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

SITE PH7: DAISHOWA EAST ACCESS

LEGAL LOCATION:	12-85-21-W5M
Location along Highway:	Station 13+300 East Hill (Daishowa Bridge is 11+000)
AI FILE:	SH986:01 (previously SH686:01)
Date of Initial Observation:	Summer 1989
Date of Last Inspection:	June 1999
Instruments Installed:	16 SIs installed in total
Instruments Operational:	10 slope inclinometers, 0 piezometers
Risk Assessment:	PF(11) * CF(4) = **44**
Last Updated:	AMEC Earth & Environmental Limited November 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 site is based on the information in the files, 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 bsed on the file review is provided. The risk assessment may change once the observations made during the site visit are incorporated.

The Daishowa East Access is located on the east side of the Peace River, climbing from river level (310 m) to prairie level (530 m) over a length of 5 km, following the valley of a small tributary of the Peace River (see Figure 1). A number of large dormant landslides existed along the valley wall. During construction of the road in 1989 and 1990 a number of slides occurred. These slides were stabilized by construction of toe berms across the valley and are considered inactive. At Station 13+300 instability also occurred during construction of the road. Pumping wells were installed in 1989, but movement was reported in 1999, such that it is considered active. Information on the other slides is included as background.

The following slide areas have been identified (the bridge is Station 11+000):

- 12+000: up to 10 m high fill, cracks along 200 m of sideslope, Summer 1989 to Summer 1990, constructed toe berm and channelled creek into culvert;
- 12+500 to 12+920: constructed a toe berm and channelled creek into culvert;
- 13+300: installed pumping wells, this site is considered active, road had settled and was re-paved in 1999;
- 13+540: constructed toe berm and channelled creek into culvert;
- 13+960: slide at ravine location, installed culvert and toe drains, installed subsurface drain in backslope ditch using geomembrane, rebuilt slope in benches, slope at 4H:1V.

GEOTECHNICAL CONDITIONS

At the site, the Peace River has eroded through deposits in an infilled pre-glacial valley. The pre-glacial valley is infilled with lacustrine and alluvial sediments and clay till. Bedrock of the Cadotte formation is exposed just above river level near Daishowa's pulp mill. Bedrock of the Shaftsbury formation, which typically consists of weak clay shale, is probably present; it is exposed along the Peace River valley several kilometres to the south (at the silica mine) and was reported in some of the boreholes.

Along the valley wall, the water table is typically close to surface. Sand and gravel layers in the soil profile result in adverse pore water pressures.

CHRONOLOGY

Table A1 provides the chronological background of the slides.

DESCRIPTION OF INDIVIDUAL SITES

Station13+300

Description of the Instability

The active slide is at a location where approximately 6 m of fill had been placed. The downhill slope is inclined at approximately 3.5H:1V. The road is 30 m above creek level.

The soil conditions consisted of the following sequence:

- clay fill, medium to high plastic (up to 6 m thick);
- clay, firm, high plastic, with sand and gravel layers (in the order of 10 m thick);
- clay till, very hard, medium plastic, may contain sand layers;
- sand and gravel;
- clay shale .

Based on the borehole logs and the slope inclinometer records, the rupture surface appears to be in lacustrine clay, and possibly partially in shale.

Cracks extending to the backslope ditch were reported in May 1991. The slide was estimated to be 100 m wide and 140 m long (side shears and a toe were not identified). Movement was detected at up to 14 m depth using slope inclinometers.

In 1999, it was reported that the roadway had been patched at this location a number of times during the year, because the road was settling.

Past Investigations

Prior to construction of the road (1989), a number of boreholes were drilled along the alignment. Records of the boreholes logs were not in the file.

In 1990, test pits were excavated at Stations 12+000 and 13+540. Slope inclinometers were installed at Stations 12+000 (3), 13+540 (4) and 13+950 (4).

In 1991, three slope inclinometers (Numbers 10, 11 and 12) and three piezometers were installed at Station 13+295.

In 1992, pressuremeter tests were performed (records are not in the file) and four slope inclinometers were installed (Numbers 13, 14,15 and 16).

Borehole logs are available for slope inclinometers 13 and 16 only.

Remedial Measures

Horizontal drains were installed in 1989 at the toe of the slope and flow was reported from the drains. By May 1991 the drains were dry. The number of drains or how long they are is not reported.

In 1994, two wells were installed near the scarp of the slide. The wells intercepted the sand and gravel layer overlying the shale. Pump tests were undertaken in the wells, indicating hydraulic conductivity of 7 $x10^{-6}$ m/s and 1 $x10^{-6}$ m/s. Slope stability analyses indicated that if the piezometric level was lowered by 5 m, the factor of safety of the slope would increase by 10%.

In 1995 a series of twenty wells was installed uphill of the road. The wells were installed to depths ranging from 10 to 34 m. It is our understanding that the wells were to be belled, such that they would connect at the base. Pumps were installed in four wells. The depths at which the pumps were installed and the completion of the wells is not described in the file.

It is not clear whether the pumps are still operational.

Monitoring Results

- Before installation of the pumps the water level at the scarp was at 2 m below surface. Two months after pumping started, the water level was at 14 m depth.

- Slope inclinometer 10, uphill of the scarp, registered clear shear movement at 8 m depth.

- Slope inclinometer 14, central and downhill of the road, registered clear shear movement at 6 m depth.

- Slope inclinometer 15, at the edge of the slide and downhill of the road, registered shear movement at 3 m and 5 m depth.

- Slope inclinometer 16, at the edge of the slide and downhill of 15, registered shear movement at 14 m. The movement rate was in the order of 20 mm per year. This movement appears to be in the clay shale.

Apparently shear movement was registered at 13 m in slope inclinometer 11, at 10 m in slope inclinometer 13, at 6 m in slope inclinometer 12, but the records for these slope inclinometers are missing.

All slope inclinometers in the slide, except slope inclinometer 15, have sheared off or have been destroyed.

Assessment

Before installation of the pumps in 1994, the slide was moving at a relatively high rate (20 mm per year). Thereafter it appears that performance of the road was good for a number of years. In 1999, it was reported that the roadway had been patched at this location a number of times during the year, because the road was settling.

The following factors are believed to have contributed to the slide:

- large fill volume placed (up to 6 m thick fill);
- possibly high precipitation at the time of the initial slide:
    - July 1989: 75 mm (normal for 1944-1980 is 62 mm),

- August 1989: 118 mm (normal for 1944-1980 is 51 mm).

- for the initial slide, possibly pre-sheared native medium to high plastic clays in a previously inactive slide;
- after the initial slide, the clays would have become sheared, such that residual strength would be mobilized;
- possibly a rising water table, if the pumps are not operational anymore.

Risk Assessment:
The probability factor is 11, settlement of the road has occurred, and it appears that the rate of movement is increasing. The consequence factor is 4, this is a thick fill and the slide affects a significant width of the road. Thus, the risk level is estimated at 44.

CHRONOLOGY

1989-1990 Construction of the road.

1989, 05 Letter from V. Diyaljee to R. Callioux. Geotechnical review of gradeline. The letter notes that a number of ancient dormant slides will be crossed by the road. The slide area between 12+500 and 12+900 is the most threatening area. Water movement through sand and silt layers is believed to be a major factor contributing to the slide. Measures to be implemented at major cut and fill sections are discussed.

1989, 10 Letter from V. Diyaljee to R. Callioux. Realignment options are discussed following a landslide between 12+500 and 12+900. Landsliding had occurred in September 1989. The creek is to be channelled into a steel culvert and a toe berm is to be installed.

1990, 05 Note to file by Karl Li. Slide at 13+950. Site was visited in May, shallow slide had encroached to 10 m from edge of shoulder of the alignment. Height of scarp was 3 to 4 m. Proposed to install toe berm and channel creek into culvert, construct slope to 3H:1V or 4H:1V.

1990, 06 Note to file by Karl Li. Slide at 13+930. Proposed design for sideslope transverse and backslope subdrains.

1990, 08 Note to file by Karl Li. Slide at 13+540 recurred after heavy rainfall in June 1990 and encroached to centreline of alignment. Slide was 40 m wide and 25 m high. Horizontal drains that had been installed were believed damaged. Test pits at backslope ditch indicated clayey silt to 6 m depth, with a sand zone from 0.5 to 3 m depth. Test pits down the slope indicated clayey silt with layers of sand and gravel. It was inferred that the sand and gravel layers were blocked off by the slide, resulting in increased pore pressures and failure. Proposed to channel creek into culvert and toe berm. A backslope interceptor drain and transverse subdrains were recommended.
Slide at 12+000. Cracks had continued to appear despite a toe berm. It was recommended to channel the creek into a culvert and construct a 10 m high toe berm. Finger drains would be installed where seepage is visible.

Recommended installation of slope inclinometers at

- 12+000: 3 slope inclinometers
- 13+540: 4 slope inclinometers
- 13+950: 4 slope inclinometers.

1991, 05 Note to file by Karl Li. Slide at 13+295. Reported cracks extending to backslope ditch. Noted that initial movement had been observed in 1989 and that horizontal drains had been installed at that time. Initially, there was flow in the drains, but by May 1991, they were dry. Proposed to install slope inclinometers and piezometers.

1994, 04 Note to file by Karl Li. Slide at 13+295. Pumped wells were installed and pumping tests are to be carried out. Borehole logs indicate fill overlying a sequence of silty clay with sand and gravel layers. (Note: these wells consisted of belled piles, connected at the base, 2 pumps were to be installed.)

1994, 05 Note to file by Fred Cheng, Results of pump tests and stability calculations to determine the effect of lowering the water level on factor of safety of the slide.

1999, 07 Letter from V. Diyaljee to D. Kohut. Roadway has been patched a number of times during the past year, indicating active slide conditions. Big O pipe at pump location could not be located. Slope inclinometers 10 to 14 at active slide location are not functional. Submitted cost to install replacement slope inclinometers.