THURBER ENGINEERING LTD.
GEOTECHNICAL • ENVIRONMENTAL • MATERIALS

ALBERTA TRANSPORTATION
LANDSLIDE RISK ASSESSMENT

SECTION A: GEOTECHNICAL FILE REVIEW

NORTH CENTRAL REGION

SITE NC44: CATTLEPASS EAST

LEGAL LOCATION:	NE29-53-6-W5M
NEAREST LANDMARK:	1.5 km East of Hwy 757 (at Magnolia)
HIGHWAY CONTROL SECTION	**HWY 633:02 km 1.43**
DATE OF INITIAL OBSERVATION:	1989
DATE OF LAST INSPECTION:	June 10, 2008
LAST INSPECTED BY:	Thurber Engineering Ltd.
INSTRUMENTS INSTALLED:	2 Slope Inclinometers (1995) 1 Standpipe Piezometer (1995) 3 Slope Inclinometers (2005) 4 Pneumatic Piezometers (2005) 1 Vibrating Wire Piezometer (2005)
INSTRUMENTS OPERATIONAL:	1 Slope Inclinometer (2008) 4 Pneumatic Piezometers (2008) 1 Vibrating Wire Piezometer (2008)
RISK ASSESSMENT:	PF(13) CF(4) = **52** (2008)
LAST UPDATED:	April 2009, Thurber Engineering Ltd.

1. LOCATION

The site is located on Highway 633:02 about 1.5 km east of the junction with Highway 757 at Magnolia, Alberta. The site is located about 650 m east of NC13, Cattlepass West. Until 2005, this site was considered part of NC13 and inspection reports and information prior to that year will be found in the NC13 Site Binder.

2. GENERAL DESCRIPTION OF DISTRESS

This slide is located on a stretch of highway constructed with a 4 m high embankment fill with sideslopes 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. The ground surface rises to the north of the highway.

There is a dugout pond located north of the site that holds water all year and may be spring-fed. The overflow from this pond drains south through a skew culvert along the east side of the slide. The original 1200 mm diameter CSP culvert was replaced in 2004 (by a 900 mm diameter SWSP) after its failure resulted in subsidence of the highway surface. There is also a treed bench located south of the highway and it is not clear if this is related to, or results from, the ongoing slide movements.

The distress affects both lanes of the highway over a distance of about 120 m. As of the 2008 annual site inspection, the cracks were up to about 30 mm in width and differential heights and settlements were measured up to about 100 mm. There were two small grabens: one in the highway surface and the other in the north shoulder. The south sideslope had a concave appearance and the fence at the south toe of the embankment was slightly deflected. A well-defined toe roll has been identified about 75 m south of the south shoulder.

The highway was constructed over the original Grande Trunk Pacific Railway grade. It is understood that instability problems were experienced at this location during 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.

Efforts to the slow the similar movements in the west slide (NC13) 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.

Based on the instrumentation installed in 1995, the shear plane was found to be about 12 m to 14 m deep in high plastic lacustrine clay near the interface with the underlying clay till. The groundwater table has been measured near the original ground surface.

Recommendations for remediation of the west and east slide areas provided after the geotechnical investigation in 1995 were roadway relocation and/or slope unloading by vertical grade modification and use of lightweight fill.

A 2006 investigation led to the recommendation of remediating the slide with combination of grade lowering and a small toe berm, a larger toe berm, or a tangle pile wall with tie-back anchors.

3. GEOLOGICAL/GEOTECHNICAL CONDITIONS

Physiographic Region: Eastern Alberta Plains of the Interior Plains (1969, Atlas of Alberta, University and Government of Alberta).

Bedrock Geology: The bedrock at the site is non-marine sandstone and bentonitic mudstone with thick coal beds of the Scollard Formation (Map 236). Bedrock elevation is about 720 m (Map 57) which is about 30 m below ground surface. The bedrock dips south toward a bedrock channel approximately coincident with the present-day Isle Lake and Sturgeon River. This is in agreement with the results of the 2005 geotechnical investigation which encountered clay shale and coal at about 24 m below ground surface to the south of the highway embankment.

Surficial Geology: A large-scale (1:500,000) surficial geology map (Map 213) indicates that the site is located on a clay till stagnation moraine with hummocky topography (relief generally between 3 m and 10 m). There will be local areas of water-sorted material (silts and sands).

Hydrogeology: The Scollard Formation bedrock would have an expected yield of 0.3 L/s to 1.6 L/s groundwater flow with lesser flows expected from the overlying sediments and deeper bedrock. The elevation of the regional groundwater table is located above the bedrock at elevation 730 m. Regional groundwater flow south toward Lake Isle. Artesian flow conditions were not noted in the vicinity although Thurber's geotechnical investigation indicates that artesian conditions are present in the general area.

Stratigraphy: Plan/profile information available for this site showed medium to high plastic clay beneath the highway although the test holes were relatively shallow (about 3 m deep). A geotechnical investigation was undertaken by Thurber in 2005 which involve drilling five test holes and installing instrumentation (five piezometers and three slope inclinometers).

The test hole drilled at the south shoulder encountered 7.5 m of fill. The fill was predominantly clay but had a sand and gravel zone between about 2 m to 3 m below ground surface. The fill thickness encountered at test holes further south of the highway was less. There was a layer of organic clay and peat encountered at the base of the fill. Below the organic layer, the native soil was high plastic clay with liquid limits up to 108%. At depth, the test holes encountered clay till and one test hole (SI05-7) encountered clay shale and coal below the clay till at about 25 m below ground surface.

The two test holes were also drilled on the shoulders of the highway near the twin centerline culverts. The test hole on the east side encountered similar stratigraphy to those drilled at the main slide location. The test hole on the west side encountered about 5 m of clay fill overlying about 1.5 m of soft, native clay. However, at this test hole, the native clay was low plastic and the measured moisture content was about 28%. As at the other locations, clay till was encountered below the native clay.

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 noted in the geotechnical files from this time period.

1989

Cracks on the pavement surface were first noted in 1989 in the west slide area (NC13) after placement of base course material during paving.

1990

Based on a site reconnaissance undertaken at the west slide (NC13), 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 Hwy 633:02 at the west site in October 1990.

The roadway was repaved twice in 1990; however, new crack and slumping reoccurred at the same location (NC13) following paving.

1991

A drilling investigation was conducted at the west site (NC13) in the spring of 1991 consisting of six test hole and the installation of three additional slope inclinometers. Previous slope indicators installed at the site had sheared off.

The rate of water flow measured from the subdrain pipe installed in 1990 at NC13 was small. In September, a total of eight vertical relief wells were drilled through the drain at the west side to provide better hydraulic connection to the underlying sand and gravel layer, creating a relatively constant flow of approximately 2.5 L/min.

The road was paved again in September and cracking reappear at the same location (NC13).

An additional nine slope inclinometers and two pneumatic piezometers were installed in November.

1992

An additional fifteen vertical relief wells were installed at NC13 in the spring and summer 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 L/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 (NC13) and east (NC44) 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.

In 1995, a drilling investigation was conducted to provide subsurface information at the east slide location (NC44). 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 measure for the sites were:

- 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 (which is above the natural ground surface south of the roadway embankment).

- All slope inclinometers located on the north side of the slide (NC13) 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 (installed in 1991).

- A failure plane was identified approximately 11 m below the shoulder of the road at the west slide area (NC13) and 12 m to 14 m below the shoulder at the east slide (NC44).

- The depth to which the drainage collection pipe could be installed at NC13 was limited by site topography. Hence, the reduction in groundwater pressure appears to have been small. No significant reduction in slope movements was measured in the inclinometers after implementation of the relief well system.

- Remedial recommendations were provided for each of the sites, including highway realignment combined with grade lowering and/or lightweight fill.

2000

Annual Geohazard site inspection visits are begun by Thurber in June. A second detailed inspection of this site, NC44, was undertaken in September.

2002

An examination of the 1200 mm diameter skew culvert during the annual site inspection visit was unable to determine if the culvert was still functional as light was no longer visible through the culvert.

A patch was applied through the area in August.

2003

At the time of the annual site inspection (May), the crack had reappeared through the 2002 patch. It was also observed that despite the absence of flow into the skew culvert, there was flow out of it. This implied that the culvert was disconnected in the highway embankment and was collecting groundwater.

In July, the asphalt surface was milled to improve ride quality.

2004

It was observed during the June site visit that the main crack pattern was essentially unchanged but that a small graben had formed in the eastbound lane. As in 2003, the skew culvert was draining more water than was flowing into from the dugout pond. Due to continued movement, and corresponding increased risk, at this location (as well as the west site, NC13), it was recommended that remediation be considered for the near future. The requirements for a geotechnical investigation were outlined. It was also recommended that the culvert be relocated to an area outside of the slide mass to prevent dugout pond overflow from entering the slide.

During the summer of 2004, a section of highway collapsed over the disconnected skew culvert. The culvert was abandoned, the highway repaired, and a new 900 mm SWSP augered just to the east.

2005

A geotechnical investigation was undertaken by Thurber in April and May. A total of five test holes were drilled at this site (an additional nine were drilled at NC13). Due to the possibility of encountering artesian groundwater conditions, vibrating wire and pneumatic piezometers were chosen as they could be installed in the grout of the associated slope inclinometer thus reducing the number of test holes required. Two standard pneumatic piezometers (sand pack and bentonite seal) were installed for comparison with the grouted piezometers. In total, five piezometers were installed: four pneumatic and one vibrating wire (PN05-4, -5, -8, and -9 and VW05-7). Three slope inclinometers (SI05-7 through -9) were installed downslope (south) of the highway. The investigation included a detailed survey of the site.

The annual site inspection was undertaken about three weeks after the drilling program was complete. It was observed that the pavement distress had increased noticeably from the prior year with the older cracks having extended and new cracks appeared. A graben was noted on the north shoulder and the south sideslope was being to have a concave appearance with a new scarp at the west end. The new SWSP culvert appeared to be performing well. It was recommended that milling and repaving be continued to maintain the roadway surface until a long-term remedial measure could be implemented.

The roadway surface was patched in October.

2006

A conceptual design report was provided to AT (addressed to Mr. Cliff Corner and dated April 4, 2006) which summarized the results of the drilling program, instrumentation monitoring, and recommended remedial measures. It was determined that the failure mechanism was rotational failure in the native clay just above the interface with the underlying clay till and facilitated by the sloping surface of this interface and that the slip plane is relatively deep with the toe about 60 m south of the highway shoulder. The groundwater levels were measured between 1.4 m and 6.5 m below ground surface. Three remedial options were provided: combination of grade lowering (about 1.5 m) and a small toe berm, a larger toe berm, or tangent pile wall with tie-back anchors.

The annual site inspection was conducted in May. The previous crack pattern had reflected through the 2005 patch and new cracks were noted beyond the east end of the patch.

5. REFERENCES

1. University and Government of Alberta, 1969. "Atlas of Alberta".

2. Ozoray, G.F. 1970. "Hydrogeological Map, Wabamun Lake, Alberta, NTS 83G". Alberta Research Council, Map 103, Report 72-8.

3. Alberta Research Council, 1971. Map No. 57. "Bedrock Topography of the Wabamun Lake Map-Area, NTS 83 G, Alberta".

4. Hamilton, M.N., Price, M.C., and Landenberg, C.W. (compilers), 1999. Geological Map of Alberta, Alberta Geological Survey, Alberta Energy and Utilities Board, Map No. 236, scale 1:1,000,000.

5. Shetsen, I. 1990. Quaternary Geology, Central Alberta. Alberta Geological Survey, Map 213.

6. Canadian Centre for Mapping, Department of Energy, Mines and Resources, 1989. NTS 1:50,000 Topographic Map, 83 G/10: Isle Lake, Alberta.

7. Alberta Transportation, Geotechnical Files.