4.4 S4 – WILLOW CREEK

Background

The Willow Creek site is located on the east side of Highway 2:08, approximately 4.7 km north of the bridge over the Oldman River.

The landslide at this site is occurring in the west slope of the Willow Creek valley, which is located to the east of Highway 2. The valley slope is approximately 15 to 20 m high and the minimum offset of the crest of the valley slope from the east edge of the highway has reduced from 25 m in July 2003 to 18 m as of December 2005. The landslide is located along the outside of a bend in the creek channel. It appears that movement of the landslide is triggered by creek erosion along the toe of the slope at the west bank of the creek which in turn leads to rotational failures within the landslide mass in the lower and middle portions of the west valley slope. The backscarps of these failures form a near-vertical bluff of exposed soil along the crest of the west valley slope. Subsequent block toppling failures along this bluff have led to retrogression of the slope crest near the fenceline. This retrogression appears to typically occur in increments in the order of 1 to 2 m at a time, rather than at a more gradual, steady pace.

This site has been monitored by AIT and consultant personnel since 1993. A series of SI's and piezometers were installed in 1994 and were read at various times up to the spring of 2003. During that time the SI's did not measure any significant movement. The SI's are not well-suited to provide early warning of crest retrogression given that the retrogression occurs as a result of block toppling failures along the existing crest rather than lateral movement along weak soil/bedrock layers underlying the slope. Therefore, the SI's are no longer being read on a regular basis and the current monitoring strategy for this site is based on surveys of the slope crest position and visual observations of the slope condition.

Please refer to Section A of the site binder for a more detailed discussion of the site background.

Site Assessment

The site assessment was performed on May 31, 2006. The weather at the time of the site assessment was sunny and clear. The inspection covered the area between the northbound lanes of Highway 2 and the slope crest, as well as a traverse down to the creek bank below the central portion of the landslide.

Please refer to Appendix S4 for a site plan (Figure S4-1) and representative cross-sections (Figures S4-2 and S4-3) from the site.

Observations

The following points summarize the observations made during the site assessment. Please also refer to Appendix S4 for a site plan, annotated photographs and figures illustrating key observations.

The overall condition of the landslide is generally the same as in previous years, however the following developments were noted to have occurred since the 2005 inspection:

- As shown in Photos S4-1 and S4-2, additional slope crest retrogression has occurred along the crest of the central portion of the landslide area to the west of the fenceline. The retrogression appeared to be relatively recent and has continued since the 2005 assessment (see Photo S4-3 for a view of the slope crest position from June 2005). The current minimum distance between the vertical/overhanging scarp (approximately 2 m high) at the crest of the slope and the east edge of the northbound lanes is approximately 15 m. This is a reduction from 18 m in December 2005 and 25 m in July 2003. The slope crest position relative to the highway is illustrated on Section B shown on Figures S4-1 and S4-2.

- The toe of the central portion of the landslide mass was thrust out into the creek channel, as shown on Figure S4-1 and in Photos S4-4 and S4-5. The position of the toe was approximately 10 to 15 m further out into the creek channel than had been noted in previous annual inspections. The visible surface of the toe thrust area appeared to have flowed downslope, however at the time of the inspection the surface was dry and hard.

- Significant additional movement at the north flank of the landslide around SI #10. Tension cracks were first noted in this area during the summer of 2002 as hairline cracks just visible through the grass cover with negligible lateral and vertical displacement. At the time of the 2006 site assessment, the blocks of soil had moved further down the slope, with vertical offsets from the top of the bank in the order of 2 to 3 m. New cracking features have also developed on top of the bank. There were several locations along the tension cracks where blocks of soil with live grass had fallen down into the open cracks, indicating recent movement prior to the inspection.

Assessment and Risk Level

- The observations from the 2006 site inspection show that the landslide remains active and continues to retrogress towards the northbound lanes of Highway 2. At the time of the inspection, the minimum offset between the slope crest and the edge of the pavement was approximately 15 m. The slope crest will continue to retrogress westwards towards the highway in response to ongoing landslide movement in the middle and lower portions of the west valley slope. It would likely take some time, possibly years, before the slope crest retrogression would directly undermine the northbound lanes of the highway. However, prior to that point a guardrail along the east shoulder of the road will be required due to the proximity of the slope crest to the road.

- The slope crest retrogression towards the highway occurs in response to landslide movement in the middle and lower portions of the west valley slope. This landslide movement is caused by creek erosion along west creek bank/toe of the west valley slope. There is a lag time between landslide movement on the middle and lower slopes and the subsequent increment of crest retrogression towards the highway. Therefore, if

mitigative measures are implemented to reduce the landslide movement caused by creek erosion the crest retrogression should also be reduced but not immediately. It is expected that even if creek erosion at the toe were fully mitigated, the slope crest would retrogress westwards until a stable angle for the material exposed in the slope face is reached. If the ultimate slope crest position along Section B (Figures S4-1 and S4-2) is estimated by extrapolating the slope angle from the lower slope up to the highway elevation, the ultimate slope crest position will eventually be within the northbound lanes of the highway. This indicates that the upper portion of the slope will need to be stabilized in conjunction with mitigative measures at the toe of the valley slope.

- It is also possible that changes to the erosion conditions at the toe of the slope resulting from hydrological changes to Willow Creek (i.e. channel shifting upstream or downstream of the site, long-term flow volumes and patterns) may affect the rate of retrogression towards the highway.

Therefore, AMEC recommends the following Risk Level factors for this site:

- Probability Factor of 9 because the landslide is active and westward crest retrogression towards the highway will continue.

- Consequence Factor of 2 for the present location of the landslide relative to the northbound lanes of the highway.

Therefore, the current recommended Risk Level for this site is equal to 18, which is the same as recommended following the 2005 assessment.

Discussion and Recommendations

AMEC understands from AIT that realignment of the northbound lanes of the highway to a location further away from the crest of the west valley slope is not considered to be a feasible option because it would create significant other work north and south of the site to reposition intersections etc.

AMEC recommends the following work for this site:

Design and implement mitigative measures to reduce the landslide risk to the northbound lanes of the highway.

1. Perform a LiDAR survey of the site in order to obtain detailed topographic data for the landslide area, adjacent highway alignment and the creek channel both adjacent to and upstream/downstream of the landslide area.
2. Hydrotechnical assessment and design of mitigative measures to reduce creek erosion along the toe of the landslide area.
3. Geotechnical assessment and design of slope regrading, surface runoff control and erosion protection/revegetation of the upper portion of the landslide slope.

4. Install a guardrail along the east shoulder of the highway adjacent to the area of maximum slope crest retrogression.

AMEC will submit a proposal and cost estimate to AIT for Items 1 to 3, above, under separate cover.

The annual assessments at this site should be continued.