

## **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 m high and the crest of the valley slope is approximately 25 m from the east edge of the highway. The landslide is located along the outside of a bend in the creek channel. It appears that movement of the landslide is triggered by 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 along with block toppling failures along the near-vertical bluff of exposed soils at the crest of the valley slope. The toppling failures along the overall crest of the landslide have led to retrogression of the slope crest near the fenceline. This retrogression typically occurs in increments in the order of 0.5 to 1 m at a time, rather than at a more gradual, steady pace.

This site has been monitored by AT 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 slope crest 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 regular 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 26, 2004. The weather at the time of the site assessment was partly cloudy with a very strong wind. The highway surface and the area between the northbound lanes and the slope crest along the fenceline were inspected. The current condition of the newest landslide block forming around SI #10 was also checked.

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 annotated photographs illustrating key observations.

- The overall condition of the landslide is generally the same as in previous years, as shown in Photo S4-1. The toe erosion due to the creek flow is continuing.

- As noted during previous assessments, the point of maximum westward retrogression of the slope crest is at the fenceline adjacent to SI #8. This gives a minimum offset of approximately 25 m between the east edge of the road and the slope crest. It did not appear that the slope crest had retrogressed significantly since the previous assessment. Photos S4-2 and S4-3 show this location.
- The new landslide block that was first noted to the northeast of SI #10 in the summer of 2002 is continuing to develop. Photo S4-4 shows a typical view of the tension crack/headscarp of this landslide block. The tension cracks for the new landslide block around SI #10 are now approximately up to 0.5 to 1 m in width, with similar maximum magnitudes of vertical displacement. When these tension cracks were first noted in the summer of 2002 they were hairline cracks just visible through the grass cover with negligible lateral and vertical displacement.

### **Assessment and Risk Level**

There does not appear to have been significant retrogression of the overall slope crest since the July 2003 assessment, however this landslide remains active. The most active movement areas are the segment of the west creek bank at the toe of the overall landslide mass and the new landslide block that is developing to the northeast of SI #10. Ongoing landslide movement at this site will result in the crest of the valley slope retrogressing further to the west, and reducing the offset between the east shoulder of the northbound lanes of the highway and the slope crest. It will likely take some time, possibly in the order of decades, before the slope crest retrogression begins to directly threaten the northbound lanes of the highway. 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.

The slope cross-sections shown on Figures S4-2 and S4-3 in Appendix S4 were used to perform a rough check of how much slope crest retrogression may ultimately occur. The existing lower portion of the landslide mass is currently at a slope angle of approximately 11.5°. If this slope angle is extended to the west from the current position of the toe of the valley slope/west bank of the creek along Section C, then the long-term slope crest could be located approximately within 5 m of the east edge of the highway. This indicates that the ongoing retrogression of the slope crest could eventually threaten the northbound lanes of the highway, however as noted above this is expected to take many years, possibly in the order of decades.

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. This is a reduction from the value of 11 recommended after the 2003 assessment because of the rate of crest retrogression observed in the past year.

- 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 a reduction from the value of 22 recommended after the 2003 assessment.

Stabilization of this landslide would be a major undertaking that would likely involve significant river training works as a minimum and likely significant earthworks on the slope itself. This work would require construction of an access route for construction equipment down to the toe of the valley slope. Therefore, it may be most practical to allow the landslide to run its course and allow for future realignment of the highway to the west as required.

### **Recommendations**

AMEC recommends the following future work for this site:

**The annual assessments at this site should be continued.**

**Perform a slope crest position survey in summer of 2004.** The current crest position should then be compared to the 2003 survey in order to provide further information towards estimating the average rate of retrogression towards the highway.

As a general note, the design of any remedial measures should be deferred at this time because any design work may become outdated before it is required to be implemented.