BRIEF FILE REVIEW
(LANDSLIDE RISK ASSESSMENT)

1)	**Site (GP1)**	Hwy 40:42 Wapiti Hill Slide (Wapiti River Valley Slope Slide)
2)	**Reference Location:**	Hwy 40:42 @ 5 km south of Jct. SH 666 and South of Wapiti River Bridge
3)	**Legal Description along Highway**	SE Section 24, Twp 70, Rge 6, W6M
4)	**UTM Coordinate:**	Northing 6107119.22 Easting -240326.779
5)	**AI File:**	Hwy 40:42

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

- Site plan (aerial photo)
- Plan of backslope ditch lateral drains (installed September 1991) (not attached; refer to AI files)
- Survey crossing (July 1991) with soil stratigraphy and monitored movement zone.
- Sketch of site plan with SI and Piezometer locations.

7) **General Description of Instability**

- Sidehill roadway located at headscarp of slide along the Wapiti River valley slope,
- Deformation evident with cracking and settlement of pavement,
- Slope indicator monitoring records indicate deep seated movement along highway. Deep-seated movements monitored at 22 to 23 m depths at edge of R/W and average movement rates of 40 mm/year,
- Affected main stretch of roadway estimated at approximately 75 m in length,
- With another adjacent affected stretch of roadway estimated at approximately 40 m in length located approximately 75 m to north,
- Toe of slide uncertain (remains to be investigated) possibly daylights at the lower part of slope along steep cuts at an access road to the gravel pits excavated along the river-gravel terrace OR the slide may daylight at the river bank level at the ox-bow channel of the Wapiti River,
- It is uncertain whether the gravel mining along the river bank (at the toe of the valley slope) provided a trigger of this instability. The history of gravel mining in the area should be investigated.
- Probable causes of sliding,
  - Downcutting by Wapiti River,
  - Gravel mining of river terrace at toe area,
  - High groundwater conditions,
  - Soil conditions.

8) **Date of Initial Observation**

- 1981 gradeline construction requires subexcavation of wet subgrade and replacement of wet subgrade with 3 to 4 m fill. Placement of fill over subexcavated wet subgrade area caused movement and required drainage measures. The drainage measures included a first stage lateral drain along the backslope ditch at the time of 1981 construction. Waste berm was also placed to the edge of R/W area to make the fill gradeline stable. It was obvious that the cut excavation exposed shallow groundwater and wet subgrade conditions. It was apparent that shallow movement was active at the time of 1981 construction.
- 1981 minor slumping of backslope and wet spots (due to daylighting of groundwater) at cut areas observed upon completion of grade;
- Approximately 1981 to 1990 the highway operated at the initial stage as a gravel road; minor

slumping and settlement movement distress of grade probable; the grade settlement was likely regraded and re-leveled by maintenance forces with surface gravel.

- Deep seated movement of slope was probably ongoing since (possibly prior to) completion of gradeline construction in 1981.

9) **Date of Last Inspection**

- July 1999 (1999 Spring Slide Tour)

10) **Instrument Installed**

- Slope Indicators: 9 pieces
  - SI# 1, 3, 5, 6, 8, 9, 11, 12, & 13
- Piezometers: 7 pieces
  - Tips # 11572, 9325, 11538, 8893, 9317, 7674, & 9347

11) **Instrument Operational**

- Slope Indicators: 8 pieces (SI-12 damaged and needs repair; reported in Fall 1999)
- Piezometers: 7 pieces

12) **Risk Assessment**

PF (9) * CF (4) = 36

PF = 9

- Active with moderate steady rate of ongoing movement (40 mm/year)

CF = 4

- Closure of road would be a direct and unavoidable result of a slide occurrence. This road is the main connection between Grande Cache and Grande Prairie with substantial industrial (all season) and road user traffic.
- A detour route via SH 666:02 Grovedale would be possible; however, one section of SH 666:02 along the Wapiti River valley slope had been unstable and undergoing slide movements since the 1980's. This chronological slide site at SH 666:02 might be an affecting factor in maintaining this detour for Hwy 40 in the event of deterioration of the SH 666 slide.

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 surficial geology of this slide site along Wapiti River Valley was affected by the erosional and deposition process of glacial advance/retreat as well as the recent process of downcutting/deposition by the Wapiti River. At the upland area, the surficial material can be a variation of glacio-fluvial material with thick sand layers; lacustrine clay with sand/silt laminations; and clay till deposits. At the bottom and toe area of the Wapiti Valley, alluvial deposits of sand/gravel or river gravel terrace deposits can be common.
- Bedrock is generally of Cretaceous Wapiti Formation which commonly consists of non-marine sandstone, shale and coal seams. At this site location, bedrock can generally be located at +40 m depth below the upland elevations.
- Shallow groundwater was observed at this site both during and post excavation of this section of roadway. Subsurface drainage measures were required to minimize the adverse effect of seepage flow from cut slope and subgrade areas. Waterlogged sloughs and wetlands infest the uplands to the south of the Wapiti River Valley. The wet uplands

provided strong groundwater recharge down the Wapiti River valley slope to adversely affect this slide location. Groundwater was also observed in an observation well along the road shoulder at 10 m depth below roadway elevation.

14) **Chronology**

Historical setting (past site problems):

- 1981 grading construction (*from interview of past AI construction staff):
  - 2 to 3 m sidehill cut/fill gradeline designed at the slide area;
  - wet subgrade and seepage areas experienced during cut of backslope;
  - the wet subgrade was subexcavated and replaced with 4 to 5 m of clay fill;
  - movement of grade and wet grounds required installation of lateral drains at backslope ditch;
  - a waste berm was also constructed at the sideslope toe area at the edge of R/W.
- 1981 to 1990 highway operated as a gravel road and it was the maintenance forces' recollection that re-leveled/regrading of gravel due to settlement at this area was required from time to time.
- In late 1990, pavement construction completed and pavement cracking and settlement observed thereafter.
- 1985 to 1990, sloughing and seepage occurred at the backslope;
- September 1990, approximately 800 m length (from Station 25+301 to Station 26+100 close to bridge or logging road overpass) of new lateral drain was installed along backslope ditch to outflow at Weyerhaeuser Road Bridge downgrade and northeast of the slide area.
- September 1990, finger drains (800 m total) were also installed at backslope to outflow to lateral drain below backslope ditch. The objective was to minimize maintenance of ditch caused by backslope sloughing into the ditch. Backslope was dressed back to shape and has performed well since.
- November 1990, cracking of pavement at the slide headscarp reported to AI Geotechnical Section.
- September 1991, survey cross-section of slope.

Past investigations (by AI Geotechnical)

- November 1990, site inspection by AI Geotechnical Section.
- March 1991, 3 slope indicators (SI# 1, 2 & 3) installed and slope profile surveyed by AI.
- March 1991, testpitting and Texoma drilling by AI revealed 4 to 5 m fill material, native lacustrine deposits, and strong groundwater flow at 10 m below roadway elevation. Original design indicated 2 to 3 m fill gradeline and a total fill of 4 to 5 m was constructed with bottom 2 m fill replacing wet subgrade.
- March 1991, 3 water wells installed by AI to observe groundwater. Strong flow of groundwater was noted at 10 m depth below sideslope shoulder elevation with a water-bearing sand layer located at approximate Elevation 613 m.
- September 1991, 5 additional SIs (SI 4 to 8) and 3 piezometers was installed by AI.
- March 1998, 3 additional SIs (SI#11, 12 & 13) to +40 m depths and 3 piezometers were installed by EBA to monitor and confirm deep seated (+20 m) movements.
- It is likely that deep movements can be occurring in clay to clay shale strata (with wet sand layers) at 22 to 25 m depths (see borehole log for SI #11 and SI #12).

Mitigative measures considered or implemented

- 1991 to 1999, yearly patching of 25 mm to 50 mm ACP (recollection of AI maintenance) for settled pavement adopted as the pragmatic maintenance measure due to the deep (+20 m) movement regime and slow movement rates monitored. The yearly patching of the settlement area was considered pragmatic in consideration of the vast cost and difficulty in design of effective stabilization measures of a deep-seated slide and adverse groundwater conditions.

- April 1994, relocation of the alignment towards the backslope away from the slide area was one of the options investigated by both AI Planning and Geotechnical Branches; but the relocation option was not recommended for further study due to vast costs and geometric concerns.

- February 1995, deep pumping dewatering wells (8 to10 wells @ 10 m spacings to 20 m depths) were considered by AI Geotechnical Branch to lessen the influence of groundwater on the slide. These measures were not implemented possibly due to the 1995 to 1996 reorganization and privatization of AI.

15) **Action**

The deep seated nature of this slide renders remediation very difficult. The following actions can be appropriate:

- continue maintenance of pavement by continual patching as a pragmatic measure
- continue monitoring of existing instrumentation on a biannual basis
- repair broken instruments when identified
- extend existing instrumentation to investigate the possible toe area of this slide as well as a settlement area (approximately 100 m) north of the instrumentation area. It is possible that the settlement area approximately 100 m to the north may be an extension of this slide.

END

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Figure 1
1993 Air Photo

ANNUAL INSPECTION REPORT

Slide Name:	**Hwy 40:42 Wapiti River Slide (GP-1)**
Location:	**Hwy 40:42 approximately 5 km south of Wapiti River Bridge (Jct SH 666)**
Inspection Date:	**June 6, 2000**
Inspection by:	**Alberta Infrastructure Staff (see list of Inspection Attendees)** **Karl Li, P.Eng., Senior Geotechnical Engineer of EBA**

1.0 BACKGROUND

The background information was mostly provided in previous 1997-1999 reports and is updated hereunder as appropriate.

Eight slope indicators and six piezometers (in 5 boreholes) are currently operational. The installation locations and depths are shown on the attached plan. SI #12 was vandalized and will require repair. Deep-seated shear movement at 22 to 23 m depths were recorded in slope indicators (SIs 9, 11 & 12) located at middle of sideslope and at edge of R/W. At the north edge of the affected sideslope area, SI-13 (previously SI-7) recorded movement at an 8 m depth with a total movement of 300 to 350 mm from 1991 to 1999; this equates to an average movement rate of 40 mm/year. Piezometric pressures recorded at most slope indicator locations as well as previous water observation well levels (1991) show a groundwater level of approximately 10 m below ground surface. The roadway was built on the upper valley slope of the Wapiti River Valley and a slope run distance of approximately 1 km from the roadway to the River. It is uncertain whether the slide daylights in the top portion of this Wapiti River valley slope or at the toe area above the river terrace (i.e. Weyerhaeuser Access Road). At the bottom of the valley slope which is be the probable toe area of this slide, mining activities along the river terrace and the presence of an abandoned ox-bow channel may also be contributory to relaxation of toe support of this slope.

Site Photos are attached in Section F of binder. Also refer to the EBA 1997-1999 reports for chronological photo details.

2.0 SITE OBSERVATIONS

No obvious deterioration of the site was observed in the June 2000 site inspection. Near the area of SI installations, the pavement patching area at the headscarp and roadway settlement area was estimated for approximately 75 m stretch of roadway and extending past centerline. Approximately 75 m north, another settlement stretch (approximately 40 m) was noted.

Apparently, these two settlement areas can be related to the movement of this large slope down the river valley wall and may be part of a large slide. Settlement of pavement at the rate of 25 mm per year was estimated by AI maintenance contractor inspectors from 1997 to 2000. No obvious changes from past settlement trend were observed at the time of inspection in June 2000.

Karl Li inspected the bottom portion of the slope along the Weyerhaeuser Access Road on August 30, 1998 and noted that rolling and terraced terrain at the toe area. The daylighting of the slide above the river bank may be possible.

3.0 SITE AND RISK ASSESSMENT

Based on risk level criteria provided by AI, the following risk rating has been assigned to this site. The details are as follows:

PF (9) * CF (6) = 54

- PF = 9
- Active with moderate steady rate of ongoing movement (50 mm/year)

CF = 6

- Closure of road would be a direct and unavoidable result of a slide occurrence. This road is the main connection between Grande Cache and Grande Prairie with substantial industrial (all season) and road user traffic.
- A detour route via SH 666:02 Grovedale would be possible; but one section of SH 666:02 along the Wapiti River valley slope has been unstable and undergoing movements since the 1980s. The chronic slide site at SH 666:02 may be a significant factor in maintaining this detour route in the event of deterioration of the SH 666 slide.

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

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

4.0 RECOMMENDATIONS

The following was provided in our 1998 and 1999 report and is still valid at the June 2000 inspection.

Since the settlement rate is slow (approximately 25 mm per year) and movement is deep (+20 m depth), it is pragmatic to maintain the roadway through continual patching as the present condition of the road surface is acceptable. This site requires a detailed review to provide an economical solution as the affected area can be huge.

The slide movement may be triggered by one of the following factors.

1. Gravel mining activities at the river terraces.
2. Groundwater approximately 10 m below ground surface at the R/W areas.
3. The presence of the abandoned ox-bow channel at the river bank toe area.

These contributing factors can render the slide movement to extend toward the river bank along this 1 km length of slope. This can be investigated by installation of 2 or more additional slope indicators at Weyerhaeuser Access road close to the toe area and just above the gravel mine terraces at the river bank. Additional SIs should also be installed in the settlement area approximately 75 m to the north to investigate the possibility of a larger slide area.

Monitoring of the SIs and piezometers should be continued. The existing damaged SI should be repaired.

Site #GP-1: Hwy 40:42 Wapiti Hill Slide (5 km S. of Wapiti River Bridge)

Looking towards Grande Prairie. headscarp crack and settlement transgressed past centreline to backslope ditch.

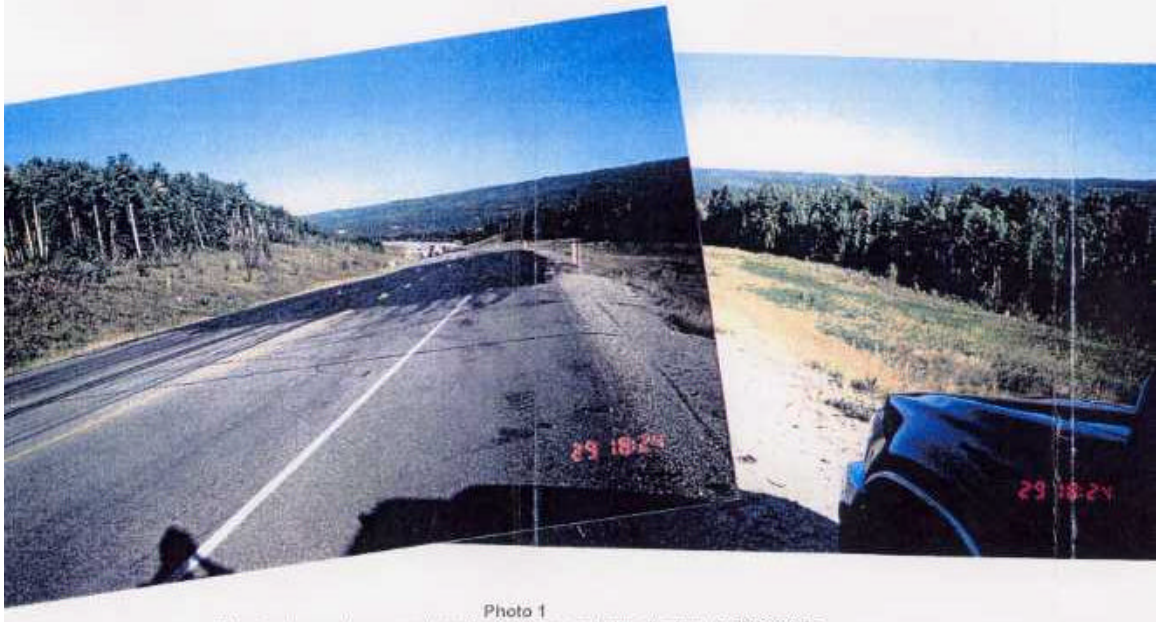

Photo 1
Slide head scarp (pavement cracking) across centerline (looking north towards Grande Prairie). Photo taken August 30, 1998.