ALBERTA TRANSPORTATION
LANDSLIDE RISK ASSESSMENT

SECTION A: GEOTECHNICAL FILE REVIEW

PEACE REGION (PEACE RIVER-HIGH LEVEL AREA)

SITE PH 22, (Old PH8E, Site#6@ km 22.8 to 23.1)

HIGHWAY CONTROL SECTION	Hwy 64:02, km 22.8 to 23.1 (Station 22+820 to Station 23+116 East of Bridge)
NEAREST LANDMARK:	13 km West of Cleardale
LEGAL LOCATION:	S28-84-11-W6
DATE OF INITIAL OBSERVATION:	1987
DATE OF LAST INSPECTION:	June 2008
LAST INSPECTED BY:	Thurber Engineering Ltd. (TEL)
INSTRUMENTS INSTALLED:	6 Slope Inclinometers (3 in 1988, and 3 in 1996)
INSTRUMENTS OPERATIONAL:	None
RISK ASSESSMENT:	PF(11) * CF(3) = 33
LAST UPDATED:	Thurber Engineering Ltd., Jan. 2009
PREVIOUS UPDATE:	Amec Earth & Enviro. Ltd., Nov. 2000

1. LOCATION

The site is located along Hwy 64:02 about 13 km west of Cleardale as shown on Figure 1 attached.

Highway 64:02 crosses the valley of the Clear River in an east-west direction. The valley of the Clear River is approximately 150 m deep. The centerline of the bridge crossing is at about km 22.5. East of the Clear River bridge, the highway climbs out of the valley following the sidehill of a tributary in a north-easterly direction. The road was constructed in cut and fill along the sidehill.

Previously, the PH8E Clear River East area encompassed a number of geohazard sites extending along an approximate 3 km length of this highway east of the bridge. However, the area has now been subdivided into a number of separate "PH" areas, and PH22 now includes only the old Site #6 located about 0.4 km east of the bridge.

2. GENERAL DESCRIPTION OF SLOPE INSTABILITY

The slide at PH22 is located along a section of Highway 64:02 that is in fill along the valley wall of a small creek. The terrain downslope of the road is inclined at about 3H:1V to 4H:1V, with the road located about 130 m horizontally from the creek bed.

The slide was examined in 1987, and lateral movement of up to 4 m was recorded by the translation of a fence on the south side of the highway. The dimensions of the slide were not documented. It was mentioned in TRANS file that water from springs in the north backslope flow down toward the north highway embankment, and water ponds in the north ditch. This water saturates and infiltrates the embankment and sideslopes through sand layers, creating a high water table. The slide is deep seated, based on one of the slope inclinometers registering movement as deep as 26 m.

3. PAST INVESTIGATIONS/RESULTS/REMEDIATION

In 1987, two test pits were excavated in the slide. Design alternatives consisting of drainage trenches or horizontal drains were proposed. A cross-section found in the file indicated the set-up point for the horizontal drains was 50 m downslope (south) of the highway. Based on an inspection sheet with pictures found in the file dated October 14 - 17, 1987, seven horizontal drains were installed (at least 3 of the drains were 100 m long) and "manifolded" together, initially producing up to 8 l/minute collectively.

In October 1988, 3 test holes were drilled by Thurber (labeled #1 to #3) in a section across the road. They were drilled to depths of between 18 m and 39 m, and inclinometers were installed. The logs and a site sketch are attached for inclusion in Section G of the binder.

Based on Amec's 2000 file review, 3 slope inclinometers (#56 to #58) were installed downslope of the road in 1996. These borehole logs are not in the file. The rate of movement over the past 5 years (at that time) in these instruments has been in the order of 10 mm/year.

4. GEOLOGICAL/GEOTECHNICAL CONDITIONS

The Clear River is located in a valley north of the Shaftesbury Channel Thalweg. The Alberta Bedrock map (1995) indicates less than 15 m of drift overlying bedrock in this area. Mollard and Associates, (1976, Feasibility Study, Dunvegan Hydro Power) indicate the Clear River occupies a buried pre-glacial valley in this area which has been infilled with lacustrine silty clay containing occasional pockets of sand/gravel overlying till.

The test hole/pit information indicate layers of clay, silt, sand and shale being encountered, up to where continuous gravel was encountered at an approximate elevation of 22 m below the road. Some of the silt/sand layers were wet with seepage.

The following map references were reviewed:

- Physiographic Region- Peace River Lowland.
- Bedrock Geology - Consists of Cretaceous age deposits: predominantly Kaskapau Formation marine dark grey silty shales, interbedded with fine-grained sandstone and thin beds of mudstone; and within the confines of the valley flanked by Dunvegan Formation deltaic to marine grey, fine-grained, feldsparthic sandstone, laminated siltstone and grey silty shale.
- Surficial Geology - Located on: Lacustrine clay/silt/sand, ranging from poor to well sorted deposits, commonly varved at depth; with Slump/Colluvium, mixed glacial and bedrock materials, mainly along flanks of valleys. There are also discontinuous areas of Alluvial sand/gravel with some silt in recent terraces, and Clayey Till with gravel/sand patches.

- Hydrogeology - Unconsolidated deposits overlying either Dunvegan Formation or Kaskapau Formation, with yields in the range of 0.1 to 0.4 litres/sec on the edges of the valley, but commonly less than 0.1 l/sec in the valley. Groundwater flow directions are mostly downward with some discharge areas and contact springs along slopes.

5. CHRONOLOGY/REFERENCES

The information found from all sources is itemized below:

Aug. 1987 Note to file by J. Miller and F. Neveu. Inspection of the slide in NW27-84-11-6 (which is the incorrect legal description). Movement of the fence line about 4 m. Springs from the north backslope flow down toward the north highway embankment, water ponds in ditch, and saturates and infiltrates the embankment and sideslopes through sand layers. North highway ditch was deepened to allow drainage. A schematic cross-section based on 2 test pits indicate soil conditions consist of clay and sand overlying organic soil, over clay and sand with seepage. Design alternatives consisting of drainage trenches or horizontal drains were proposed and costs estimated.

Oct. 1987 1 page letter dated October 15 from V. Diyaljee to Roy Callioux and drafted cross-section. Letter shows legal description of NW27-84-11-6 (which is incorrect). Letter states that minor surface drainage was completed by lowering the west ditch bottom through slide area by 0.5 m and water is draining steadily from it, and that they are currently in the process of installing seven horizontal drains through the center of the slide to improve subsurface drainage. The drafted section includes the 2 test pits (see above Aug. 1987) and indicated the set-up point for the horizontal drains was 50 m downslope (south) of the highway, and drain(s) to extend 100 m north from this point beneath the highway and 50 m north.

Oct. 1987 Inspection sheet with 4 pictures indicate seven horizontal drains were installed and "manifolded" together. Three of the drains were noted as being 100 m long. One drain installation encountered difficulties and the screen had to be washed in. The drains initially produced from a drip up to 3 l/min separately (~8 l/minute collectively). Dirt was used to fill the slough. Permission to enter was received and beaver dam removed.

Nov. 1988	Drill Inspection and Slope Inclinometer installation report by Thurber. 3 test holes drilled, and slope inclinometers installed (SI1 to SI3), in a section along Sta. 22+820 (see attached site sketch and logs). Some inclinometer plots are in the file.
Jun. 1989	Laboratory test results (sieves and limits) on selected soil samples from SI1 to SI3.
Jul. 1996	3 slope inclinometers (#56 to #58) installed downslope of the road. Borehole logs not in file. Some inclinometer plots in file.
Mar., 1999	GAEA annual landslide inspection. Site 6 – East: SI's #1, 2, 3, 56, 57, 58 are located at this site. A dip was observed in the road, but no indication of major slide movements.
Jun. 2004	Thurber annual geohazard inspection. At Site #6, the horizontal drain outlets could not be located. A substantial dip in the eastbound lane of the highway about 0.4 m deep. SI58, the only remaining inclinometer, registered a combined movement of 10 mm/year at three separate depths between 21 m to 26 m. Recommendation to locate the horizontal drain outlets and clean them out if they are still functioning.
Jun. 2004 - Jun. 2008	Site visits during Thurber's annual geohazard inspections indicated gradual deepening of the dip, emergence of a second dip in the highway about 200 m east of the first dip, a bow in the fence and bent trees downslope of the highway, and some ongoing cracking and patching of highway surface through this area. In 2005, SI58 was blocked at a depth of 18.5 m and no longer functional. It was speculated that the slide scarp may extend north of highway and pass through the 2 dips in the highway. Potential recommendations include installing some instrumentation, installing additional horizontal drains, rerouting highway further upslope (north) around the slide, or installing a pile wall with tiebacks.

NOTE: There was no information newer than 1995 available for viewing at TRANS Twin Atria office during this file review (May 28 & June 18, 2008).

PART A: FILE REVIEW
LANDSLIDE RISK ASSESSMENT
PEACE REGION (PEACE RIVER VALLEY/HIGH LEVEL)

SITE PH8: CLEAR RIVER EAST HILL

LEGAL LOCATION:	84-11 W6M
Location along Highway:	Stations 22+820 to 23+116 and Stations 23+440 to 24+060 (the eastern edge of the bridge is 22+516)
AI FILE:	H64:02
Date of Initial Observation:	1987
Date of Last Inspection:	September 1999
Instrument s Installed:	31 slope inclinometers
Instruments Operational:	7 slope inclinometers
Risk Assessment:	PF(9) * CF(2) = **18**
Last Updated:	AMEC Earth & Environmental Limited November 1, 2000

INTRODUCTION

This section is a review of files made available by Alberta Infrastructure for the site. The file review was prepared prior to the site visit. The description of the sites is based on the information that was present in the file, topographical and geological information was added if it was not present in the file and if the site was familiar, previous observations were also included. A risk assessment, solely based on the file review is provided. The risk assessment may change once the observations made during the site visit are incorporated.

Clear River East includes sites along a 3 km long section of H64:02, to the east of the Clear River. H64:02 crosses the Clearwater River in an east-west direction. The valley of the Clear River is approximately 150 m deep. East of the Clear River bridge, the highway climbs out of the valley following the sidehill of a tributary in a north-easterly direction. The road was constructed in cut and fill.

After construction of the highway in 1968, extensive erosion occurred along a channel adjacent to the highway. This problem appears to have been solved with the construction of four large gabion drop structures.

GAEA had identified six sites where erosion or slope instabilities had occurred in the last few years. These are the following:

Site 1 East: Station 24+916: no information in file
Site 2 East: Station 25+016: no information in file
Site 3 East: Station 25+016: no information in file
Site 4 East: Station 25+016 (near top of the hill), installed geotextile lining in ditch and installed corrugated plastic downdrain pipe (elephant trunk)
Site 5 East: Stations 23+440 to 24+060, large slide, toe buttress constructed, creek channelled through culvert.
Site 6 East: Stations 22+820 to 23+116 (0.6 km east of bridge): large slide

GEOTECHNICAL CONDITIONS

The Clear River occupies a buried pre-glacial valley (Mollard and Associates, 1976, Feasibility Study, Dunvegan Hydro Power). The valley is infilled with lacustrine, silty clay with occasional pockets of sand and gravel overlying till. It appears that boreholes drilled at the base of the valley reached bedrock. Any of the boreholes that were drilled higher up along the valley wall did not reach bedrock (some were drilled to a depth of almost 50 m).

The soil conditions at the road embankments consist of clay and sand fill overlying an organic layer, which overlies lacustrine clay and clay till. The lacustrine clay is high plastic and stiff, and contains layers of sand and gravel.

CHRONOLOGY

Table A1 provides the chronological background of the slides.

DESCRIPTION OF INDIVIDUAL SITES

In the following, the individual sites are described. Sites 1, 2 and 3 are not described, because there is no information in the file on what the issues are at these sites. At Site 4, geotextiles were placed in the ditch and a downdrain was installed. So only Sites 5 and 6 are discussed.

Site 5 East: Station 23+440 to 24+060

Description of Instability

At this site, the road appears to be in fill. As indicated in the borehole logs, the fill thickness is only a few metres. Before construction of mitigative measures, the slope downhill of the road was inclined at 5H:1V on average and the road was approximately 40 m above the creek level.

It appears that the slide occurred in 1986. Cracks appear to have extended over a length of 500 m along the highway, based on a plan in the file. The slide displaced the road. Later that year, the road was re-aligned uphill of the slide. It appears that in 1987, the slide retrogressed further uphill, since remedial measures were undertaken in that year.

The slide was deep-seated, with movement occurring in the high plastic lacustrine clay (at depths up to 42 m). The toe appears to have been just above the creek bed. There are no field observations on the location of the toe in the file.

Past Investigation

In 1988, two shallow boreholes were drilled at the southern edge of the site.

In 1988, ATU installed 16 slope inclinometers (4 to 19) at the site. Borehole logs are in the file.

In 1994, ATU replaced six slope inclinometers (40 to 45). The borehole logs are not in the file.

In 1996, three slope inclinometers were installed (59 to 61). The borehole logs are not in the file.

Remedial Measures

In 1988, it appears that extensive drainage trenches were installed. The drainage trenches were installed under the road alignment and uphill and downhill of the road. The width of the area to be drained, measured along the road, was 160 m.

There is a drawing in the file by GAEA indicating that a toe buttress was constructed using material excavated from the backslope and that the creek was channelled into a culvert. In addition, the top of the toe buttress was armoured with rip rap and gabion baskets. The rip rap and gabion baskets were installed in 1997. It is not known when the toe buttress was installed (probably 1996).

Monitoring Results

Only five of the slope inclinometers are still operational. All other slope inclinometers have either sheared off or have been destroyed.

Distinct shear zones were registered in many of the slope inclinometers: slope inclinometer 6 at 12 m depth, 9 at 11 m and 13 m; 10 at 26 m; 11 at 17 m; 12A at 42 m and 47 m; 13 at 25 m and 42 m; 17 at 8 m, 18 m and 28 m; 18 at 32 m and 33 m; 19 at 19 m, 23m, 25 m and 26 m; 40 at 25 m; 42 at 20 m; 44 at 41 m, 48 m and 49 m; 59 at 25 m; 60 possibly at 15 m.

The following slope inclinometers did not indicate distinct shear zones: 7, 12, 19, 45, and 61. Slope inclinometers 7 and 19 are at the toe of the slope, 12 and 61 are at the head of the slope. Slope inclinometer 45 is in the centre of the slide, it appears that it sheared off before shear could be registered.

Records for the slope inclinometers that are not listed above were not in the file.

Based on the slope inclinometer records, the rate of movement between 1988 and 1994 appears to have been slow, because few of the slope inclinometers sheared off in that period. Between 1995 and 1997 the rate of movement was higher (40 mm per year), but movement appears to have slowed down thereafter (8 mm per year).

Assessment

The slide is a deep-seated failure. Probably, after construction of the toe buttress, the rate of movement has slowed down considerably. Possibly, some of the movement that is being recorded corresponds to the movement required for the buttress to mobilize resistance.

Risk Assessment:
The probability factor is 9, the slide is moving very slowly, with little surface expression. The consequence factor is 2, the fills are low and the slopes are gentle.
Thus, the risk level is estimated at 18.

Site 6 East: Station 22+820 to 23+116

Description of Instability

At this site, the road is in fill along the valley wall of a small creek. The road is approximately 130 m from the creek bed. Downhill of the road, the slope is inclined at 4H:1V.

When the slide occurred, lateral movement of up to 4 m was recorded (by the movement of a fence). The dimensions of the slide are not mentioned in the file.

The water table in the slide area was high, it is reported that water was ponding next to the highway and there were springs in the backslope above the slide.

The rupture surface appears to be deep seated. One of the slope inclinometers registered shear movement as deep as 26 m.

Past Investigations

In 1987, two test pits were excavated in the slide.

In 1988, ATU installed three slope inclinometers (1 to 3) in the slide. Borehole logs are in the file.

In 1996, three slope inclinometers (56 to 58) were installed downhill of the road. Borehole logs are not in the file.

Monitoring Results

Records for slope inclinometers 1 and 2 are not in the file.

Distinct shear movement was registered in slope inclinometers 56 at 5 m and 17 m; 57 at 23 m and 58 at 21 m, 22 m and 26 m.

Slope inclinometer 3 has not registered significant movement.

The rate of movement over the past four years has been in the order of 10 mm per year.

Remedial Measures

It appears that horizontal drains were installed in 1987. The drains were approximately 70 m long.

Assessment

It appears that the performance of the road at this location is good. GAEA reported a dip in the road, but cracks are not reported.

The probability factor is 9, the slides are moving very slowly, with little surface expression. The consequence factor is 2, the fills are low and the slopes are gentle.
Thus, the risk level is estimated at 18.

TABLE A1: CHRONOLOGY

1968	Initial route studies for H64:02. Boreholes to a approximately 20 m depth were drilled. A water diversion ditch was constructed to the south of the road alignment. The diverted water was channelled back to the ditch through a 300 m long 1200 mm diameter culvert, leading into four drop structures.
1976, 10	Letter by L.Sharma to H. Hetu. Drop structures have failed.
1977, 09	Letter by Thurber to L.Sharma. Results of dispersion tests on soil sample from Clear River drop structure site. Tests indicate the soil is not dispersive.
1979	Four gabion basket drop structures had been constructed.
1980	Letter by D. Dodds to R. Hilton. Serious erosion had occurred as a consequence of the diversion ditch.
1987, 06	Note to file by V. Diyaljee. Severe erosion at channel that discharges roadway run-off to the Clear River.
1987, 08	Note to file by J. Miller and F. Neveu. Inspection of slide at 22+820 (?). Movement of fence line approximately 4 m. Schematic cross section indicates soil conditions consist of clay and sand fill overlying organic soil, over clay and sand. Water ponding in ditch and feeding into embankment. Recommended subsurface drain.
1987, 08	Cost sheet for installation of horizontal drains. These drains were installed in October 1987.
1988, 08	Note to file by M. Pariti. Lateral and longitudinal drainage trench system is being installed (Station 24+060). The drainage trench system consists of 5 laterals 150 m long, and one longitudinal drain.
1988, 12	Slope inclinometers installed.

1994, 06	Memorandum by M. Pariti to M. Raheem. Slide from station 23+440 to 24+060. The movements are deep-seated and remedial measures are difficult to implement.
1994, 06	Note to file by K. Li. Slide at Sta. 23+440 to 24+060. Slide appears to have become re-activated, 0.5 m drop of pavement. Re-installation of SIs 16-19.
1994, 09	Note to file by k. Li. Slide approximately 1 km east of Clear River bridge (Sta. 23+440 to 24+060). Proposed to install 6 slope inclinometers (40-45).
1994, 10	Drilling of boreholes at Clear River bridge by Thurber.
1999,	GAEA Annual landslide inspection. Site 6 - East (Station 22+820): SIs 1, 2, 3, 56, 57, 58. Roadway is considered satisfactory. A dip was observed in the road, no indication of major slide movements. Site 5 - East (Station 24+100): creek at base of slope, heavy rip rap and gabion baskets were installed in 1997/98. There is a design in the file to offload the upper part of the slope, channel the creek through a culvert and construct a toe berm. However, it is not clear whether it was constructed. North bank of creek had slumped. Sites 3/4 (at top of valley): a corrugated downdrain pipe failed and was repaired in 1996/97.