



**ALBERTA TRANSPORTATION  
LANDSLIDE RISK ASSESSMENT**

**SECTION A: GEOTECHNICAL FILE REVIEW**

**PEACE REGION (PEACE RIVER-HIGH LEVEL AREA)**

**SITE PH 23, (Old PH8E, Site#5@ km 23.4 to 24.1)**

HIGHWAY CONTROL SECTION	Hwy 64:02, km 23.4 to 24.1 (Station 23+440 to Station 24+060 East of Bridge)
NEAREST LANDMARK:	12 km West of Cleardale
LEGAL LOCATION:	NE28 & NW27-84-11-W6
DATE OF INITIAL OBSERVATION:	1986
DATE OF LAST INSPECTION:	June 2008
LAST INSPECTED BY:	Thurber Engineering Ltd. (TEL)
INSTRUMENTS INSTALLED:	25 Slope Inclinometers (16 in 1988, 6 in 1994, and 3 in 1996)
INSTRUMENTS OPERATIONAL:	2 Slope Inclinometers (1 in 1988 and 1 in 1996)
RISK ASSESSMENT:	PF(13) * CF(5) = 65
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 12 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 PH23 now includes only the old Site #5 located about 0.9 km to 1.5 km east of the bridge.

## 2. GENERAL DESCRIPTION OF SLOPE INSTABILITY

The slide at PH23 is located along a section of Highway 64:02 that is in fill along the valley wall of a small creek. Before construction of mitigative measures, the terrain on the downslope side of the road was inclined at about 5H:1V on average, with the road located about 40 m vertical above the creek.

It appears that the slide occurred in 1986. Based on a plan in the TRANS files, cracks appeared to have extended over a length of about 500 m along the highway. The slide displaced the road. Later that year, the road was re-aligned at a location upslope of the slide. It appears that in 1987, the slide retrogressed further uphill, since remedial measures were undertaken 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, however there are no field observations available in the files to confirm this.

## 3. PAST INVESTIGATIONS/RESULTS/REMEDIATION

In 1988, Amec reported in their 2000 file review that 2 shallow boreholes were drilled at the southern edge of the slide. The logs were not found in the files.

In October 1988, Thurber on behalf of ATU installed 16 slope inclinometers (SI-4 to SI-19). A sketch and the logs are attached for inclusion in Section G of the binder.

In 1988, extensive drainage trenches were installed under the road alignment and upslope and downslope of the road. The width of the drainage area was 150 m along the road.

In October 1994, Agra Earth & Environmental on behalf of ATU replaced six of the slope inclinometers (SI-40 to SI-45). A sketch and the logs are attached, also for inclusion in Section G.

In about 1996, the slide movements were mitigated using a toe buttress constructed with material excavated from the backslope, based on a drawing in the file by GAEA. The buttress blocked the creek, and the watercourse was channeled into a culvert. The culvert beneath the toe buttress failed at some time, and in 1997 the watercourse was directed into an armoured channel consisting of riprap and gabion baskets on top of the buttress.

In 1996, three slope inclinometers were installed (SI-59 to SI-61). The logs were not found in the files.

To date, only 2 slope inclinometers are still functional (SI-9 and SI-61). SI-9 is located south of the highway near the west end of the site, and has been showing movements up to 4 mm/year at 3 separate depth zones between 4 m to 14 m, but also appears to be creeping from the base (30 m) upwards, so it may not be deep enough. SI-61 is located north of the highway, and is showing creep movements of less than 1 mm/year. The movement zones and shear depths for the remaining non-functional inclinometers were described by AMEC in their 2000 file review. Since that review, SI-59 has sheared off at a depth of 24.5 m.

Based on the inclinometer readings in the past, movement was generally slow between 1988 and 1994, and between 1997 and 2000 (8 mm/year), with higher rates of movement indicated between 1994 and 1997 (40 mm/year). In the last few years, movements appear to be increasing based on observed dips in the highway and asphalt patching across this site, slope movements near the west end of the site. In addition, toe erosion and gabion/riprap liner destruction has occurred near the east end of the site.



#### 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 information indicated a variable soil profile consisting of fill mixed with organics extending up to depths of 4.5 m, peat/organics at surface or below the fill at some locations (and in SI#42 at a depth of 10 m within the clay), random layers of clay/silt/sand/gravel/till/shale of variable thickness within/overlying a predominant lacustrine clay matrix. Clay shale was reportedly encountered at depths of 33 m, 42 m, and 35 m at SI #5, #13, and #17, respectively. Some of the silt/sand layers were wet with seepage. Much of the clay was slickensided, and circulation was lost during drilling some of the test holes.

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, feldspathic 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. 1988 Note to file by M. Pariti, along with 2 figures showing the drainage system. The lateral and longitudinal trench drainage system with Big O Pipe is being installed (Sta. 24+060). The drainage system consists of 5 lateral drains up to 150 m wide parallel to the road, bi-sected by a central longitudinal collector draining to the ravine.
- Oct. 1988 3 Photos by R. Neuman, showing test pits being excavated (Sta. 23+730 area), and a section of failed centerline culvert removed (Sta. 23+675). A note on a separate page indicate that the culvert at Sta. 23+675 has been filled in on the north side of road, and the north ditch was graded to facilitate drainage; a sketch on this page shows a zone of cracking above the Big O Pipe outlets between SI-18 and SI-19.
- Oct. 1988 16 Slope inclinometers installed by Thurber (locations and logs). Some inclinometer plots in file.
- Jun. 1989 Laboratory test results (sieves and limits) on selected soil samples from SI17 to SI19. Also strength testing as follows:
 

<u>Test Hole</u>	<u>Depth (m)</u>	<u>Results</u>
16	22.8	Consolidated undrained triaxial test results varied from 13 <sup>o</sup> & 0 kPa to 18 <sup>o</sup> & 10 kPa. A direct shear test yielded a peak strength of 17 <sup>o</sup> & 30 kPa, and a residual strength of 12 <sup>o</sup> & 5 kPa.
17	27.5	Consolidated undrained triaxial test results yielded 17.5 <sup>o</sup> & 56 kPa. A direct shear test yielded a peak strength of 20 <sup>o</sup> & 45 kPa, and a residual strength of 19 <sup>o</sup> & 19 kPa.
- Jun. 1994 Memo from M. Pariti to M. Raheem. Slide from Sta. 23+440 to Sta. 24+060. Movements are deep seated (27 m to 41 m), and remedial measures are difficult to implement.
- Jun. 1994 Note to file by K. Li, plan and 2 photos. Slide from Sta. 23+440 to Sta. 24+060 appears to have re-activated. 0.5 m drop and pavement upheaval. Department patched it. Replace SI's 16-19.



- Sept. 1994 Note to file by K. Li, plan and 2 photos. Slide ~1 km from Clear River Slide (Sta. 23+440 to Sta. 24+060). Proposed to install 6 slope inclinometers (40 to 45).
- Oct. 1994 Six inclinometers (40 to 45) installed by Agra Earth & Environmental (locations and logs). Some inclinometer plots in file.
- 1994 GAEA annual landslide inspection. Site 5 – East (Sta. 24+100): creek at base of slope, heavy riprap and gabion baskets were installed in 1997/98. There is a design in 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.
- Jun. 2004 - Site visits during Thurber's annual geohazard inspections. Gradual  
Jun., 2008 deepening of the dip and progressive cracking near the east end of the site (~km 24.0), emergence of two more dips in the highway (~km 23.9 and km 23.8), some ongoing cracking and patching of highway surface through the area of the easterly 2 dips (~km 23.9 to 24.0), enlargement and transgression of two embankment slumps and some embankment seepage south of the highway near the west end of the site (~km 23.6 to km 23.7), continuous accelerating enlargement of the downstream slump on the north side of the channel caused by active seepage, severe erosion and almost total destruction of the gabion/riprap lined portion of the channel below the slump, continued siltation from further upstream, and continued aggressive erosion/bank slumping of the stream channel south of the highway all along this site. Recommendations include performing a study entailing survey/hydraulics/airphotos, reconstructing the lined portion of the channel, and reconstructing the north channel slump.

**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

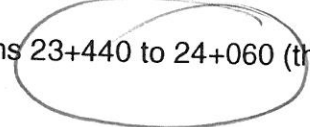
Instruments Installed: 31 slope inclinometers

Instruments Operational: 7 slope inclinometers

Risk Assessment:  $PF(9) * CF(2) = 18$

Last Updated: AMEC Earth & Environmental Limited  
November 1, 2000

PH 23  
SITE 5



## 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 down drain 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.