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THURBER

ALBERTA TRANSPORTATION
LANDSLIDE RISK ASSESSMENT

SECTION A: GEOTECHNICAL FILE REVIEW

PEACE REGION
(SWAN HILLS)

SITE SH6: KLUMPH CREEK SLIDE

LEGAL LOCATION:	**SW34-70-9-W5M**
NEAREST LANDMARK:	**48 KM NORTH OF SWAN HILLS**
Highway Control Section:	**HWY 33:14 km 18.2 to km 18.8**
Date of Initial Observation:	**1977**
Date of Last Inspection:	**2004**
Last Inspected By:	**Thurber Engineering Ltd. (Thurber)**
Instruments Installed:	**22 Slope Inclinometers (6 in 1994, 7 in 1999, 9 in 2000), 9 Standpipe Piezometers (2000)**
Instruments Operational:	**5 Slope Inclinometers (2004), 5 Standpipe Piezometers (2004)**
Risk Assessment:	PF(9) · CF(3) = **27**
Last Updated:	July 2004 – Thurber Engineering Ltd.

1. LOCATION

The site is located on Highway 33:14 approximately 48 km north the Town of Swan Hills (Figure 1.1, Section G).

2. GENERAL DESCRIPTION OF SLOPE INSTABILITY

The site is at a location where the highway climbs the Swan River valley slope on a fill section of varying heights. At the north part of the site, the embankment is between 4 to 6 m high with 3H:1V sideslopes. At the south part of the site, where two culverts are located, the embankment is approximately 8 to 10 m height with sideslopes of 3.5 to 4H:1V. The main culvert (north one) is 1200 mm diameter while the overflow (south one) is 900 mm diameter. The culverts are about 6 m apart and are located where the highway crosses Klumph Creek.

The distress at this site had been affecting a 500 m-long portion of the highway. Originally, the distress observed at the north end of the site was a series of transverse cracks on the highway. These cracks required yearly maintenance (patching). At the south end, surface distortions of the highway required routine maintenance though not as frequently as the transverse cracks. Active erosion at the culvert outlets had caused the lower part of the embankment slope to fail separating the 1200 mm culvert about 9.5 m back from the outlet.

Later, based on aerial photography review and site reconnaissance, it was apparent that one large landslide was causing the transverse cracking on the north end and the distress near the culverts on the south end of the slide. The overall slide mass was about 57 m high and had a maximum width of about 700 m. The overall slope of the slide mass was about 7° to 8° with a steep section up to 15 m high and close to 40° at the toe. Portions of the backscarp had vertical displacements between 3 to 8 m with the greatest displacements towards the south end. It is likely that this scarp predates the highway. Ponded water was observed on part of the slide block.

The slip surface of the slide appeared to be located mainly in the weathered bedrock or in the bottom of the clay till near the shale bedrock contract. The shallow slope angle of the slide area suggested that movements must have been occurring along a very weak slip plane where soil and bedrock shear strength were at or approaching the residual values. While the slide appeared to be moving generally as a unit, there were indications that some portions were creeping faster than others. The middle portion was moving about 13 to 15 mm per year while the outer portions were moving about 5 mm per year. The presence of intermediate scarps in the slide mass suggested that continual movement of the lower slide would eventually reduce the stability of the upper slide causing retrogressive failure. It was suspected that the slide may have been originally triggered by toe erosion resulting from historic flood events of the Swan River.

The first investigation at the site was done by J.R. Paine & Associates Ltd. (J.R. Paine) in 1994. Thurber performed a geotechnical review in 1997 and GAEA Engineering Ltd. (GAEA) performed a second assessment in 1998 with supplementary work in 2000. Later in 2000, Thurber provided preliminary design report for remediation options. Construction to repair the slide was done in 2001 consisting of slope offloading and a large toe berm.

Since the remedial repairs in 2001, the movement observed in the slope inclinometers (SI) has been fairly limited with a current maximum rate of movement of 9.6 mm/year in SI21. Some of the SIs showed no discernable movement during the Spring 2004 monitoring event. No new cracks have appeared at the site though older cracks are still visible. As of Spring 2004, the groundwater level had risen in the standpipes 0.3 m compared to Fall 2003; however, this may be a seasonal fluctuation as a similar behaviour was observed in Spring 2002. Copies of the routine monitoring inspections including slope indicator and piezometer plots are included in Sections C and D.

3. GEOLOGICAL/GEOTECHNICAL CONDITIONS

Physiographic Region: Swan Hills Upland (1969, Atlas of Alberta, University and Government of Alberta).

Bedrock Geology: The bedrock at the site is nonmarine grey feldspathic clayey sandstone, bentonitic mudstone, and bentonite, with scattered coal beds of the Wapiti Formation. Depth to bedrock is likely greater than 15 m.

Surficial Geology: No information available.

Hydrogeology: The bedrock at this site may be capable of providing groundwater flow up to 2 L/s though immediately to the west, the sands and gravels of the Swan River valley may be capable of up to 8 L/s. Near-surface groundwater flow is interpreted to be downward at this location with horizontal flow toward the Swan River to the west and ultimately to Lesser Slave Lake to the north. A flowing well was reported to the north of the site within the same Section. Some groundwater seepage was observed in the slide mass at the site.

Stratigraphy: Geotechnical investigations were conducted at the site by J.R. Paine (1994), GAEA (1998 and 1999), and Thurber (2000). Based on Thurber's August 2000 report and GAEA's test pits, the main soil units encountered at the site, in descending order, were clay fill, clay till, gravel, and bedrock (clay shale, siltstone, and sandstone). The fill material was up to 6.7 m thick and was underlain by the original sod line which, in some cases, contained trees and stumps. At some locations the sandy clay till contained rafted bedrock. The gravel was likely of medium to coarse consistency but no samples were obtained due to rotary drilling methods. The bedrock was interbedded and the sequence of units appeared to be fairly consistent. J.R. Paine's test hole logs show only clay shale bedrock up to 31.7 m below ground. The test hole logs with site plans for all investigations are included in Section G.

4. CHRONOLOGY

1977

Highway was constructed. Slope movements began and the downstream portions of the culverts were replaced following localized embankment failures.

1988

The site was inspected by AT in October after a 35 m-long slide damaged both culvert outlets. The resulting sinkhole from the unrestrained flow was about 1.0 m deep. Three alternatives were recommended:

- replace both culverts with a 1520 mm diameter culvert and reshape the bank,
- excavate and replace the failed sections and lower the upstream creek bed (this alternative was implemented), or
- abandoned the overflow culvert, retrofit a 900 mm polyethylene inside the main culvert and reshape the bank though reduced capacity will pond water upstream of the culvert.

1994

J.R. Paine installed six SIs at the site in September as part of a series of investigations done on Hwy 33:12 & 33:14.

1997

A brief geotechnical assessment was carried out by Thurber which concluded that the pavement distress at the transverse cracks and culverts were caused by a single large landslide.

1998

A geotechnical investigation was performed by GAEA. The GAEA report included test holes from the 13 slope indicators installed at the site and the test pits excavated along the highway and are attached in Section G with corresponding site plans.

2000

A supplementary investigation was done by GAEA in which they suggested two potential remedial options:

- implementation of drainage measures in the ditch and sideslope along the uphill side of the highway; or
- excavation of material from the uphill side of the slide and re-placement of the material as a toe berm at the base of the slope.

Subsequently, Thurber was retained in March to re-asses the proposed remedial options and to identify any additional alternatives that should be considered. Part of the investigation included additional test hole drilling and slope indicator installations to assist with establishing the extent of the slide area and the rate of movement. Thurber reviewed previous geotechnical information and existing slope indicator data, studied the available air photos, and undertook a site reconnaissance. A digital contour map was prepared from aerial photography and field-proofed by global positioning surveying (GPS). Additional surveying was done for cross-sections and general site features. Test holes (12) were drilled in March and the logs and site plan are included in Section G. A total of three SIs and nine standpipe piezometers were installed in the test holes.

The alternatives considered, with estimated costs, were:

- do nothing except surface drainage improvements and culvert repairs and continue with routine asphalt patching maintenance measures ($120,000 and annual patching costs),
- excavate above the highway (unload slope) and use the material to construct a toe berm for $2,255,000,
- lower the highway alignment through the slide area,
- lower the water table with a subdrain in the upslope ditch, and
- realign the highway to the east above the slide area for $3,000,000.

The cost of lowering the highway was not considered to be worth the marginal stability increase and using a subdrain was not recommended due to the relatively low permeability of the soils at the site and the risk of failure during the installation. Ultimately, the slope unloading and toe berm option was selected for implementation.

2001

The main remedial construction was accomplished between January and March with rock weir construction (extra work) and landscaping done between May and August. The Contractor was North American Rock and Dirt Inc. of Prince Albert, Saskatchewan. Supervision and quality control field testing were done by Thurber. A majority of the work was done with winter construction to improve the soft and wet conditions at the toe area though care was required to prevent freezing of soils before compaction. The total construction cost was $2,044,251. A brief summary of the work is as follows:

- site preparation consisting of brush clearing and topsoil and subsoil stripping and stockpiling,
- slope off-loading and toe berm construction,
- placing a sand drainage blanket at the existing toe,
- repair the culvert outlets, place riprap over non-woven geotextile at the inlets and outlets, install synthetic porous ditch checks for erosion control in the eastern ditch, and create an additional prepared channel to collect groundwater from a spring,
- replace subsoil and topsoil on site,
- install rock weir ditch checks in catchwater ditch at toe of berm, and
- landscaping consisting of seeding, fertilizing, harrowing, and planting trees.

As-built construction drawings are included in Section G.

REFERENCES

1. Thurber Engineering Ltd., October 4, 2001. "Project Summary Report, Klumph Creek Area Slide Repair, 45 km North of Swan Hills, Highway 33:14, km 18.2 to km 18.8, Contract 6302/00, Peace Region." File 15-76-9.

2. Thurber Engineering Ltd., August 18, 2000. "Highway 33:14 Klumph Creek Slide Area Slope Stability Assessment." File 15-76-9.

3. GAEA Engineering Ltd., February 2000. "Supplementary Engineering Reports: Hwy 33:14 – Klumph Creek & Hwy 33:14 Island Creek Slide Areas." (Reviewed in Thurber's August 2000 report.)

4. GAEA Engineering Ltd., March 1999. "Geotechnical Investigation Report: Hwy 33:14 – Klumph Creek and Transverse Crack Slide Areas (46 kiometers North of Town of Swan Hills)." (Reviewed in Thurber's August 2000 report.)

5. J.R. Paine & Associates Ltd., September 29, 1994. "Slope Indicator Installation – Highway 33, Control Sections 12 & 14 – Near Swan Hill, Alberta."

6. Alberta Transportation & Utilities, Internal Memorandum, November 8, 1988. "Hwy 33:14 – Embankment Sidelsope Failure and Culvert Collapse – Klumph Creek Culvert Crossing – Imp. Sta. 1658+50."

7. Alberta Research Council, 1978. "Hydrogeological Map, Lesser Slave Lake, Alberta (83-O)."

8. Alberta Research Council, 1976. "Bedrock Topography of the Lesser Slave Lake Map Area, NTS 83 O, Alberta."

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