Alberta Transportation
Site S15 – Crowsnest Rockfall
Highway 3:02, km 3.431, west of Blairmore
Site Data – Summary Binder

Section A
File Review

1 SITE LOCATION

The S15 – Crowsnest Rockfall site (the site) is located on highway 3:02 (H3:02) at km 3.43, which is approximately 13 km west of the Municipality of Blairmore, Alberta, and approximately 3 km east of the Alberta-British Columbia border. The site is located at:

- 49°37.535' N, 114°38.960' W (NAD 83),
- Legal land description (LSD) NW 5-8-5 W5,
- NTS Mapsheet 82G10.

2 SITE DESCRIPTION

At the site, H3:02 is a paved two-lane highway orientated in the southwest-northeast direction. There is a culvert under the highway with the outlet draining into Crowsnest Lake on the north side of the H3:02. On the south side of H3:02, a barrier net preventing rocks and debris from falling onto the highway was constructed around a gully outlet in a rock cut slope. The net has not been entirely effective in preventing rocks from reaching H3:02 as the guardrail on the opposite (north) side of the highway has been damaged by falling rocks that have bounced across the highway.

3 CHRONOLOGICAL BACKGROUND

The table below provides a brief chronological background of the site. The first known inspection of the site was completed in 1999. However, KCB was only able to locate annual site inspections from 2006 to 2013 and 2016. There are no inspection records for 2014 or 2015.

Klohn Crippen Berger Ltd. • Suite 301, 2627 Ellwood Drive SW • Edmonton AB T6X 0P7 • CANADA
780.444.0706 t • 780.481.2431 f • www.klohn.com

Table 1 Chronological Background of Site S15 – Crowsnest Rockfall

Date	Description
1999	A geotechnical assessment of the site was performed for Alberta Infrastructure and Transportation (AIT, now AT). It is unclear who completed the geotechnical assessment. The assessment led to the construction of a 2 layer, concrete lock-block wall downslope of the outlet of the gully outlet (Amec, 2006).
Fall 2000	A concrete lock-block wall was constructed in the fall of 2000. Scaling of the adjacent rock slopes was completed at the same time as construction of the wall (Amec, 2006).
2003	The maintenance contractor noted an increased volume and frequency of rockfalls at the site, with rocks the size of small boulders reaching the wall and on several occasions, being deposited in the eastbound (south) lane of the highway (Amec, 2006). Amec inspected the site and recommended the concrete lock-block wall be replaced with a rockfall barrier net.
April 2004	A large boulder (approximately 2.2 m x 1.3 m x 0.9 m) was deposited on the centerline of the highway (Amec, 2006).
November 2005	The concrete lock-block wall was replaced with a rockfall barrier net (Amec, 2006).
May 2006	An annual site inspection was completed by Amec Infrastructure and Transportation (Amec). In April 2006, a large boulder struck the rockfall barrier, destroying one of the barrier support columns, damaging the barrier ring net, and the line of concrete jersey barriers between the barrier net and the edge of the highway (Amec, 2006). The east anchor pile for the rockfall barrier net appeared to have been pulled approximately 50 mm laterally to the west toward the barrier net. Amec recommended that the barrier net be repaired, and noted the expected repair is to be completed in July 2006.
June 2007	In early 2007, the maintenance contractor noted three of the four barrier support posts were lying flat on the ground and the pins through the base of each post had been sheared off (as designed) by an impact. The pins had to be replaced and the posts placed back in the upright position. Damage observed on the barrier included a damaged barrier post, a broken seam rope, and a missing net ring (Amec, 2007). The east anchor ropes were left disconnected by the maintenance contractor to allow access for a loader to remove debris from behind the barrier. Amec noted this significantly reduced the capacity of the rockfall barrier net.
June 2008	An annual site inspection was completed by Amec and AT personnel. An erosion gully on the slope above the barrier net was noted to have continued to increase in size and the rockfall source area in the upper portion of the gully may have expanded laterally. Several anchor and seam cables were not sufficiently tensioned (Amec, 2008). A large accumulation of rockfall debris in a cone extending downslope from a gully outlet was observed.
June 2009	An annual site inspection was completed by Amec and AT personnel. Amec (2009) noted the barrier as being in fair condition after the late 2008 maintenance, repairs, and removal of debris from behind the barrier. One support post was bent and leaning towards the highway. Some wire rope rings had been severed and there are several gaps were observed in the chain link mesh. Anchor cables on the east end of the barrier were disconnected at the time of the inspection, reducing the barrier's ability to withstand an impact from falling debris. The erosion gully had expanded since the 2008 site inspection.
June 2010	An annual site inspection was completed by Amec and AT personnel. The barrier was noted as being in poor condition and requiring maintenance. Amec (2010) noted a large cone of rockfall debris; the east post support cables were disconnected; two middle posts had activated braking elements on the support cables or broken cables entirely; at least one post had a broken shear pin at its base; debris in the barrier net has pulled the net down, reducing its effective height; and damage to the barrier net has resulted in gaps in the net. Gravel and cobble sized rocks were on the road shoulder, indicating that rocks may bounce over or through the barrier. A rockfall west of the barrier was

Date	Description
	noted as being a concern with predominantly gravel to cobble sized rock being in the ditch and edge of the road. The erosion gully upslope of the barrier expanded since the 2009 site inspection.
June 2011	An annual site inspection was completed by Amec and AT personnel. The barrier was noted as being in poor condition and requiring maintenance. Amec (2011) noted a large cone of rockfall debris; debris pushing the net toward the highway; one barrier net support tilted (at approximately 45°) toward the highway; braking elements on support cables had been activated; several holes and tears in the chain link fence and barrier net; insufficient tensioned cables. The erosion gully upslope of the barrier was noted to have retrogressed since the 2010 site inspection. The guardrail on the north (opposite) side of the road showed damage from rock strikes. The rockfall west of the barrier was noted as remaining a concern, with the same issues as noted in 2010. The volume of rockfall and debris behind the barrier is large and required frequent and expensive removal of the accumulated debris. Rockfalls observed since 2006 have been larger (up to approximately 6 m^3) than the 2005 design estimates. A revised analysis showed the larger rockfalls will exceed the barrier capacity.
June 2012	An annual site inspection was completed by Amec and AT personnel. A replacement rockfall barrier was installed in the spring of 2012 (prior to the June 2012 site inspection). The replacement barrier consists for two offset barriers allowing room for equipment access. No significant amounts of rockfall had accumulated behind the barrier at the time of the inspection. The erosion gully upslope of the barrier had increased in size since the 2011 site inspection. The rockfall west of the barrier was noted as remaining a concern, with the same issues as noted in 2011.
May 2013	An annual site inspection was completed by Amec and AT personnel. Amec (2013) noted the site condition was relatively unchanged from the 2012 inspection, with the rockfall barrier being in good condition. A large amount of rockfall debris had accumulated behind the barrier since the 2012 site inspection. Impact marks were found on the road surface and guardrail west of the site, which were reportedly due to scaling during the barrier replacement in 2012. The erosion gully upslope of the barrier appeared steeper and had retrogressed since the 2012 site inspection. A rock at the edge of the appeared to have outflanked the barrier on the west side.
June 2016	An annual site inspection was completed by KCB and AT personnel. KCB noted that the 2012 barrier net was recently replaced by two free-standing barrier nets. The erosion gully at the top of the slope appeared to have retrogressed since the 2015 site inspection (pers. Communication with AT during the 2016 inspection, records of 2015 inspection not available). KCB recommended adding jersey barriers at the edge of the road ad removing debris from behind the barrier nets on a regular schedule.

4 SITE GEOLOGY, HYDROGEOLOGY, AND GEOMORPHIC SETTING

Topographic maps from the Department of Energy, Mines and Resources (1980) show the ground surface elevation at the site is approximately 1370 m above mean sea level (a.m.s.l.). AGS (2015) sediment thickness maps show there is likely 0 m to 5 m of sediment near the site. This agrees with the AGS interactive soil maps, which indicate that exposed bedrock is present near the site. Since the site is in a valley, there are likely colluvial and fluvial deposits nearby. The colluvial deposits may contain pre-existing bedrock, till, glaciolacustrine, glaciofluvial and/or eolian sediments, that are generally poorly sorted, and in places may include a significant component of fluvial deposits. The

fluvial deposits are poorly- to well-sorted, stratified-to-massive sand, gravel, silt, clay, and organic sediment.

At the site, AGS bedrock topography maps show the bedrock is near the ground surface elevation (approximately 1370 m a.m.s.l.). This agrees with the AGS interactive soil maps, which shows the ground surface consists of bedrock that is mainly of clastic rocks, and limestone and dolostone are near the site. AGS bedrock geology maps of the site area show the bedrock is likely Uppermost Devonian and Carboniferous, or Devonian. The Uppermost Devonian and Carboniferous group includes the Banff and Exshaw Formations. The Banff Formation consist of cherty and argillaceous limestone that is grey and black, siltstone, shale, dolostone, and banded chert. The Exshaw Formation consist of grey and brownish grey shale, calcareous dolomitic shale, argillaceous siltstone, and silty dolostone. The Devonian group includes the Palliser Formation, Alexo Formation, and Fairholme Group. The Palliser Formation consists of dolomitc limestone, mottled, thick bedded to massive; limestone, dense, grey, micritic; dolostone, greyish brown, fossiliferous. The Alexo Formation consists of silty dolostone, thinly to medium bedded; argillaceous siltstone, grey and greenish grey, laminated; dolomitic sandstone; dolostone, vuggy, light grey; dolostone and limestone breccia. The Fairholme Group consists of the Southesk, Cairn, Mount Hawk, Perdrix, Maligne, and Flume Formations.

Hydrogeological maps from AGS (2005) show the ground water in the area is very close to the ground surface and flowing from higher elevations towards the valley where the site is located. Amec (2006) noted standing water in the ditch around and upslope of the rockfall barrier net, as well as groundwater springs in the talus slope and rock cut slope behind the rockfall barrier.

5 SITE PROBLEMS

The record of site problems is given in Table 1. The site was identified as posing a safety issue to the public and AT's infrastructure in 1999. Between 1999 and 2016, three different rockfall barrier structures have been installed on the south side of H3:02 at the site. There is an erosion gully upslope of the rockfall barriers that is noted to be increasing in size with each annual site inspection. This erosion gully is thought to be one of the contributing factors to the rockfalls at the site.

6 PREVIOUS SITE INVESTIGATIONS

The first noted geotechnical inspection of the site was in 1999. Site inspection reports between 1999 and 2006 were not readily available. Annual site inspections were completed between 2006 and 2013. It is unclear if the site was inspected in 2014 and 2015. The most recent site inspection was completed in 2016. There are no boreholes or instruments at the site.

7 REPAIR WORK AND MITIGATIVE MEASURES IMPLEMENTED

A 1999 geotechnical investigation of the site resulted in the placement of a two-layer concrete lock-block wall at the base of the gully. In 2003, Amec recommended the concrete lock-blocks be replaced with a rockfall barrier net. The concrete lock-blocks were replaced with a rockfall barrier net in

November 2005. Annual site inspections between 2006 and 2011 indicate there was ongoing damage to the rockfall barrier net including damaged support posts, damaged or sheared pins, broken cables and seams, as well as damage and holes in the barrier net. In the spring of 2012, a replacement rockfall barrier was installed. The 2016 site inspection indicates that two free standing barrier nets replaced the rockfall barrier that was installed in 2012. Throughout the lifespan of this site, the maintenance contractor has been required to remove rockfall debris from behind the barriers.

8 MONITORING OVERVIEW

There are no instruments at the site, therefore, the only monitoring of the site is based on visual inspection.

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