BRIEF FILE REVIEW
(LANDSLIDE RISK ASSESSMENT)

1)	**Site (GP4a)**	Hwy 49:06 Burnt River Bridge Location (3) West Approach Slide
2)	**Reference Location along Highway:**	Hwy 49:06 Burnt River Bridge @ 10 km east of Rycroft West Approach Slide @ 400 m west of bridge
3)	**Legal Description:**	SW Section 10, Twp 78, Rge 4, W6M
4)	**UTM Coordinate:**	Northing 6180884.098 Easting -222035.124
5)	**AI File:**	Hwy 49:06, BF 73877

6) **Alberta Infrastructure Plan and Profile (attached in Section F)**

- Site plan (aerial photo)
- Survey plan of slope and river
- Slope Profile 3 surveyed cross-sections of the slope

7) **General Description of Instability**

The roadway was constructed along the valley of the Burnt River where the valley wall exhibited past sliding activities caused by the lateral degradation of the meandering Burnt River incurring erosion of the toe of the slope. This slide occurred at the river valley slope along the scouring side of a meandering bend of the Burnt River. The existing highway was realigned once to shift away from the same slide. Realignment of the previous roadway to the present highway location was undertaken in 1991 with an approximate 50 m shift towards the backslope together the construction of a new bridge. Sliding of the roadway was mainly caused by lateral erosion of the river which undercut the toe area of this slope incurring potentially a block slide movement mode. The block slide mode of failure was assessed as the most likely failure mechanism from late 1999 SI readings. The retrogression of the headscarp inland caused settlement and cracking of the pavement. The headscarp crack had transgressed across the abandoned (previous) highway location (with block cracking) and has retrogressed past existing highway centreline.

The block slide movement is mainly propagated along the basal slip planes to generate retrogressive headscarps inland despite the flatness of the valley slope. The average gradient of the slope (to river level) is estimated at 7H:1V over approximately 30 m elevation difference.

The main causes of the slide include undercutting of toe of slope by lateral erosion of the river bank, high piezometric groundwater pressure and weak lacustrine soil conditions. After 2 years of instrumentation monitoring (1998 to 2000), a block slide failure mode was assessed as the likely failure mechanism. The slide is complex and the possibility of a series of circular failures remains to be further investigated. Along the road sideslopes with the R/W, the headscarp sliding surfaces are estimated at depth zones ranging from 8 to 10 m depths to 11 to 19 m depths. At the toe area, main slip plane with movement at 11 to 19 m depth can be inferred as the basal slip plane which is assessed at close to river bed elevation. At the cut backslope above the roadway elevation, slope movement was not monitored by slope indicator and cracks were not observed so far. Movement rate of approximately 80 mm/year is estimated along major (main basal as well as headscarp) movement zones monitored.

8) **Date of Initial Observation**

- May 1998 (1998 Slide Tour)

9) **Date of Last Inspection**

- June 1999 (1999 Slide Tour)

10) **Instrument Installed**
Slope Indicators (SI):

- SI #11, 12, 13, 14, 15, 16 & 17 — along sideslope R/W at head of slide (installed in 1998)
- SI #18, 19, 20 & 21 — at toe and midslope of slide (installed in 1999)
- SI #22 — at backslope above head of slide (installed in 1999)

Piezometers (PE):

PE #	Depth	SI Location	Remarks
11	15.2 m	SI #11	PE 11 to 17 installed in 1998
12	15.2 m	SI #12	
15	23.8 m	SI #15	
17	9.1 m	SI #17	
18	9.5 m	SI #18	PE 18 to 21 installed in 1999
19	9.5 m	SI #19	
20	7 m	SI #20	
21	8.5 m	SI #21	

11) **Instrument Operational**

- Same as above

12) **Risk Assessment**
PF (11) * CF (6) = 66

PF = 11

- Active with moderate but increasing rate of movement.
- Shear movement monitored at 8 to 10 m depths below surface at movement rate of approximately 80 mm/year at sideslope at R/W (most probably headscarp zones and included slip surfaces).
- Shear movement monitored at 11 to 19 m depths at toe area and can be interpreted as a main basal slip plane of an apparent block slide. Site inspection (Fall 2000) revealed lake clay exposures along the steep bank at the toe area. It is probable that the main slippage of the block slide can be occurring along zones of weak clay deposits close to river elevation.
- Shallow groundwater table with high piezometric pressure equivalent to 0.5 m below ground surface at the head of the slide at highway ditch areas.
- Average slope at approximately 7H:1V (30 m elevation difference over 200 m horizontal distance with a 9 to 10 m height steep toe scarp). Surface slope gradient is considered flat above toe scarp areas, average slope at approximately 8H:1V to 10H:1V (20 m to 25 m elevation difference over 200 m horizontal distance).

CF = 6

- Closure of road would be a direct and unavoidable result of a slide occurrence.
- Detour of 30 km distance required to Rycroft junction through SH 733/SH 677/Hwy 2.
- Major crossing and bridge structure at Burnt River will be rendered out of service.
- The inferred block slide may require toe restraint and nailing design as one form of effective remediation for increasing shear resistance at the major slip surface.
- Diversion of the river to eliminate future toe undercut may be one effective measure to eliminating the major slide trigger mechanism; however, approval from DFO will be very difficult for instream works and will be lengthy process. However, the toe restraint and other retention measures to increase shear strength along the main slip plane should be the foremost measures to be considered.
- The option of construction of a granular shear key may be one option of stabilizing the slide after extent of slide area and the shear plane and the block failure sliding mechanism are

further confirmed by further instrumentation monitoring. However, this option is not considered workable due to vast excavation requirements.

- The alternative options of toe pile or soil nailing (using sheet piles) or intensive armouring of the scouring bank as a toe protection measure should be considered and will be very expensive.

Note:
This Risk Assessment rating is based on the Scheme proposed by AI in the Request for Proposal. (2000)

Probability Factor (PF) :	1 to 20 scale
Consequence Factor (CF) :	1 to 10 scale

13) **Geotechnical Conditions**

- The site is located within the general Peace River upland area and the Burnt River is a tributary to the Peace River. The upland topography above the Burnt River is gentle rolling terrain. Surficial deposits are generally glacial till and mostly glacio-lacustrine clay deposits with thickness varying from a few metres to a 100 metres range. Generally, the surficial deposits thin towards the upland areas and are thicker in the valley areas.
- Slumping and sliding can be frequently noted along the river bank areas adjacent to this site and part of the surficial deposit along the valley can be colluvial material.
- Bedrock consists of Wapiti Foundation of non-marine sandstone, clay shale, and coal seams. At the site area, bedrock can be +50 m below general elevations of the uplands of the Burnt River.
- Lacustrine clay with high groundwater and seepage is noted at this site.
- Lateral and vertical degradation of river provided undercutting of toe of the slope.
- Weak clay deposit can be present along the basal area of the apparent block slide at elevations close to riverbed.

14) **Chronology**

Historical setting: past site problem (including construction problem)

- Prior to 1991, slides along the river bank occurred to distress the previous alignment as well as the previous truss bridge and forced the abandonment of the old alignment and bridge. The sliding activities necessitated the shifting of the previous alignment to its present location together with the construction of a new bridge.
- 1991 construction of new alignment, the shifting of the highway (50 m towards backslope and away from the river) was undertaken. At approximately 100 m east of this west approach unstable area, the construction of the fill at the west headslope encountered sliding movement. Cracking of the new highway approach fill at west approach area was observed during construction. This movement was stabilized with the use of lightweight fill and tangent pile retaining wall at the west headslope.
- 1991 to 1997, new alignment operated satisfactorily with no settlement and pavement cracks observed at the west approach.
- 1998, settlement and cracking of pavement observed at the west approach.
- 1998 to 1999 installation of Slope Indicators and Piezometers at the west approach.

Past Investigations (adjacent headslope and this site)

- 1991 (by AI) slide of the west headslope (approximately 300 to 400 m east) occurred during construction. A gently inclined slip plane was observed to daylight at the valley wall.
- 1991, west headslope construction (approximately 300 to 400 m east) stabilized by AI and completed with top 3 m fill using lightweight material (wood chips).
- 1997, slope indicators and piezometers installed at the west approach as retrogression of the slide incurred cracking and settlement of the existing highway. It took 6 to 7 years from 1991 for the slide to retrogress approximately 30-40m from the previous highway to the present headscarp crack at present highway location.

- 2000, instrumentation data at the toe area (at this west approach site) indicated a block sliding failure mode to be a very likely failure mechanism. Measures to eliminate toe erosion due to river degradation (both lateral and vertical downcutting) as well as toe restraint remediation should be considered.

Mitigative measures implemented (temporary maintenance)

- Patching of settlement area was considered pragmatic maintenance measures from 1997 to date.

MITIGATIVE MEASURES UNDER CONSIDERATION (will require further investigation)

The appropriate measures for stabilizing movement:

- divert river flow to eliminate toe erosion process or/and;
- install armouring along existing scoured bank and/or;
- install shear key or piles at toe to increase shear resistance.

15) **Action**

- Continue the visual and instrumentation monitoring.
- Continue the pavement patching (when required) as a pragmatic maintenance measure.
- Further investigate and confirm the extent and nature of block slide or other modes of failure. This includes investigating the depths of movement (whether it is occurring along a major basal slip plan or multiple slip planes), soil zone information of the movement zones especially at the toe area where toe restraint measures can be designed.
- Further drilling investigation and SI (4 nos) has been planned in early 2001.
- To discuss with AI on the remediation options after further investigation results area becomes available. To provide a feasibility study on remediation options after the results of above-mentioned additional instrumentation are available.

END