August 28, 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 S4 – Willow Creek, Highway 2:08
2009 Annual Inspection Report

This letter documents the 2009 annual site inspection of Site S4 – Willow Creek, along Highway 2:08, south of Claresholm, AB 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 ongoing landsliding driven by creek erosion along the toe of the slope is causing the slope crest to retrogress westwards towards the northbound lanes of Highway 2.

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 9, 2009 by Mr. Andrew Bidwell, P.Eng., Mr. Liv Hundal, P.Eng. and Mr. Bryan Bale, EIT of AMEC in the company of Mr. Ross Dickson, Mr. Fred Cheng, P.Eng. and Mr. Neil Kjelland, P.Eng. 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 the Geotechnical File Review (Section A of 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 occurred.

[1] AMEC report "Southern Region Geohazard Assessment, Annual Assessment Report, 2007", project number CG25263, submitted to AT on November 6, 2007.

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A repair was performed in late 2008 and consisted of:

- Rock armouring, channel training measures and bioengineering treatments to reduce creek erosion along the toe of the slope in the landslide area.

- Regrading and the installation of launched soil nails to stabilize the segment of the slope crest that had retrogressed towards the highway and westwards 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 1 and 2, attached, which are adapted from the as-constructed drawings for the 2008 repair and show the type and layout of the various repair measures at this site.

SITE OBSERVATIONS

Please refer to Photo S4-1 for a general view of the site as it appeared at the time of the June 2009 inspection. Key observations from the inspection were as follows:

- The longitudinal peak stone toe protection (LPSTP) along the right creek bank and the rock vanes angled into the channel to protect the bank from stream erosion were in good condition, as shown in Photos S4-2 and 3. The creek flow at the time of the June 2009 inspection was less than the design flow, however visual observations of the flow patterns and the location and distribution of visible turbulence in the flow showed that the most rapid flow was being diverted away from the right bank and there were a series of back-eddies along the right bank due to the influence of the vanes. The live siltation/brush layering (willows) installed along the LPSTP was beginning to “green-up” at the time of the inspection, however the willow growth had not yet started in earnest.

- The various bioengineering treatments that were applied across the site were, in general, “greening-up” well since application in October/November 2008. There were areas where specific treatments were performing relatively more poorly at the time of the June 2009 inspection, however in at least some of the areas this may have been due to the variable quality of workmanship by the field workshop participants. Specific areas where the bioengineering treatments were relatively less successful, as of the June 2009 site inspection, were as follows:

    - The fiber rolls that were staked into the upper slope in the soil disposal area a short distance south of the soil nailing area had slid downslope and accumulated on the bench formed by the soil disposal area on the lower slope, leaving behind an exposed soil slope with an indeterminate amount of the broadcast seed and fertilizer

remaining in place. See Photo S4-4 for an illustration. It was not clear if the staking for the fiber rolls that had slid away was not deep enough to hold them in place when exposed to slope wash flows earlier in 2008 or if localized areas with relatively steeper slope gradients had resulted in relatively greater amounts of slope wash and eroded soil loading the upslope side of the fiber rolls and causing them to slide away despite the staking, or a combination of those factors. There was negligible "greening-up" of the slope in the area where the fiber rolls had slid away, in contrast to the adjacent slope areas where the fiber rolls remained in place.

- As shown in Photo S4-5, there were only very minor amounts of vegetation growth in the flexible growth medium (FGM) application area on the regraded slope face below the soil nailing area. It appeared that specific areas were beginning to vegetate, but not uniformly across the treated area. This may have been due to windy conditions during the application of the FGM that prevented an even distribution of the sprayed material across the area. The rows of fiber rolls that had been staked into the slope in this area were in good condition. There were a number of well-developed tension cracks on the regraded slope in this area with aperture and downdrop up to roughly 50 mm at the time of the site inspection (see Photo S4-6). Based on the distribution and overall appearance of the tension cracks it appeared that they were caused by post-construction settlement of the areas on the slope that were regraded during construction along with ongoing downslope movement of this area towards the creek bank, which should be tapering off now that the creek bank is armoured.

- Gullying due to surface runoff had developed on the slope face across the lower portion of the soil disposal area and just above the LPSTP. Please refer to Photos S4-7 and S4-8 for an illustration, along with the approximate locations of these photos marked on Figure 1. The extent of the gullying varied between areas with different bioengineering treatments. The gullying in the portion of the slope face that had been reinforced with soil flaps and live brush layering was essentially restricted to the upper portion of the slope above the uppermost live brush layer (Photo S4-7). It appeared that the live brush layer prevented the gully erosion from propagating further downslope, and the middle and lower portion of the slope was well-covered with grass growth. In contrast, the area with live plantings and a blown compost blanket had well-defined gullies extending from crest-to-toe (Photo S4-8) with little to no vegetation growth on the slope aside from the live plantings which themselves were in reasonably good condition but only serving to prevent erosion around their immediate location at this early stage in their growth.

- The blown compost that was applied to several areas during the late 2008 repair did not stick sufficiently to the slopes in some locations, resulting in an uneven and patchy distribution. Based on observations during and shortly after the application of the blown compost, it appeared that windy conditions during and shortly after

application eroded away some of the compost material. This should be borne in mind during future applications of this method at other sites, and if necessary covering the blown compost with a biodegradable netting after application to help retain it on the slope until revegetation takes hold.

- The live staking and blown compost used on the gully sidewalls at the south end of the site was generally unsuccessful as of the June 2009 site inspection. It appeared that the live plantings staked directly into the native silts exposed in the gully sidewalls were not growing. In addition, little to none of the blown compost had stuck to the slope.

- The regraded and soil nail reinforced segment of the slope crest was in good condition at the time of the June 2009 site inspection with no apparent additional retrogression towards the highway since the completion of the repair. The unreinforced, and in places near vertical, slope crest in adjacent areas did not appear to have retrogressed significantly towards the fenceline since completion of the site repairs in late 2008.

- Surface erosion and the early stages of some erosion gully development were noted at several locations along the upper portion of the graded equipment access trail between the upland area adjacent to the north end of the site and the right bank of the creek (Photos S4-9 and S4-10). This erosion might have been prevented with the installation of diversion berms and cross-ditches to direct surface runoff off of the access trail at multiple locations during the site clean-up. To date, the consequences of this erosion have been relatively minor and it appeared that over time the erosion may begin to attenuate as the gullies forming where surface runoff flows off the access trail essentially begin to act as cross-ditches and the slope areas below the access trail continue to "green-up" and become more resistant to erosion.

- The segment of the headscarp of the landslide across the graded access trail has redeveloped (up to 0.5 m depth and roughly 0.25 m downdrop relative to the upland area) since the end of construction in November 2008, as shown in Photo S4-11. This indicates that the upper portion of the landslide area has continued to move since late 2008, however the slope crest position has not retrogressed towards the fenceline during that time. This type of continued movement in the upper valley slopes is expected to continue because, notwithstanding the armouring of the right creek bank that is intended to eliminate the erosion across the lower slope that is the root cause of the landsliding, the oversteepened upper portion of the valley slope will eventually eroded back to a more stable, long term slope angle. Such movements adjacent to the segments of the slope crest at greater than 20 m offset from the highway are of little consequence to the highway.

ASSESSMENT

Overall, the late 2008 repair works appeared to be in good condition and generally effective at the time of the June 2009 site inspection. A few more years will be required to confirm the continued effectiveness of the armouring and rock vanes along the right creek bank after multiple peak annual flows, however there are no indications of problems at this point. It is expected that the willow growth from the live siltation/brush layering along the armoured right bank will become established after the 2009 and 2010 growing seasons. This will further increase the effectiveness of the repair works along the right bank over time and lend a more aesthetic appearance to the armoured bank.

The trial applications of various bioengineering methods on the slopes above the creek bank are generally successful to date. However, as described in the previous section there are a few areas where specific methods have been relatively less successful either due to problems with the installation or site preparation. More time is required (e.g. at least one full growing season) to make a definitive assessment of which bioengineering measures worked best for this site.

The slope crest offset from the highway is essentially unchanged from the last observations in November 2008. The approximately 50 m segment of the slope crest that was regraded and reinforced with launched soil nails remains in good condition and is not expected to retrogress further towards the highway in the future. This can be confirmed with follow-up annual site inspections. Other segments of the slope crest that are currently east of the fenceline may retrogress westwards towards the fenceline and highway in the future as the upper portions of the valley slope erode back a longer term stable angle over time, notwithstanding the bank armouring along the toe of the slope. it may become necessary to perform additional stabilization work (e.g. launched soil nails or perhaps other measures on a trial basis) to prevent loss of ground around the existing fenceline. It is expected that this may become an issue only around the north and south flanks of the soil nail reinforced area, and the need for any supplementary work can be assessed as part of annual follow-up site inspections.

The tension cracking across the uppermost portion of the equipment access trail is of no consequence to the highway and of little to no consequence with respect to the landslide and surface erosion conditions on the valley slope. For reference, the access trail was intended for use during construction only with minimal decommissioning in order to keep it available for re-use if equipment access to the right bank of the creek is required in the future.

The surface erosion and gullying along the access trail may require some repair if the greening-up of the adjacent areas over the next year is not sufficient to prevent erosion by surface runoff from significantly affecting the slopes adjacent to the access trail. If such repair is required, it would likely be suitable to have laborers excavate cross-ditches and build-up diversion berms along with revegetation measures targeted at the damaged areas (e.g. hand seeding etc.). The

need for this can be evaluated again during the annual site inspection in 2010 and no action is recommended for the balance of 2009.

RISK LEVEL

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

- Probability Factor of 5 after the 2008 repairs. This is a reduction from the value of 9 recommended prior to the 2008 repairs. This value of the Probability Factor corresponds to an "Inactive, remote probability of remobilization……or active but very slow or indeterminate level of activity", and is judged appropriate now that the armouring and channel training measures are in place along the right bank of the creek and the segment of the slope crest that is closest to the highway has been stabilized by trimming it back to a gentler angle and installing launched soil nails. It may be possible to further reduce the Probability Factor after follow-up inspections during the next few years confirm that the repair work is holding up well after several more peak annual flows and the continued "greening up" of the erosion protection/bioengineering treatments.

- Consequence Factor of 2 for the present location of the landslide relative to the northbound lanes of the highway. This is unchanged from the 2008 assessment.

Therefore, the current recommended Risk Level for this site is 10, which is a reduction from the value of 18 recommended prior to the 2008 repair.

RECOMMENDATIONS

Maintenance and Short Term Measures

- As discussed during the site inspection, blown compost should be re-applied to the gully walls where the application during the late 2008 repair did not "stick" sufficiently. The re-application of the blown compost should be covered with biodegradable netting (pinned into the slope) to prevent the compost from blowing away before vegetation growth in the compost-covered areas becomes established.

- The 2009 and 2010 site post-construction environmental site assessments as required under Item 5 of the Department of Fisheries and Oceans (DFO) authorization for the 2008 repair work should be performed during low (summer) flow conditions, with reporting to DFO as required by July 31, 2010. AMEC has submitted a proposed scope and budget estimate to AT for this work and can start the 2009 site inspection upon approval by AT.

Long Term Measures

- The annual site inspections by AT and AMEC personnel should be continued in 2010 in order to check the site conditions after a full growing season since the repair and also after peak flows along Willow Creek in the spring of 2010. Specific items that should be checked during the 2010 annual inspection are:

    - The condition of the bank armouring and rock vanes, along with the growth of the willows along the armoured bank.

    - Vegetation growth at the various trial applications of the bioengineering treatments on the slopes above the armoured bank.

    - Surface erosion conditions along the equipment access trail. If necessary, flag locations for supplementary cross-ditches and diversion berms to be excavated along the access trail.

    The requirement for further annual inspections should be evaluated after the site observations in 2010.

- It would also be of interest to perform a bathymetric survey of the creek channel (including the thalweg position and profile) after a few years in order to compare to the 2007 channel survey and assess changes in the channel cross-section and profile as a result of the installation of the bank armouring and rock vanes in late 2008. 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, and could be cross-referenced to post-construction creek flow records for further interpretation.

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,

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a division of AMEC Americas Limited

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APEGGA Permit to Practice No. P-04546

Reviewed by:

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Attachments: Figures 1 and 2
Photos S4-1 to S4-11