KLOHN CRIPPEN

July 18, 2005

Alberta Infrastructure & Transportation
Central Region
#401, 4902 – 51 Street
Red Deer, Alberta
T4N 6K8

Mr. Alain Momedi, P.Eng.
Project Engineer

Dear Mr. Momedi:

Central Region GeoHazard Assessment
H837:02 Riverbank Erosion at km 2
Geotechnical Callout Report

This geotechnical callout report was prepared by Klohn Crippen Consultants Ltd. (Klohn Crippen) for Alberta Infrastructure & Transportation Central Region under the Geohazard Assessment Agreement CE 045/2004. The site inspection was undertaken on July 12, 2005 by Mr. Darren Ratcliffe, P.Eng., of Klohn Crippen Consultants Ltd. This site was previously inspected on May 27, 2005 as part of the annual review tour.

The site is illustrated on Figure 1 and in the attached photographs for the two inspections.

1. PROJECT BACKGROUND

About 10 km northwest of Drumheller, Highway 837:02 was constructed at the base of the Red Deer River valley. The highway is primarily used by tourists in the summer as part of the "Dinosaur Trail" to access the Royal Tyrrell Museum of Paleontology, the Midlands Provincial Park and the surrounding Badlands area.

The highway is located at the toe of a steep valley slope (about 1.5H:1V) and for a length of about 860 m is directly adjacent to the Red Deer River. It is believed that the road was constructed on an original trail along a narrow terrace in the area and the surfacing was placed on native material. Drilling was performed in 1981 and indicated about 0.5 m to 5.5 m of medium to high plasticity clay (weathered bedrock) over sandstones and shales. For this 860 m long section of the highway, the surfacing consisted of gravel and an oil-bound surface.

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Over the last twenty years numerous proposals have been put forward to improve this highway to a minimum RCU 209 design standard. Due to the narrow terrace, various types of reinforced earth retaining walls or riprap protected granular fills pushed out into the river have been proposed. In 1988, it was agreed that it was unreasonable to spend the $1.0M to $1.5M required to carry out these measures and protect this section of highway. Instead, a 2.5 m deep ditch was proposed beside the road at the base of the hill, with a target for the riverside fill slopes towards the river set at 2H:1V. Guardrails were also proposed to be installed adjacent to the river. Although a nominal ditch was constructed at the toe of the valley slopes, no other improvement works were undertaken.

A study in 1992 recommended providing a 0.5 m minimum freeboard above the 1:100 year flood level (highwater elevation 688.6 m). The recommended bank protection measures using Class II rock riprap would cost about $700,000 for the 860 m long section. This section of road has washed away at least twice, most recently in either 1948 or 1951. No additional erosion protection measures were installed at the toe of the slope, so additional repair work was anticipated in the future along this section of highway.

During the summer of 2000, Alberta Transportation noted an instability in the riverbank at about km 1.9 in the 860 m section adjacent to the river. The slide was observed for at least the first two weeks of July while highway patching work in the area was carried out. Deterioration in the condition of the slope following a period of rain was reported on July 14, 2000. Further deterioration of the slide area was subsequently reported to Klohn Crippen on July 25, 2000.

At this location, the highway pavement is 6.7 m wide and the scarp of the slip was about 0.8 m from the edge of the paved surface. By July 25, 2000 the scarp had further advanced towards the road and was 0.7 m from the edge of the pavement. The width of the slide at this point was about 4 m, however, cracking and evidence of slide/slumping activity extended for about 14 m. The road surface was about 7 m above river level. The existing riverbank slopes were typically very steep (about 1H:1V or steeper) and slow erosion of the toe of the riverbank by the river was ongoing. The slide material at the edge of the river appeared to consist of fine-grained, clay-rich soil-like material, most likely consisting of weathered bedrock material. The material becomes very soft when wet and is erodible.

Sloughing of the steep backslopes above the road was highly apparent. The road ditch on the west side of the road, at the toe of the backslope, completely silts up at this location on a regular basis. It appeared that storm runoff was flowing across the road and down the slide area towards the river. The flow of water was causing both erosion and softening/slumping of slope material. It appeared that a substantial portion of the material that would have comprised the original slope between the road and the river had

been eroded away and thereby reduced the stability of the slope. Common practice in the past was to excavate the ditch and place the waste material at the crest of the riverbank. It was recommended that this practice should stop due to the adverse effect on the stability of the riverbank.

In the fall of 2000, the ditch on the west side of the road was excavated to a depth of about 0.5 m. Pit run gravel was placed in the scour zone by dumping over the edge of the scarp. No riprap was placed at the toe. Despite significant movement of the gravel out into the river, a shoulder of about 2 m wide was formed at the road edge.

In May 2001, the area was largely unchanged from the previous fall, but precipitation levels had been low. However, in July 2001 higher precipitation levels were experienced in the area. The resulting runoff caused the gravel to slide and create a scarp at the road edge. To alleviate the hazard to traffic, native fill was placed at the top of the slide area to create a shoulder. In a matter of days, the new fill had also slid down towards the river. The slide area appeared to be extending both upstream and downstream. Beyond the slide itself, cracks were also appearing at the crest of the riverbank. The location of the cracks tended to suggest that the near vertical banks located immediately to the north and south were also becoming unstable.

From a review of the riverbank along the highway section, it was believed that river erosion was a contributing factor in the observed instability. However, areas along the river, on the outside of the same river bend, were well vegetated and were showing less sign of erosion. The primary trigger for the observed instability at this site is the change in road camber at the top of the slide. It would appear that the highway grade concentrates the sheet runoff flow moving down the road over the bank in the area of the slide. It is observed that the native material becomes very soft when wet. The combination of the very steep slope, the close proximity to the Red Deer River, and the runoff flow softening the slope material is creating the slide conditions.

Based on a review of previous stabilization proposals and the relatively low usage of the road, it was considered that a “low-cost” remedial solution was required. The recommended remedial action was to use of a rip rap toe berm in conjunction with compacted pit run gravel fill to reinstate the overall slope to about 2H:1V with a 2 m wide shoulder at the highway edge. Changes to the pavement drainage were also recommended, but were not included in the repair work. These changes included: the provision of asphalt curbs either at the road edge to stop water flow down the slope to the river or at the edge of the ditch to increase capacity; or adding asphalt surfacing to reverse the camber away from the river into the ditch.

During construction, a slide occurred in the very soft riverbed sediments when the gravel berm was close to completion. The remediation design was subsequently revised to include a flattened toe area at about 3H:1V, with a steepened upper portion at about 1.5H:1V. Additional rip rap was provided to replace material buried in the berm and river bed.

The repair work was awarded to the local highway maintenance contractor, Ledcor Industries in September 2002. Construction started on October 1, 2002 and was substantially complete by October 10, 2002. The total cost of construction work completed in October 2002 was $53,758.

2. JULY 2005 INSPECTION

From the inspection conducted on July 12, 2005 the following features were observed and are shown on Figure 1:

- ditch excavation spoil piles are still being placed at the crest of the riverbank despite our recommendations not to do so in our previous reports.
- gravel bank section constructed in 2002 is performing well
- the steep adjacent section of riverbank north of the gravel berm has slumped over a width of about 13 m due to the June 2005 flood.
- slumping is occurring in the wider riverbank section to the north of the gravel berm and has been worsened by the recent heavy rain. The section is about 75 m long. The mechanism appears to be related to erosion caused by runoff flowing down the backslope and over the road. The toe of the slope by the river shows no instability. Cracks are appearing in the pavement due to the loss of soil support.
- sloughing of the steep backslopes above the road was highly apparent with some blockage of the ditch below.

3. SITE ASSESSMENT

As previously noted, the combination of the close proximity to the Red Deer River, and the runoff flow softening the slope material is creating the slumping conditions. The slumping of the bank north of the existing gravel fill was caused by the June 2005 flood. The slumping in the wide riverbank section was considerably worsened by the June 2005 flood.

Based on the risk level criteria provided by Alberta Infrastructure & Transportation relating to safety, a risk rating of 36 was assigned to this site. This is based on a probability factor of 9 for an active erosion feature, and a consequence factor of 4 due to the potential for the loss of the highway edge.

4. PROPOSED REMEDIATION

The following remediation is recommended for the narrow riverbank section adjacent to the gravel berm and for the wide riverbank section to the north shown on Figures 2 and 3.

Narrow Riverbank Section

- It was originally proposed that the most efficient and economical remedial action was to make use of a protection/retention toe berm in conjunction with compacted pit run gravel to reinstate the overall slope to about 2H:1V. To effectively stabilize the slope, the reinstatement must occur working from the bottom to the top. It is recommended that the existing gravel berm be extended northwards of similar construction. To reduce the risk of movement, geo-grid reinforcement is to be included within the gravel at 0.5 m vertical spacing.
- At the previous request of DFO, the toe berm is to comprise traditional Class II rock riprap with no in-stream work occurring between April 16 and June 30. It is proposed to place the berm with a backhoe or similar equipment to lower the rocks into place. The function of the rip rap toe berm is to provide confinement for the pit run gravel, to initiate consolidation of the soft river bed sediments, and for long term protection against river flows.
- Based on the proposed design of a 2 m wide shoulder beside the highway and a 2H:1V slope, the toe location is to be determined. Non-woven filter fabric is to be placed at all soil-gravel interfaces (laid perpendicular to the road alignment) and between the gravel and the riprap.
- Gravel placement and grading will be undertaken to grade the new fill with the existing.

Wide Riverbank Section

It is considered that the observed slumping is related to softening of the bank due to runoff flows from the road. The proposed remediation is therefore to reinstate and flatten the riverbank slopes, provide a hard shoulder, and provide protection against runoff flows over a riverbank length of about 75 m. Seeding is also recommended to improve the stability of the slope and improve the appearance. The following approach is recommended:

- Flatten slopes to about 3H:1V using compacted common fill. Non-woven filter fabric is to be placed at all soil-fill interfaces laid perpendicular to the road alignment.
- Place and compact a min. 2 m wide gravel shoulder at least 0.6 m thick with 2 layers of geo-grid reinforcement at the crest of the slope
- Seed the slope at double the normal application rate and cover with a layer of permanent turf reinforcement mat (TRM) installed as per BMP 13b.

It is recommended that this work be performed in conjunction with the provision of new asphalt surfacing to reverse the cross grade on the highway towards the ditch. It is estimated that adding about 150 mm of asphalt at the riverside edge grading to zero at the west edge would be sufficient to reverse the grade. Adding this asphalt over a length of about 150 m requires about 80 m³ of material (say, 180 tonnes).

An approximate cost estimate for the work is provided in the table below. For the wide riverbank section, quantities have been increased to include a 100 m long section of riverbank if the site has deteriorated further since the last site assessment.

Item	Quantity	Unit	Rate	Total
Mob/Demob	1	LS	LS	$20,000
Narrow riverbank section				
Site Clearing and ECO Work	1	LS	LS	$5,000
Class II Rip Rap	30	m³	$350	$10,500
Gravel Fill	300	m³	$40	$12,000
Geo-Grid	1000	m²	$10	$10,000
Filter Fabric	250	m²	$5	$1,250
Wide Riverbank Section				
Common Fill	1,500	m³	$25	$37,500
Gravel Fill	100	m³	$40	$4,000
Geo-Grid	400	m²	$10	$4,000
Filter Fabric	1,800	m²	$5	$9,000
Seeding	1	LS	$5,000	$5,000
TRM	1,800	m²	$15	$27,000
Road Improvement				
Type 4 ACP	180	tonnes	$100	$18,000
Total				**$163,250**

As previously discussed, the June 2005 flood caused the slump on the narrow riverbank section and worsened the situation on the wide riverbank. The following cost breakdown is suggested for the allocation of work caused by the flood and work required at the site before the flood:

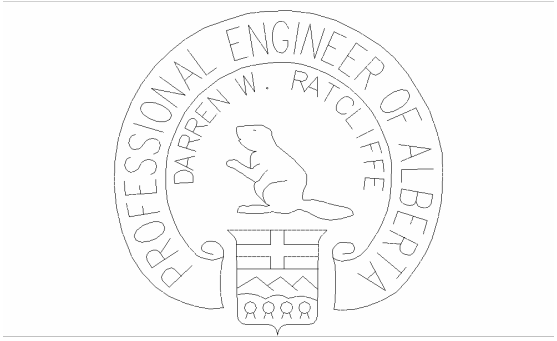
- Flood Cost - $101,000
- Pre-Flood Cost - $62,250
- Total - $163,250

5. CLOSURE

Please contact the undersigned at (403) 730-6811 if you have any questions regarding this report.

Yours truly,

KLOHN CRIPPEN CONSULTANTS LTD.



Darren Ratcliffe, P.Eng.
Project Manager

APEGGA Permit to Practice No. 433

cc. Mr. Roger Skirrow, Alberta Transportation

Attachments