THURBER ENGINEERING LTD.

Suite 200, 9636 - 51st Avenue
EDMONTON, Alberta T6E 6A5
Phone (780) 438-1460
Fax (780) 437-7125

THURBER

ALBERTA INFRASTRUCTURE
LANDSLIDE RISK ASSESSMENT

SECTION A: GEOTECHNICAL FILE REVIEW

NORTH CENTRAL REGION

SITE NC13: SH633:02

LEGAL LOCATION:	**LSD14 29-53-6-W5M**
NEAREST LANDMARK:	**1 to 2 km East of Junction with SH757, North of Gainford**
Highway Control Section:	**SH633:02**
Date of Initial Observation:	**1989**
Date of Last Inspection:	**1995**
Last Inspected By:	**Thurber Engineering Ltd.**
Instruments Installed:	**20 Slope Inclinometers (1990, 1991, 1995) Piezometers (number and date undetermined) 1 Standpipe Piezometer (1995)**
Instruments Operational:	**West Slide: Instruments likely not functioning. East slide: SI95-2 functioning, SI95-1 and standpipe likely functioning.**
Risk Assessment:	PF(6) * CF(2) = **12**

1. LOCATION

The site is located on SH633 approximately 1 km to 2 km east of the junction with SH757. Two areas of slope instability (labelled west slide and east slide) have been noted; each approximately 100 m in length spaced at a distance of about 650 m along the highway.

A site plan (Figure NC13-1, Section F) shows relationship of the slides to each other, and the approximate location of the cracking patterns and monitoring instrumentation installed at these sites.

2. GENERAL DESCRIPTION OF SLOPE INSTABILITY

The west and east slides are located within a stretch of highway constructed with a 4 m high embankment fill, with side slopes of approximately 3H:1V or flatter. The embankment was constructed on relatively flat to gently sloping ground, generally at an original slope of about 12H:1V or flatter. The drainage in the area is poor, with low lying wetland areas extending south and east of the site toward Lake Isle. North of the highway the ground surface rises.

The highway was constructed over the original Grande Trunk Pacific Railway grade. It is understood that instability problems were experienced at these locations during and/or shortly after the railway construction.

Artesian conditions within a buried channel feature (sand and gravel) appear to be the major destabilizing factor. The modest fill placed during roadway construction likely has triggered the slope instability. Continued movements in the roadway embankment since upgrading in 1989 have required regular maintenance. Movements have been more pronounced and regular in the west slide area.

Efforts to slow the movements in the west slide area by the reduction of artesian pressures via subdrainage have been unsuccessful to date. These drainage measures included a trench drain to the north of the embankment, combined with vertical relief wells to connect the aquifer with the drainage system. Natural drainage from the area is restricted due to the flat topography of the region, hence the effectiveness of the drainage system has been limited.

Recommendations for remediation of the west and east slide areas have been provided, including roadway relocation and/or slope unloading by vertical grade modification and use of lightweight fill.

3. GEOLOGICAL/GEOTECHNICAL CONDITIONS

Physiographic Region: Eastern Alberta Plains

Bedrock Geology: Paskapoo Formation of Tertiary age. The site is located on the north side of the preglacial North Saskatchewan River Valley.

Surficial Geology: Hummocky topography, with irregularly shaped and poorly defined knobs and kettles indicative of stagnation moraine deposits (i.e. till with local water sorted material).

Hydrogeology: Groundwater flow is generally to the southeast toward Lake Isle. Groundwater yields typically up to 2 L/s, however reports of yields of over 35 L/s have been made. There is potential for groundwater discharge in areas along slopes in the area.

The above geological discussion is based on published information.

Stratigraphy:

The west slide area stratigraphy generally consists of up to about 4 m of embankment fill material overlying the following layers in succession; 3 m of high plastic lacustrine clay, 5 m of clay till, 10 m of sand and gravel. Sandstone bedrock is located below the sand and gravel. Several test holes encountered buried debris and old timber pilings at depth (up to 8 m below the existing road surface).

The general stratigraphy of the east slide area consists of about 3 m of fill over 2 to 3 m of gravel and sand, overlying 7 to 8 m of high plastic lacustrine clay, over 12 m of clay till, over bedrock.

The sand and gravel layer is under high artesian pressure, above the native ground surface in this area.

4. CHRONOLOGY

1930's

It is understood that a section of the abandoned Grande Trunk Pacific Railway grade was converted for use as a local access road in about 1937. It is expected that slope instability was encountered in this area during construction of the original railway grade.

1984–1985

The old local access road was widened and upgraded to Secondary Highway standards. No record of instability was provided in the geotechnical files from this time period.

1989

Cracks on the pavement surface were first noted in 1989 in the west slide area after placement of base course material for paving. The main cracks and slump followed the shape of an arc on the road approximately 14 m long. A drop of the road surface of up to 75 mm and the presence of a toe bulge to the south of the roadway were observed at the site. Observations were also made of a displaced fence line to the south, and distress was noted in a large culvert constructed to allow cattle to pass under the roadway (cattle pass).

1990

Based on a site reconnaissance, it was suggested that massive movement in the highway embankment fill was occurring toward a small, unnamed creek to the south of the roadway. It was suspected that the main cause of instability was water seepage from the north into the fill along an old drainage course.

A 120 m long cut-off trench backfilled with gravel and perforated pipe was constructed on the north side of SH633 at the west site in October 1990.

Seven slope inclinometers (SI#1 through SI#7) were installed in test holes at the west slide site, including three on the north side and four on the south side of the highway. A void was noted during drilling of one of the test holes. One test hole was attempted further south of the highway, however artesian conditions were encountered and the hole was abandoned.

In September of 1990 a total of seven test pits were excavated at the west site; three on the north side and four on the south side. Seepage and sloughing conditions were observed in some of the test pits. Wooden piles and planks were also encountered in the test pits.

The roadway was repaved twice in 1990, however new cracks and slumping reoccurred at the same location each time new pavement was placed.

1991

The cattle pass was moved to the east to a location outside of the slide area.

A drilling investigation was conducted at the west site in the spring of 1991, consisting of six test holes and the installation of three additional slope inclinometers (SI#2A, SI#7A, and SI#8). Previous slope indicators installed at the site had sheared.

The rate of water flow measured from the subdrain pipe installed in 1990 was small. In September of 1991 a total of eight vertical relief wells were drilled through the drain at the west site to provide better hydraulic connection to the underlying sand and gravel layer, creating a relatively constant flow of approximately 2.5 litres/min.

New cracks were observed after the road was paved in September 1991. Observations indicate the reoccurrence of cracks along the same locations of the highway pavement surface. A 50 mm wide crack had formed and 75 mm of settlement occurred at the old cattle pass location.

An additional nine slope inclinometers (SI #9 through #17) were installed in November of 1991. Two pneumatic piezometers were also installed.

1992

An additional fifteen vertical relief wells were installed in the spring/summer of 1992 through the drainage trench constructed in 1990. The wells were installed to approximately 12 m below ground surface into the water bearing sand and gravel layer.

In September the flow rate from the drainage system was the same as measured in 1991 (2.5 litres/min).

1994-1995

A file review and engineering site reconnaissance were undertaken in 1994.

Cracking was noted in the pavement surface at both the west slide and east slide locations. Ongoing slope movements similar to those reported previously were noted. It was determined from Alberta Transportation maintenance personnel that the east slide requires less maintenance than the west slide area.

In 1995 a drilling investigation was conducted to provide subsurface information at the east slide location. One standpipe piezometer and two slope inclinometers were installed. It was determined that a failure plane had developed at a depth of about 12 m to 14 m below the south shoulder of the roadway. Movements of 4 mm at the shear plane were measured over a 5 week period in the fall of 1995.

A summary of the results and recommendations for remedial measures for the sites is provided as follows:

a) Groundwater pressure in the sand and gravel are high, and are likely artesian in the area south of each of the slide zones. Groundwater levels measured in piezometers installed into the permeable zone rise to within 3.5 m of the road surface (i.e. above the natural ground surface to the south of the roadway embankment).
b) All slope inclinometers located on the north side of slide showed no significant movements, whereas all the slope inclinometers on the south side of the highway had either sheared off or were blocked by 1993.
c) A failure plane was identified approximately 11 m below the shoulder of the road at the west slide area, and 12 to 14 m below the shoulder at the east slide.
d) The depth to which the drainage collection pipe could be installed was limited by site topography. Hence the reduction in groundwater pressure appears to have been small. No significant reduction in slope movements were measured in the inclinometers after implementation of the relief well system.
e) Remedial recommendations were provided for each of the sites, including highway realignment combined with grade lowering and/or lightweight fill.