-term stability, with only minor retrogression in the last year and improved vegetation cover. The observed tension cracks near the bank crest are likely indicative of 0.5 to 1.0 m of retrogression that could occur within the next year.

- The slope crest retrogression is expected to eventually affect the highway right-of-way. The slope crest in the area of the closest encroachment to the highway (the soil nail area) may eventually retrogress to approximately 5 m offset from the highway surface; based upon a simple extrapolation of the slope angle in the landslide mass in the mid to upper valley slope. A guardrail will be required.

- If further retrogression into the highway right-of-way is not considered acceptable, additional remediation will be required. Remediation could involve a deep drainage trench installed between the slope crest and the highway to minimize groundwater seepage discharging from the crest. Investigation work would be required to establish groundwater conditions along the headscarp and develop remediation techniques. Monitoring of the headscarp retrogression could be done more efficiently and accurately with established survey monuments or 3D laser scanning type surveys.

Lower Slide Area

- Overall, the bioengineering techniques have been effective on the lower half of the slide mass across the site. Vegetation has not become well established on the upper slope due to earth flows and erosion. The slope benching has helped to prevent the formation of erosion gullies.

- The lower slope has appeared to be stable relative to the upper half of the slope since the 2008 repairs. An area of the lower slope observed during the 2013 inspection had signs of movement. Subsequent inspections will help to determine if slope movement is occurring in this area, and if additional investigation or mitigation is required.

Riverbank Area

- The LPSTP and vanes have been very effective. Sediment deposition between the vanes and diversion of the thalweg of the river channel away from the bank has

occurred. Erosion at the toe of the slope has been stopped. Refer to the 2010 inspection report for details on the performance of each remediation technique[2].

5.0 RISK LEVEL

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

- Probability Factor of 5 since the rate of retrogression has not been observed to increase relative to the 2011 and 2012 inspections, possibly indicating that in general landslide conditions are approaching a stabilized condition. This is equal to the value from 2009 after the repairs were completed, and a decrease from the value of 6 assigned the last two years when the soil nailed area was observed to become less stable. The creek bank erosion protection and other reclamation measures have remained functional.

- Consequence Factor of 2 for the present location of the landslide relative to the northbound lanes of the highway. This is unchanged from the previous assessments.

Therefore, the current recommended Risk Level for this site is 10, which is decreased from the 2012 Risk Level of 12.

6.0 RECOMMENDATIONS

The recommendations for this site have changed from 2012, and are summarized below.

6.1 Maintenance and Short Term Measures

- The site has established vegetation growth and earth flows have become less apparent. The grading and vegetation recommendations from 2012 may become relevant again if conditions are observed to deteriorate in the future. No maintenance is required.

- A survey of the LPSTP crest is recommended if AT would like to confirm if deflection of the riverbank armouring has occurred due to slide movement.

6.2 Long Term Measures

- A drainage trench installed along the ditch-line parallel to the slope crest may reduce the rate of slope crest retrogression. Such a drainage trench should include an outlet pipe to an area midway down the slope. Alternatively, perforated soil nails could be installed at the head scarp to attempt to provide drainage outlets from within the slope. The slope face would need to be protected against erosion with either vegetative cover or erosion resistant matting (attached to the nails). AMEC could provide design details for either of these options if requested.

[2] AMEC Environment & Infrastructure, 2010.*Southern Region Geohazard Assessment, Annual Assessment Report, 2010*, Project Number CG25332.200, report submitted to AT October 14, 2010.

- The annual site inspections by AT and AMEC personnel should be continued.

6.3 Investigation

Based on observations within the last few years, future monitoring and investigation of this site was determined to be warranted to aid design of any future mitigation. AMEC is able to provide a cost estimate and proposal at AT's request. A summary of the expected scope of work is provided below.

- A site survey of the LPSTP, crest, ditch invert and several sections through the site area to allow for comparison of the current conditions with the as-built conditions for assessing the performance of the repair. A survey of the thalweg position and profile after a few years would allow comparison to the 2007 channel survey and assess changes in the channel cross-section and profile as a result of the 2008 installation of bank armouring and rock vanes. This would be of interest in further assessing and documenting this case history of the use of rock vanes and their effect on channel conditions.

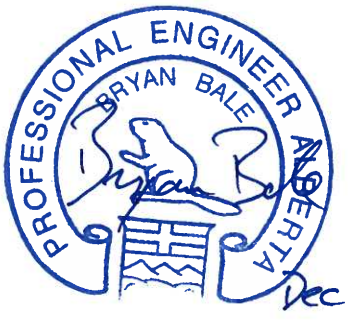
7.0 CLOSURE.

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



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