July 25, 2001

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

Mr. Melvin Mayfield, P.Eng.
Construction Services Coordinator

Dear Mr. Mayfield:

Central Region Landslide Assessment Site C18
SH837:02 Riverbank Slide @ km 1.9
July 2001 Inspection Report & Repair Recommendations - DRAFT

Further to the annual site inspection undertaken on May 22, 2001 an additional inspection of this site was undertaken on July 24, 2001 at the request of Alberta Transportation. The inspection was undertaken by Mr. Darren Ratcliffe, P.Eng. and Mr. Robin FitzGerald, P.Eng., of Klohn Crippen Consultants Ltd. Also in attendance were Mr. Roger Skirrow, P.Eng., Mr. Melvin Mayfield, P.Eng., Mr. Frank Vidmar, Mr. Nelson Chipiuk and Mr. Tony Chelick of Alberta Transportation; Mr. Mike Stoneman and Mr. Jeff Armstrong of Fisheries and Oceans Canada; and Mr. Byron Jensen from Alberta Environment.

This report was prepared by Klohn Crippen Consultants Ltd. for Alberta Transportation Central Region under Contract No. CE053/2000.

1. PROJECT BACKGROUND

About 10 km northwest of Drumheller, SH837 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 Palaeontology, 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.

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. Without the installation of protective measures at the toe of the slope, additional repair work should be expected 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. A joint site inspection was undertaken on July 18, 2000 by Mr. Darren Ratcliffe, P.Eng., of Klohn Crippen Consultants Ltd. and by Mr. Lyle Newman and Mr. Frank Vidmar of Alberta Transportation to determine the nature and condition of the slide. Further deterioration of the slide area was subsequently reported to Klohn Crippen on July 25, 2000.

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 was observed to be highly erodable and becomes very soft when wet. At about 0.9 m below the road level, a saturated sandy seam was observed in the scarp.

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 are typically very steep (about 1H:1V or steeper) and erosion of the toe of the riverbank by the river was ongoing.

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, had completely silted up at this location. It appeared that storm runoff was flowing across the road and down the slide zone towards the river. This 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.

In the fall of 2000, the ditch on the west side of the road was excavated to a depth of about 0.5 m. Washed gravel was placed on the east side of the road in the slide area 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. This significantly improved the safety of the highway.

In May 2001, the area was largely unchanged from the previous fall, but precipitation levels had been low. However, in July 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 current features of the site are illustrated in Figure 1 and in the attached photographs.

2. SITE OBSERVATIONS & ASSESSMENT

From a review of the riverbank along the highway section, it is believed that river erosion is not a major factor in the observed instability. Areas along the river, on the outside of the same river bend, are well vegetated and are showing no signs of erosion. The primary trigger for the observed instability 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. It is therefore concluded that this is more of a slope stability issue than an erosion issue.

The slide area appears to be extending both upstream and downstream. Beyond the slide itself, cracks are appearing at the crest of the riverbank. The location of the cracks would tend to suggest that the near vertical banks located immediately to the north and south are becoming unstable. The overall extent of the unstable riverbank measures approximately 40 m.

It is apparent that placing fill material from the top is not stabilizing the area and the practice should be stopped as it could create more instability.

As discussed in the annual inspection report, it is intended that specific instances of instability along this length of highway would be repaired. Based on the high cost to upgrade the whole length of the section, it is probably more cost effective to repair the critical erosion features as they occur. Based on previous reports, it is possible that a significant storm could wash out a significant section of road. If major repairs to the entire section are undertaken, the highway could be reconstructed to RCU 209 design standard with erosion protection. It is recommended that the road camber also be adjusted at this time if not carried out as part of the remedial work discussed later.

3. RECOMMENDATIONS

3.1 Immediate Action

Barricades should be placed as soon as possible to warn motorists of the dangerous edge.

An asphalt curb should be built up along the edge of the pavement for a suitable length to prevent runoff water from flowing down the slide area.

3.2 Proposed Remedial Action

It is believed that the most efficient remedial action to take is the use of a protection/retention toe berm in conjunction with compacted pit run gravel to reinstate the slope to about 2H:1V (Figure 2). To effectively stabilize the slope, the reinstatement must occur working from the bottom to the top. This approach requires no further investigation or analysis.

The toe berm can comprise traditional Class II rock riprap or gabion baskets. To place the berm, a crane or similar equipment could be used to lower the rocks into place. The pit run gravel can be placed by dumping from the road edge and compacting in horizontal lifts with hand operated tampers or small compaction equipment.

A more economic solution is to develop an access trail from the south side of the slide area using a “Bobcat” or similar small-sized equipment. At the river edge, it will be necessary to push out a narrow strip of gravel, say 1.5 m wide, to gain access to the slide area. The bobcat would then be used to transport construction materials to the toe area. For the gabion basket option, a further strip of gravel is required on which the baskets can be placed above the water line. Upon completion of the work, the access trail would be removed.

However, it is understood that both gravel and rock are very expensive in the Drumheller area. A quote obtained from Quadrock Trucking and Excavating in Drumheller indicated a delivered cost of \$15/m³ for pit run gravel and \$50/m³ for rock of nominal dimensions of 0.6 m. It is estimated that 80 m³ of rock and 1000 m³ of gravel are required. Based on these quantities, the estimated cost for the materials is \$19,000. Including an allowance for placement and compaction, and the provision and removal of the access trail, the total cost for the project is about \$35,000.

A more economic solution is shown in Figure 3. This design uses gabion baskets at the toe, pit run gravel in the base area, and native fill above. This scenario requires approximately 40 m³ of gabion baskets, 600 m³ of gravel, and 400 m³ of fill. An estimated total cost for this option is about \$28,000.

In Section 3.1, the provision of an asphalt curb was recommended to direct water further along the road away from the slide area. A more effective long-term solution is to change the grade of the highway pavement to direct drainage to the side ditch away from the river. This would require the placement of about 75 m³ of asphalt to provide about a 2% cross fall over a length of about 100 m. The cost for the overlay would be about \$15,000 to \$20,000.

3.3 Alternative Remedial Methods

The alternative to the placement of fill to stabilize the slope is the use of a retaining wall system. Due to the high cost of granular materials, wall systems such as gabion baskets or mechanically stabilized earth (MSE) are likely not viable from a cost perspective. A steel bin wall could be filled with the native material, but the resulting metal wall would likely not be acceptable from an aesthetic viewpoint. Similarly, a sheet pile wall would not be acceptable.

A recommended alternative retaining wall system is a steel H-pile timber lagged wall. The H-piles would be driven at about 6 m spacing along the crest of the slope and would project above road level to allow a guardrail to be bolted on. The ground between the piles would be excavated one panel at a time and timber sections would be slotted into the piles. Fill would then be placed back against the wall face.

Typical costs for this type of retaining wall system are in the range of \$400 to \$500 per m² of wall face. For a wall area of about 7 m high by 50 m long, the estimated cost is \$140,000 to \$175,000.

However, for this remedial system, there is an additional design cost involving a site investigation to determine the ground conditions, and a retaining wall analysis and design to determine the wall requirements. An estimated cost for this work would be about \$10,000.

3.4 Long Term Action

Due to the highly erodable nature of the local bedrock, the backslope ditch rapidly silts up with transported sediment. In the past, the ditches have been cleaned out and the spoil placed on the riverside slopes. In the future, it is recommended that areas be delineated along this section of highway where waste fill placement can occur. Suitable sites are located along the river where the distance from the road to the river is greater than 20 m.

4. CLOSURE

This letter has been prepared for the exclusive use of Alberta Transportation for the specific application to the SH837:02 slide area. The report's contents may not be relied upon by any other party without the express written permission of Klohn Crippen. In this letter, Klohn Crippen has endeavored to comply with generally accepted geotechnical practice common to the local area. Klohn Crippen makes no other warranty, express or implied.

Please contact the undersigned if you have any questions regarding this report.

Yours truly,

KLOHN CRIPPEN CONSULTANTS LTD.

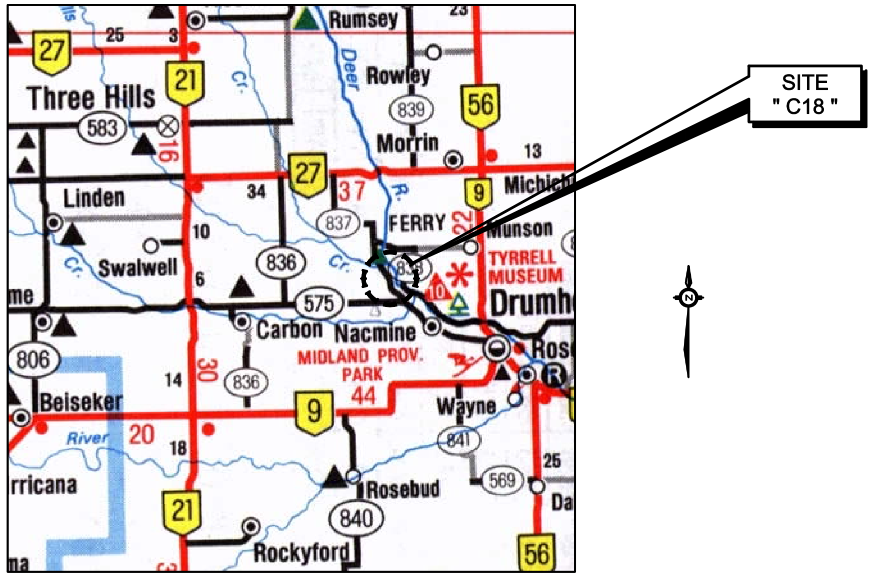
Darren Ratcliffe, P.Eng.
Senior Geotechnical Engineer

Robin FitzGerald, P.Eng.
Manager, Water Resources

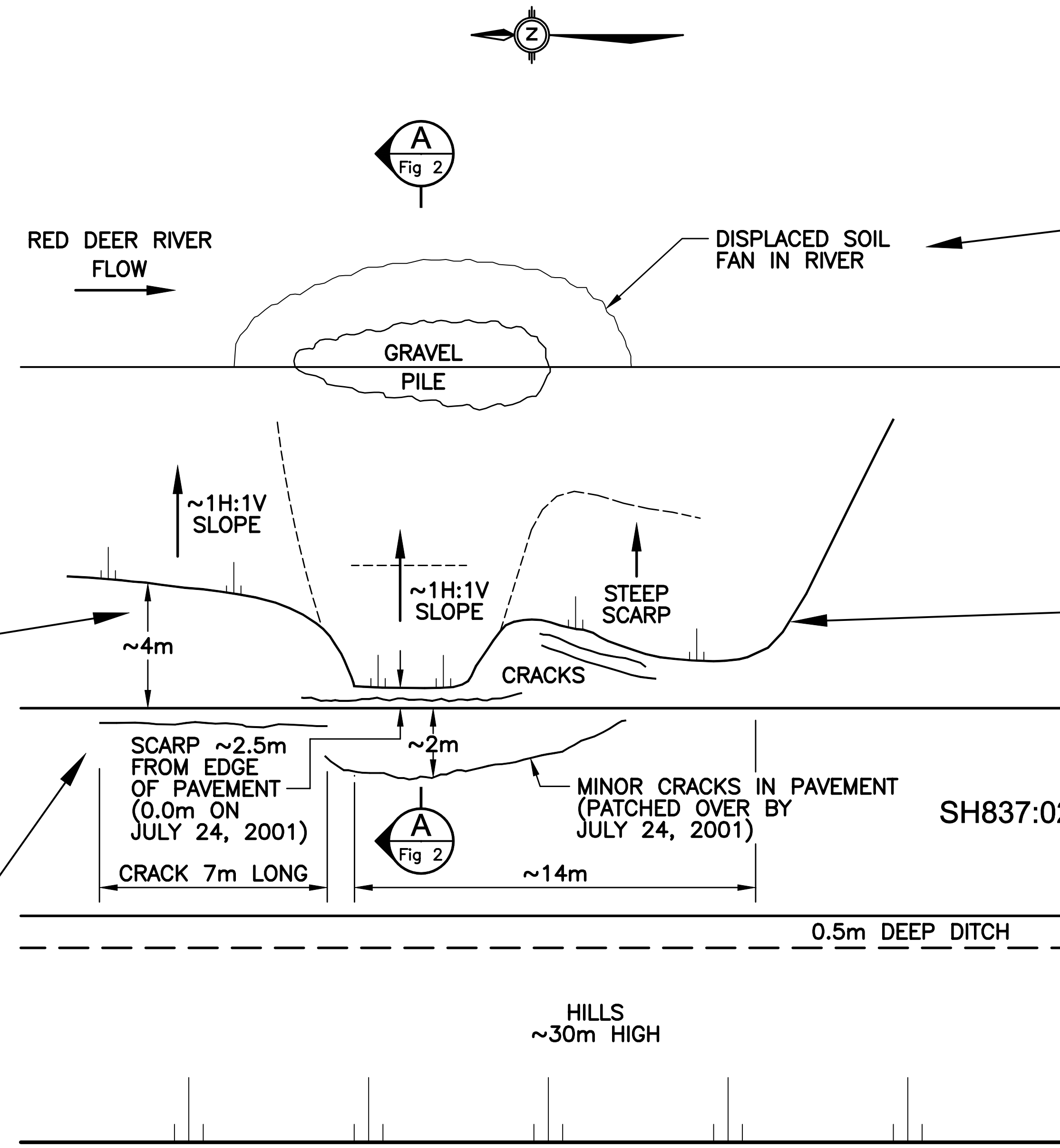
FIGURES

NOTES

1. PHOTOS TAKEN MAY 22, 2001.



KEY MAP
N.T.S.



PLAN
1:250

MICROFILM DATE
PWSS PLAN No.
DRAWING No.
CENTER CODE No.
PROJECT FILE No. 2908.06.C18.F1.A.dwg

PERMIT	SEAL	MARK	DESCRIPTION OF REVISIONS	DATE	DWN.	ENG.
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		E				
		D				
		C				
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DESIGNED BY S.A.T.
APPROVED BY D.W.R.
DRAWN BY E.N.L.
CHECKED BY
SCALE 1:250 0 2.5 5 m

CONSULTANT
KLOHN CRIPPEN

Alberta TRANSPORTATION

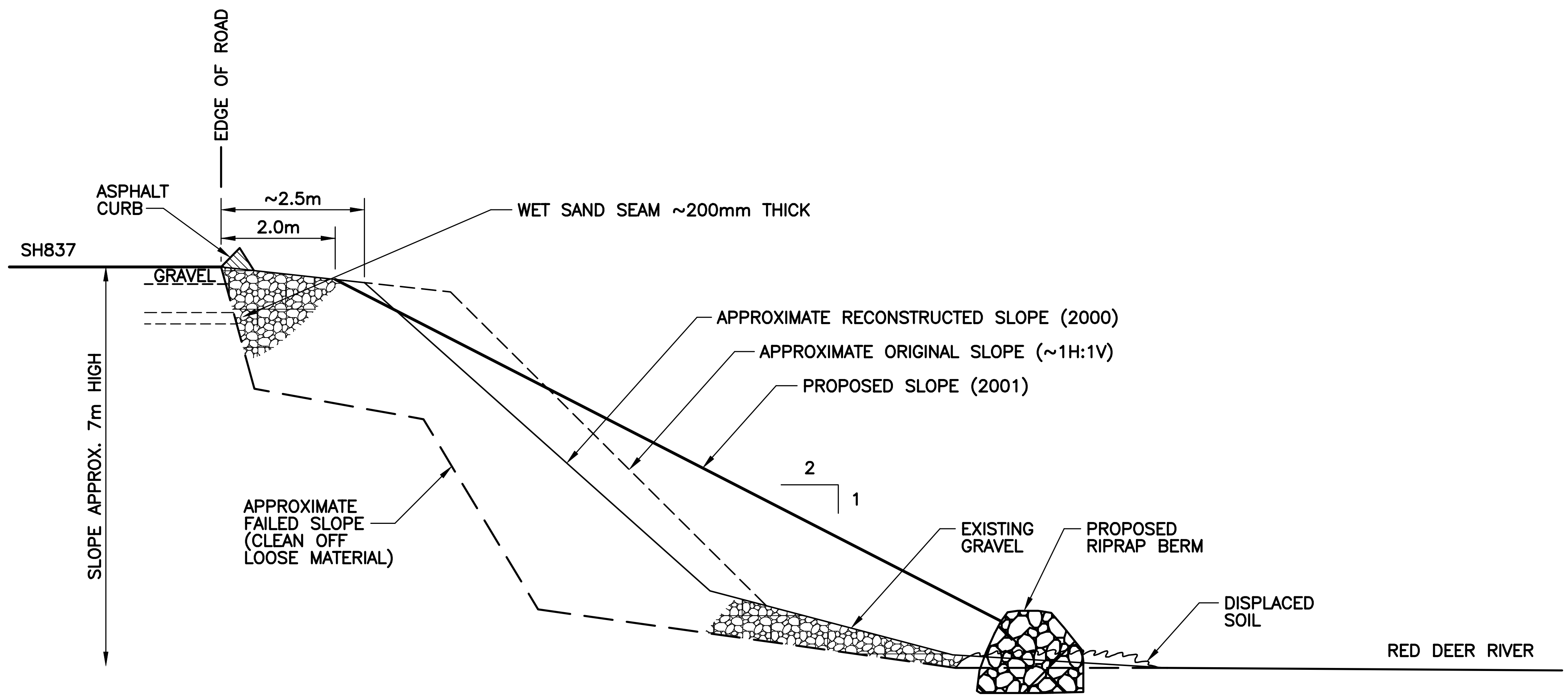
PROJECT
CENTRAL REGION
LANDSLIDE RISK ASSESSMENT

TITLE
SITE C18 : SH837 RIVER SCOUR
SITE PLAN

DATE	SHEET	DRAWING No.	REV.
JULY 2001	1 of 3	FIGURE 1	A

NOTES:

1. PROPOSED LENGTH OF RECONSTRUCTED SLOPE IS 40m (FIELD FIT CONFIGURATION SHOWN TO SUIT SITE CONDITIONS).



SECTION A (Fig 1)
1:100

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DESIGNED BY S.A.T.	APPROVED BY D.W.R.
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SCALE 1:100 0 1 2 m	

CONSULTANT: KLOHN CRIPPEN

Alberta TRANSPORTATION

PROJECT: CENTRAL REGION
LANDSLIDE RISK ASSESSMENT

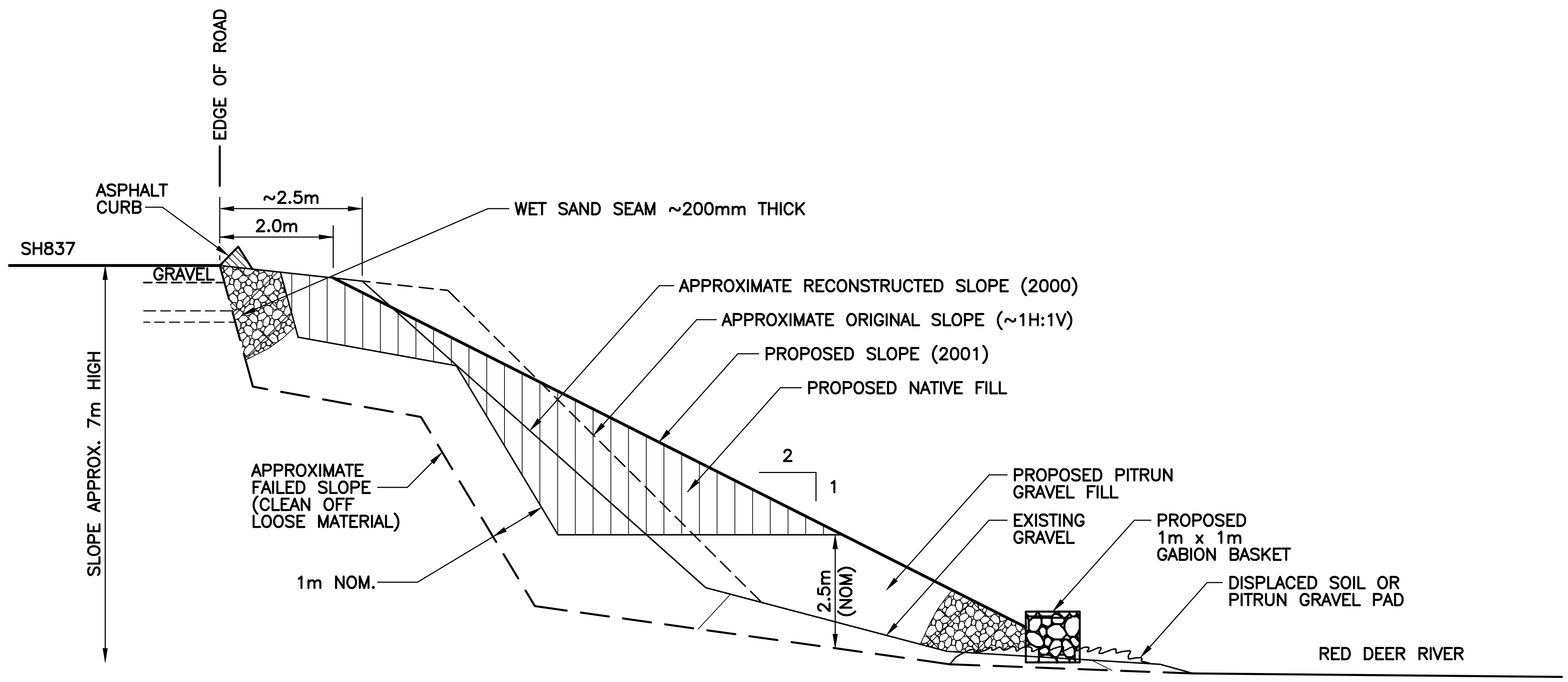
TITLE: SITE C18 : SH837 RIVER BANK SLIDE SECTION A–A

DATE	SHEET	DRAWING No.	REV.
JULY 2001	2 of 3	FIGURE 2	A

MICROFILM DATE
PWSS PLAN No.
DRAWING No.
CENTER CODE No.
PROJECT FILE No. 2908.06.C18.F3.A.dwg

NOTES:

1. PROPOSED LENGTH OF RECONSTRUCTED SLOPE IS 40m (FIELD FIT CONFIGURATION SHOWN TO SUIT SITE CONDITIONS).



SECTION A
1:100 Fig 1

PERMIT	SEAL	MARK	DESCRIPTION OF REVISIONS	DATE	DWN.	ENG.
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DESIGNED BY S.A.T. | APPROVED BY D.W.R.
DRAWN BY E.N.L. | CHECKED BY
SCALE 1:100 0 1 2 m

CONSULTANT: KLOHN CRIPPEN

Alberta TRANSPORTATION

PROJECT: CENTRAL REGION
LANDSLIDE RISK ASSESSMENT

TITLE: SITE C18 : SH837 RIVER BANK SLIDE SECTION A–A

DATE	SHEET	DRAWING No.	REV.
JULY 2001	3 of 3	FIGURE 3	A

Site C18 SH837 River Scour – July 24, 2001

Site C18 SH837 River Scour – July 24, 2001