4.16 S19 – HIGHWAY 40 – KING CREEK

Background

The King Creek crossing on Highway 40 is located approximately 200 m north of the junction between Highway 40 and Highway 742, which is also the winter gate at the northern end of the segment of Highway 40 that is closed between December 1st and June 15th every year. Please refer to Figure S19-1 in Appendix S19 for an illustration of the site location.

Highway 40 crosses King Creek via a fill embankment over a large, multi-plate culvert. The embankment sideslopes are at approximately 20° inclination. The height of the upstream face of the embankment is approximately 16 to 18 m. Photo S19-2 in Appendix S19 shows the upstream face of the highway embankment. The height of the downstream face of the embankment is approximately 20 to 22 m.

An inspection of this site was performed by AMEC in July 2005 after a debris flow hazard was identified during the airphoto review as part of the geohazard review for the Highway 40 / Highway 541 corridor. This debris flow hazard was previously noted by Cruden and Eaton during their 1984/1985 review[5] of potential geohazards with respect to infrastructure development in Kananaskis Country. The key points regarding the debris flow hazard from the 2006 report on the highway corridor geohazard review are summarized as follows:

- The source material for potential debris flows accumulates in the narrow bedrock canyon upstream of the highway crossing from the following sources:
    - The colluvium from widespread rockfall areas on the slope above the bedrock canyon that is transported down to the King Creek channel by snow avalanches and debris flows along tributary gullies.
    - Slope instability along the walls of the bedrock canyon upstream of the highway. These slopes are prone to toppling failures due to the orientation of the jointing and fracturing of the exposed rock.
- Due to the accumulation of debris from these sources, debris flows can occur along the King Creek channel and may be triggered by heavy precipitation and the melting of relatively heavy annual snow packs in the spring. It is also possible for “rain on snow” events in the spring to trigger debris flows.
- Debris flow deposits were noted within the bedrock canyon and along the active floodplain of the alluvial fan downstream of the canyon outlet during the 1984 and 1985 traverses by Cruden and Eaton. The same conditions were noted in the 2005 inspection by AMEC.

[5] Cruden, D.M., and Eaton, T.M. (1985). “Reconnaissance of Rockslide Hazards in Kananaskis Country.” Report to The Minister of Transportation, Government of Alberta, 204 p.

Debris flows along the King Creek channel have the potential to damage the highway culvert and embankment due to:

- Debris impact, possibly intensified by blockage of the bedrock canyon upstream of the highway (by avalanches from tributary gullies and/or damming by debris), that would result in a headpond forming and subsequently breaching or overtopping with a larger and more powerful debris flow.

- Blockage of the highway culvert by debris and the potential for a large headpond of water to form along the upstream side of the embankment. Even though the culvert has a large diameter, an accumulation of logs and various sized rocks could build up around the inlet and cause a blockage.

There is also a possibility of debris flows causing flooding of the former gravel pit downstream of the highway embankment and perhaps some concurrent damage to the adjacent highway maintenance yard and provincial park administration and residential facilities. This could occur if the creek channel shifts through an existing levee along the left bank (facing downstream) of the channel adjacent to the gravel pit, either under peak flow conditions or possibly intensified by a peak flow following the overtopping and breach of a debris dam or culvert blockage upstream.

The June 2007 site inspection was the first annual site inspection under the Southern Region GRMP and the first site inspection since late 2005. This site was added to the annual site inspection tour because its recommended Risk Level was one of the highest in the geohazards review of the Highway 40 / Highway 541 corridor.

Site Assessment

The site assessment was performed on June 19, 2007. The weather at the time of the site assessment was clear and mild.

The site assessment consisted of a visual inspection of the culvert inlet, east slope of the highway embankment and the creek floodplain between the highway and the outlet of the bedrock canyon approximately 200 m upstream.

Observations

Overall, there were no significant changes to the site condition since the 2005 inspection. The following points summarize the observations made during the site assessment. Please also refer to Appendix S19 for photographs.

1. The culvert inlet was clear of debris at the time of the inspection.

2. There was debris on the floodplain between the culvert inlet and the outlet of the bedrock canyon approximately 200 m upstream of the highway. The amount of debris was similar to that noted during the 2005 inspection.

Assessment and Risk Level

The overall assessment of the risk to the highway from the debris flow hazard along the King Creek channel has not changed since the 2005 inspection. There is a possibility of the following worst case scenario occurring:

- Peak creek flow volumes in the spring/early summer cause the culvert inlet to become mostly blocked with debris over a short period of time (e.g. in the order of 1 to 2 days).

- Prompt mobilization of heavy equipment is required to clear the accumulated debris from the culvert inlet and prevent full blockage and impoundment of water on the upstream side of the highway embankment. If full blockage occurred and a significant volume of water was impounded, a sudden breach of the debris blocking the culvert and/or of the highway embankment itself would release a volume of water that would likely overtop the levee along the south side of the creek channel downstream of the highway. This would flood the sports fields in the former gravel pit and possibly also impact on the provincial park and highway maintenance yard facilities.

Granted, this is for a worst case scenario but one that is considered possible during the lifetime of the highway given the evidence of previous large debris flows at this site.

After further consideration and the more recent inspections, it is judged that for a 'typical' year, the area upstream of the culvert inlet and the culvert itself are of sufficient size to accommodate annual debris accumulations/flow.

Therefore, AMEC recommends the following Risk Level factors for this site using the debris flow frequency-severity matrix (Table A3, in Appendix A):

- Probability Factor of 10 based on the channel morphology and condition upstream of the highway and the debris flow deposits along the channel that suggest that debris flows of some magnitude occur most years.

- Consequence Factor as follows:

- For most years, a Consequence Factor of 1 because the annual debris flows occur without consequence to the highway.

- For the estimated most likely worst case scenario, a Consequence Factor of 5.

Therefore, the recommended Risk Levels for this site are 10 and 50, for 'typical' years and the worst-case (but lower probability) scenario, respectively.

It should also be noted that it is possible that future avalanching and/or forest fires could reduce the tree cover on the slopes in the upper portion of the King Creek watershed and increase the runoff/erosion that erodes debris into the creek channel. The Probability Factor may rise under such conditions.

Recommendations

In order to manage and reduce the Risk Level at this site, AMEC recommends that "trash racks" be installed in the creek floodplain upstream of the culvert inlet to protect against debris accumulation around the culvert inlet and provide additional buffer against the likely worst case scenario described above. With such "trash racks" in place, the Consequence Factor could be lowered to 1 or 2. There is suitable access for heavy equipment to the creek floodplain upstream of the culvert inlet for installation and follow-up cleaning of the trash racks. The design of the "trash racks" and planning of the work would include an assessment of environmental permitting requirements and regulations regarding construction work along the creek channel.

Based on discussions on site with AIT during the June 2007 inspection, AMEC understands that AIT does not want to investigate or design the recommended "trash racks" because it is anticipated that their construction would not be permitted for environmental reasons.

Another option for managing the debris flow hazard at this site that was discussed during the June 2007 site inspection is to install a second culvert through the highway embankment at an elevation above the existing culvert and offset from the creek channel. This second culvert would act as an "emergency drain" for creek flow in the event of a debris flow blocking the existing culvert and causing water to impound upstream of the highway embankment. The installation of the second culvert could likely be done using a trenchless method in order to avoid disruption to traffic along the highway. A potential location for the culvert inlet is marked on Photo S19-2 in Appendix S19. The construction equipment could access this area via the old access trail from the King Creek picnic area parking lot on the south side of the creek channel.

AMEC recommends that a design and cost estimate for the second culvert be prepared so that AIT can consider the cost/benefit of this method to help reduce the risk to the highway embankment.