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THURBER

# ALBERTA TRANSPORTATION
# LANDSLIDE RISK ASSESSMENT

## SECTION A: GEOTECHNICAL FILE REVIEW

### NORTH CENTRAL REGION

### SITE NC24: KEHIWIN LAKE

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|---|---|
| LEGAL LOCATION: | **NE25-58-07-W4M** |
| NEAREST LANDMARK: | **9 KM NORTH OF JCT HWYS 28 AND 41 SOUTH OF BONNYVILLE** |
| Highway Control Section: | **HWY 28:16 km 8.8** |
| Date of Initial Observation: | **1988** |
| Date of Last Inspection: | **2003** |
| Last Inspected By: | **Thurber Engineering Ltd. (Thurber)** |
| Instruments Installed: | **5 Slope Inclinometers (2002), 5 Standpipe Piezometers (2002)** |
| Instruments Operational: | **5 Slope Inclinometers, 5 Standpipe Piezometers** |
| Risk Assessment: | PF(9) · CF(4) = **36** |
| Last Updated: | July 2004 – Thurber Engineering Ltd. |

## 1. LOCATION

The site is located along Hwy 28:16 about 9 km north of the junction of Highways 28 and 41 on the east side of Kehiwin Lake. The site location is shown on Figure NC24-1, Section F.

## 2. GENERAL DESCRIPTION OF SLOPE INSTABILITY

The area of pavement distress extends over a 35 m long section of highway oriented approximately in a south to north direction. The slope failure is on the west side of the highway toward Kehiwin Lake. This section of highway was a sidehill cut/fill with a 7 m slope height at an angle of about 3H:1V. There is a terrace feature at the toe of the slope that appears to be fill placed during highway construction. The observed distress includes cracks with approximately 10 mm width and a 5 to 10 mm differential across the crack. A culvert located 25 m south of the extent of pavement cracking has a 6 m long and 35 mm wide crack at the top of the outlet (in the side slope).

The site has had history of instability going back to 1988 when initially slumping was observed on the sideslope though the highway was not affected at that time. In 1988, a backhoe and auger rig soils investigation was undertaken to assess this site and two other sites located less than 2 km to the north. At that time, the instability at all three areas was related to wave action eroding the toe of the slopes. Repairs at this site have been limited to subgrade excavation and replacement in 1992 and overlaying in 2000. A large slide to the north was treated with a subdrain on the upslope side and the slide mass was stabilized with lime columns prior to repairing the surface of the highway.

Several slope inclinometers (SI) and standpipe piezometers (SP) have been installed at the site to monitor ground movements and groundwater levels. The locations of the instruments are shown on NC24-1, Section F, and the test hole logs from both 2002 and 1988 are included in Section G. All 5 SI's and 5 standpipe piezometers are still functional and the latest readings for these are provided in Sections C and D.

Cross-sections of the site, Figures NC24-2 and -3, Section F, show the stratigraphy of the site, slope inclinometer shear zones, and the inferred slip surface. The slide appears to be the result of a combination of weak reworked clay shale strata between 5 and 15 m below ground level, high ground water table (1.1 m to 4.2 m below ground), and possibly aggravated by erosion of the toe of the slope by the lake. The slide was creeping at a rate of 7 to 10 mm/year in the early part of 2003 and increased to 11 to 25 mm/year in the later part of the year. The toe of the slide appears to be below the lake level so movement will be effected by changes in the lake level as well as changes in the groundwater level.

## 3. GEOLOGICAL/GEOTECHNICAL CONDITIONS

**Physiographic Region:** East Alberta Plains (1969, Atlas of Alberta, University and Government of Alberta).

**Bedrock Geology:** The bedrock at the site is marine dark grey shale and light grey, glauconitic silty shale with ironstone concretions of the Cretaceous Lea Park Formation and Upper Colorado Group. The bedrock in the uplands area is approximately 40 m below ground level with a south-westerly slope toward the meltwater channel running southeast to the North Saskatchewan River. To the southwest of the site on the other side of the valley, the bedrock consists of the Wapiti Formation (sandstone, mudstone, and bentonite).

**Surficial Geology:** The site is located in a stream and slopewash eroded deposit as part of a meltwater channel tributary (leading to the North Saskatchewan River) through morainal area. Surficial soils are expected to consist of exposed clay till and bedrock covered with slump material. The topography is rolling with local relief limited to 3 to 9 m.

**Hydrogeology:** Upper bedrock formations may be able to provide up to 0.1 L/s of groundwater flow; however, in most of the township, the surficial drift formations close to Kehiwin Lake may be able to provide up to 2 L/s with about 0.4 L/s in the higher terrain away from the lake. Groundwater flow directions are downward on the upland areas and upward along the valley slope at approximately elevation of 564 m at the site.

**Stratigraphy:**

Two stratigraphic cross-sections from the AT files have been included as Figures NC24-2 and -3, Section F. The logs of the test holes drilled at these sections (local Stations 0+458 and 0+644) are included in Section G. At Station 0+458, the test holes indicate clay till over clay underlain by shale with the water table sloping from 3.7 m on the right (east) to 4.6 m depth on the left (west). Two test holes were drilled at 0+644 where clay till over clay underlain by shale was encountered. Sand and gravel layers were observed only on the west side of the highway.

Based on test holes drilled by Thurber in 2002 for instrumentation installation, the soils at the site are clay fill over native clay over reworked clay shale and undisturbed clay shale.

## 4. CHRONOLOGY

**1988**

An auger rig investigation was performed at this site and at two unstable areas less than 2 km to the north. There was free water at 3.0 to 4.5 m below ground level on either side of the highway in two test holes at the site in question. The movement was determined to be from water flow through the embankment and the recommendation was to install a subsurface drain in the upslope ditch. A site further to the north was stabilized using lime columns and a subsurface drain.

**1993**

Based on conversations, in 2003, with AT's Maintenance Contract Inspector (MCI), Mr. Ralph Gilbertson, the subgrade at the location of current (2003) distress was excavated to repair cracking.

**2000**

Road surface was overlaid.

**2001**

Cracking reappeared in same pattern observed previously.

**2002**

Thurber carried out a geotechnical site investigation of the slide area at which time cracking with differential settlement was observed. Trees near the shore at the toe of the slope were also leaning away from the lake though this may be due to the prevailing wind. It was recommended at this time that consideration be given to repairing the site in the near future to avoid more expensive repairs over the long-term. In order to better understand the potential failure mechanisms at the site, several slope indicators and standpipe piezometers were installed in September.

**2003**

During the yearly inspection carried out by Thurber, a second set of cracks were observed about 65 m to the of the original area of distress north which are believed to be part of the same slide block. A preliminary design report presented the results of the initial monitoring of the instrumentation and several remediation alternatives including installing a pile retaining wall, relocating the highway to the east to offload the slope, lowering the highway, or constructing an earth berm.

## REFERENCES

1. Thurber Engineering Ltd., November 18, 2003. "Hwy 28:16 Kehiwin Lake – Preliminary Engineering Report."

2. Thurber Engineering Ltd., July 19, 2002. "Hwy 28:16 Embankment Side Slope Instability – Kehiwin Lake, Near Bonnyville, Alberta." (Emergency Call Out)

3. Alberta Research Council, 1990. "Quaternary Geology, Central Alberta."

4. Alberta Transportation and Utilities, April 12, 1988. Memorandum: "Hwy 28:16 – Jct. Hwy 41 to Jct. Hwy 28A."

5. Alberta Research Council, 1979. "Surficial Geology, Muriel Lake, Alberta (73 L/2)."

6. Alberta Research Council, 1978. "Hydrogeological Map, Sand River, Alberta (NTS 73O)."

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