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THURBER

ALBERTA TRANSPORTATION
LANDSLIDE RISK ASSESSMENT

SECTION A: GEOTECHNICAL FILE REVIEW

PEACE REGION
(SWAN HILLS)

SITE SH10,11,12,13: LITTLE SMOKY RIVER VALLEY CROSSING

LEGAL LOCATION:	**NE18-, S19-, 20-, 21-, & SE28-76-22-W5M**
NEAREST LANDMARK:	**12.2 TO 19.3 KM SOUTH OF JCT HWY 49 & 744**
Highway Control Section:	**HWY 744:02 km 14.55 to 21.65** **(Details on attached table)**
Date of Initial Observation:	**1966**
Date of Last Inspection:	**2003**
Last Inspected By:	**Thurber Engineering Ltd. (Thurber)**
Instruments Installed:	**Details on attached table**
Instruments Operational:	**Details on attached table**
Risk Assessment:	**Details on attached table**

SITE	LOCATION	LENGTH OF AFFECTED ROAD	AT RISK ASSESSMENT			INSTRUMENTS INSTALLED	INSTRUMENTS OPERATIONAL
			PF	CF	RA		
#1 (SH10)	km 14.55	100 m	13	5	65	2002: 5 SI, 4 SP	2004: 2 SI, 3 SP
#1a (SH10)	km 14.6	20m	6	4	24		
#1b (SH10)	km 14.7		9	2	18		
#2 (SH10)	km 15.9	80 m	3	4	12		
#3 (SH11)	km 18.2 to 18.4	200 m	8	3	24		
#4 (SH11)	km 18.7 to 18.8	100 m	5	3	15		
#5 (SH11)	km 19.0	50 m	5	3	15		
#6 (SH11)	km 19.1 to 19.3	300 m	5	3	15		
#7 (SH12)	km 19.55	40 m	10	5	50		
#8 (SH12)	km 19.6 to 19.65	50 m	10	4	40		
#9 (SH12)	km 19.7 to 19.9	200 m	10	4	40		
#10 (SH12)	km 20.2 to 20.25	50 m	9	3	27		
#11 (SH13)	km 20.4 to 20.65	250 m	12	5	60	2000: 1 SI, 1 SP 2002: 1 SI, 1 PZ, 4 SP	2004: 1 SI, 1 PZ, 4 SP
#12 (SH13)	km 20.8 to 20.9	100 m	10	4	40		
#12a (SH13)	km 21.2	10 m	13	4	52		
#12b (SH13)	km 21.0	20 m	9	4	36		
#13 (SH13)	km 21.45	50 m			n/a		
#14 (SH13)	km 21.45 to 21.65	400 m			n/a		

Notes: Bridge location = km 17.0 to 17.1 SI = slope inclinometer PZ = pneumatic piezometer SP = standpipe piezometer

1. LOCATION

The site is located where Highway 744:02 crosses the Little Smoky River and surrounding valley. The site and individual distress locations (18 total) are shown on Drawing 15-76-18-1 of Thurber's September 20, 2000 report included in the site binder.

2. GENERAL DESCRIPTION OF SLOPE INSTABILITY

The present alignment of SH744:02 crosses through the Little Smoky River valley for an approximate distance of 7.4 km comprised of 2.7 km on the South Hill Section and about 4.7 km on the North Hill Section. The North Hill Section crosses the north slope of the valley for about 2 km and then follows the valley of a tributary (Peavine Creek) to the Little Smoky River for the remainder of the ascent to the uplands area. Based on contour plans, the Little Smoky River valley is about 125 m (400 feet) deep with crest and toe elevations of about 550 m and 425 m, respectively. The highway approaches are side hill construction with typical cut slopes inclined at 20° to 30° (2.7 to 1.7H:1V) on the upslope side and embankment fills ranging from 2 to 8 m in height at 3H:1V. However, in some locations the embankment fills are as much as 20 m. The highway crosses the Little Smoky River on the flat flood plain.

A review of aerial photography in 2000 identified progressive landslide activity affecting the valley walls of the Little Smoky River and adjoining tributaries. The contours and directions of movement of the major slides are identified on Drawing 15-76-18-2 of the September 2000 report. In the past, north-facing slopes have been subjected to large slides but no longer appear active while the south-facing slopes are more active. Valley slope instability is a continuing process in this area.

Sites #1, #1a, #1b, and #2 (SH10) are located on the south hill and the remainder of the sites, #3 to #14 (SH11 to SH13) are located on the north hill. Both highway approaches to the bridge over the Little Smoky River are constructed on the valley side slope. Sites #13 and #14 are severe erosion problems rather than slope movement. Specific site descriptions are given below.

- **Site #1:** The slide has caused cracking and distortion of the paved road surface. There is evidence of instability in the high backslope cuts above and to the north as shown by squeezing of slumped material into the upslope ditch. The site worsened significantly between 2002 and 2003.
- **Site #2:** The slide has been active resulting in the failure of the downslope side of the highway in Spring 2000 but was successfully, so far, repaired in 2001.
- **Site #3:** The pavement has become deformed into a wavy surface from slope movements.

- **Sites #4, #5, #6:** The pavement surface is uneven with cracks parallel to the centreline. There are marshy areas with ponded water on the upslope side of the highway at Sites #5 and #6.
- **Site #7:** The backscarp of a deep-seated slide crosses the highway resulting in an abrupt drop in the road surface.
- **Site #8, #9, #10, and #11:** These sites are located on the same slide block. Cracks cross the highway at Site #8 and follow the upslope shoulder area crossing back across the highway at Site #9. At Site #10 there are a few cracks parallel to the centerline of the road and an uneven section of pavement. At Site #11, the backscarp of the deep-seated slide crosses the highway and follows the shoulder area before dropping off into the downslope bush area. This has resulted in a sudden drop along the road surface and a 2-3 m high scarp along the downslope shoulder. Ongoing movements have disturbed the asphalt and the road is being maintained as a gravel surface at this location.
- **Site #12, #12a, and #12b:** The highway was rebuilt in this area with pitrun gravel after past instability. There are signs of potential cracking in the downslope of the embankment fill. It is possible that these are more localized slumps related to overly steep side hill embankment fills.
- **Site #13:** The highway embankment crosses a 1 m-diameter CSP whose outflow is directed into a corrugated CSP surface culvert to discharge water further down the slope. Water flow has been eroding the slope below the culvert to form a deep gully into the natural slope beyond the outlet.
- **Site #14:** A deep erosion gully, up to 30 m deep, has formed over a distance of about 500 m from the end of the highway ditch to the Peavine Creek. This gully parallels the highway for about 400 m approximately 65 to 80 m away.

Instrumentation has been installed at a few of the sites. At **Site #1**, five slope inclinometeres (SI) and 4 standpipe piezometers (SP) were installed in 2002. A maximum rate of movement of 90 mm/year was observed in 2002 which slowed to 40 mm/year in 2003. Three of the SIs have sheared off between 5.5 and 7.9 m below ground level. The movement is occurring at 5 m to 9 m below highway surface. At **Site #11**, one SI, one pneumatic piezometer (PZ), and four SPs in 1999 by AGRA and one SI and one SP were installed in 2001 by Thurber.

3. GEOLOGICAL/GEOTECHNICAL CONDITIONS

Physiographic Region: Peace River Lowland (1969, Atlas of Alberta, University and Government of Alberta).

Bedrock Geology: The bedrock at the site, in descending order, consists of the Upper Cretaceous Puswaskau, Bad Heart, and Kaskapau Formations. These bedrocks are mostly composed of shale, sandstone, and mudstone.

Surficial Geology: The surficial geology, as described by E.P. Henderson, 1959, consists of silt deposited in preglacial lakes. The silts can be up to 5 m thick in some areas. However, the actual thickness of these deposits is not known in the area of interest along the highway. On the uplands north and south of the Little Smoky River valley, deposits of silts are found with the appearance of remnants of frost polygons over large areas. The flood plain contains coarse-grained to medium-grained alluvium. The river valley walls consist of colluvium formed from erosion and landsliding of bedrock and surficial sediments.

Hydrogeology: At this site, the shallower bedrocks are only capable of up to 0.1 L/s groundwater flow while the underlying sandstones of the Dunvegan Formation may be capable of providing up to 0.4 L/s. Groundwater flow at this location in the bedrock is horizontal toward the Smoky River valley to the north while near-surface flow is interpreted, as evidenced by the visible seepage, to be toward the Little Smoky River valley.

Stratigraphy: Clay till was noted in the exposure of the outside bank of the river at the meander to the west of the bridge possibly indicating that most of the valley has been carved down through clay and till with bedrock located at or below the present river level. Minimal stratigraphic information is available for the sites as few intrusive investigations have been done.

> **Site #1:** A drilling investigation was done by Thurber in 2001. The general stratigraphy was clay fill over clay over clay till. The clay till ranged in depth from 3.2 m to 10.5 m below ground surface. The test hole logs are included in the binder.
>
> **Site #2:** Test pits done by Thurber at about mid-height of the South Hill Section, indicate high plastic clay on the upslope side of the highway fill and clay till on the bench area downslope of the highway fill. A test pit in the slide area revealed that the embankment was constructed mainly of medium to high plastic clay fill at this location.
>
> **Site #11:** Test holes drilled by AGRA indicate the presence of medium to high plastic clay fill layers over at least 40 m of medium to high plastic clay till. Wet sand and gravel seams were noted below 30 m depth in one hole and slickenslides were noted between 32 and 42 m in two test holes.

4. CHRONOLOGY

The history of this site was taken from Thurber's files and conversations with AT and MD personnel documented therein and from a review of AT files for the control section.

1963

The highway was first constructed with granular surface.

1966

The section of highway around **Site #2** was moved upslope due to slide activity.

1974

The section of highway at **Site #1** was moved upslope due to slide activity. The section of highway southwest of the bridge was partly paved.

1980

The section of highway northeast of the river was paved.

1983

The highway southwest of the river was realigned.

1984

The section of highway southwest was based.

1986

An overlay was done on the northeast part section of the highway. In September, AT personnel inspected several sections left out of the overlay contract due to subgrade slippage between Sta. 19+710 to 20+070 and 20+630 to 20+840. Four test holes drilled in October between Sta. 19+855 and 20+773 (present-day **Sites #9 to #11**) identified groundwater seepage from the backslope as the cause of the instability. The soil profile encountered was silty or sandy clay over clay.

1987

In July, AT inspected three areas of distress between km 18 and 20. It was concluded that the failures resulted from poor subgrade and poor drainage. A test pit investigation was conducted in August in the uphill ditch to find the locations of significant seepage. A total of 15 test pits were dug. Another inspection was carried out in October which identified several sections needing reconstruction (by Sta.): 19+100 to 19+200 (**Site #6**), 19+700 to 19+900 (**#9**), 20+000 to 20+060, and 20+460 to 20+820 (**#11**).

1988

The southwest section was paved. In May, AT conducted another investigation of three subgrade slippage areas between km 18 and 21. The recommended repair was to install a subdrain about 6 m deep in the upslope ditch for the entire section. to save costs it was decided to construct the trench in two segments each with its own outlet. The subdrains were installed in July from Sta. 20+600 to 20+860 and from Sta. 19+600 to 20+300. Significant problems with slumping and seepage were encountered in some sections. From Sta 20+215 to 20+300 and 20+760 to 20+860, the subdrain was installed without the liner as the trench would not stay open long enough to place it. After installation, the subdrain starting at Sta. 20+600 was flowing at 350 mL/5 min. The cost of this work was estimated to be $135,000.

1995

Cracking began to appear at **Site #2**.

The distresses in the North Hill Section became more obvious though movement had been occurring for sometime. Slope movement began to encroach on the 1 m diameter culvert at **Site #13**.

1996

Major movement at **Sites #1 and #2** occurred. Cracking had begun to appear in the late 1980's. **Site #2** was repaired by replacing the slumped soil with compacted fill and installing a gravel drain through the slide zone. Patching was still required once or twice per year up to 1999. The slide at **Site #11,** the worst in the North Hill Section, reached the highway surface after cracking had begun in the early 1990's. Gravel was placed regularly to maintain the road surface.

1997

GAEA investigated **Site #13** and designed remedial measures consisting of slope reconstruction including a gabion wall at the toe of the slope and a surface culvert pipe direct water from the culvert outlet part way down the slope.

1999

AGRA performed a geotechnical investigation at **Site #11** and installed one slope inclinometer, one pneumatic piezometer, and four standpipe piezometers. Test hole logs and instrumentation installation details are provided in the Site #11 section of the binder.

The highway was converted to gravel through **Site #2**.

2000

Remedial measures were carried out at **Site #11** by AGRA (AMEC) consisting of the installation of a granular drainage blanket and subdrain pipe. Details of the repairs are presented on the design drawings in the Site #11 section of the binder. The subdrain was trenched along the southeast side of the highway to drain into the bush at **Site #10**. A slope inclinometer and standpipe piezometer were installed at **Site #11** in April and monitored to assess the effectiveness of planned remediation.

Site #2 started moving daily in July and gravel has been used to maintain the road surface since that time. Later in July, an emergency call-out inspection for **Site #2** was done by Thurber at which time three test pits were excavated. Recommended short-term actions were to inspect the site daily and maintain the gravel surface as necessary. The proposed long-term solution was to construct a toe berm and install gravel drains through the slide area.

Thurber was retained to prepare a compilation of the slides and erosion conditions in this section of Highway 744:02 which was reported in September. At that time, it was recognized that the Little Smoky River was still actively downcutting a valley in weak clay deposits and that the valley slopes have been subjected to large-scale movement as they try to achieve a stable angle. The South Hill Section was only being affected in two localized locations (**Sites #1 and #2**). It was recommended that the current alignment for the South Hill Section be maintained and the slides repaired.

The North Hill Section was in an area of relatively deep-seated active landsliding affecting most of the highway. Reduced speed and slide area warning signs were in place. The recommended repair was to realign the highway straight up the valley slope from the bridge crossing reducing the length of highway in landslide terrain and eliminating sidehill construction. A preliminary cost estimate of the ongoing maintenance of this section determined that in 10 years half of the cost of realignment would be spent without having corrected the problem. This report is included in the beginning of the binder and the appendices to it contain preliminary grade realignment options and tables summarizing potential short- and long-term remedial alternatives.

In fall, AT performed several maintenance operations at two of the sites: at **Site #1,** asphalt patching, ditch clearing, and removal of slumped material; and at **Site #11**, drainage blanket installation below the toe of the embankment fill slope. In addition, some asphalt patching, bush clearing, ditch cleaning, and removal of slumped backslope material was done.

2001

In April, Thurber installed 1 SI and 2 SP's at **Site #11**. The annual landslide assessment was carried out by Thurber in early June. It was recommended that instrumentation be installed at **Site #1** to properly develop suitable remediation options. Later in June, the North Hill Section received an asphalt overlay as part of a previously scheduled maintenance program.

A new slide, **Site #12a**, occurred in the recent overlay about 200 m north Site #12. The slide reappeared through the initial repairs. A shallow slump also occurred in the downslope side of the embankment at **Site #13**.

Remedial works were carried out for **Site #2** in the fall of 2001 consisting of a subdrain below the upslope ditch, four French drains through the slide area, fill placement to create slope flattening to 5H:1V, and rebuilding the pavement structure. As-constructed drawings and photographs are included in the Site #2 section of the binder.

2002

Some asphalt patching was done at **Site #1** in early spring.

Thurber conducted the annual landslide assessment inspection in June. It was noted that the distress at **Site #1** was worsening and the instrumentation had a high rate of movement. It was recommended that remedial measures be undertaken at this site in the following year. **Site #2** appeared to have stabilized following the remediation done in Fall 2001. The recent overlay had improved surface quality though it was anticipated that ongoing movement would eventually affect the highway again in the future. It was recommended that routine inspections of the sites be done and consideration be given to realignment of the highway.

The slumps at **Site #12a** and **#13** were repaired in July. **Site #12a** was subexcavated, the culvert extended, a subdrain installed, the slope reconstructed with pit run gravel to 2H:1V, and a 2 m high toe berm built and the slideslopes extended to 3H:1V. At **Site #13**, the slump was subexcavated, a subdrain installed in a wet area, and reconstructed with imported drier clay. In August, five SIs and 4 SPs were installed at **Site #1**. Soil samples were also recovered for laboratory analysis. The logs from this investigation are included in the appendices of the Site #1 section of the binder.

2003

In July, Thurber conducted the annual landslide assessment inspection. At that time it was observed that **Site #1** continues to be worsening and the cracks had become more severe. It was recommended that this site be remediated the next year. **Site #2** was still stable. The 2001 overlay on the North Hill Section improved the overall highway condition but ongoing movements have lead to cracks reappearing in the surface. It was anticipated that movements would progressively get worse leading to increased maintenance. It was recommended that the MCI carry out regular inspections to promptly identify any changes and that ditch erosion in several locations be repaired soon.

REFERENCES

1. Thurber Engineering Ltd., July 21, 2003. "Peace River (Swan Hills) Region Landslide Assessment Hwy 744:02 Slides (SH10, 11, 12, and 13) – 2003 Annual Inspection Report." File 15-16-166.

2. Thurber Engineering Ltd., January 8, 2003. "Peace River (Swan Hills) Region Landslide Assessment SH744:02 Slides (SH10, 11, 12, and 13) – 2002 Annual Inspection Report." File 15-16-166.

3. Thurber Engineering Ltd., September 3, 2002. "SH744:02 – Site 1 (SH10) Slope Indicator and Piezometer Installations." File 15-16-153.

4. Thurber Engineering Ltd., January 18, 2002. "Peace River (Swan Hills) Region Landslide Assessment SH744:02 Slides (SH10, 11, 12, and 13) – 2001 Annual Inspection Report." File 15-76-13.

5. Thurber Engineering Ltd., September 25, 2000. "SH 744:02 Little Smoky River Valley Crossing – Geotechnical Investigation." File 15-76-18.

6. AGRA Earth & Environmental Ltd., July 2000. Site #11 remedial design drawings and test hole logs prepared for M.D. of Smoky River No. 30.

7. Alberta Transportation and Utilities, August 30, 1988. Internal Memorandum: "Secondary Road 744:02."

8. Alberta Transportation and Utilities, October 14, 1987. Internal Memorandum: "SR744:02 – Jct Hwy 49 to Little Smoky River: Reconstruction of pavement surface in four small slide areas between km 19 and km 21."

9. Alberta Transportation and Utilities, July 27, 1987. "Note to File: Field Inspection."

10. Alberta Transportation and Utilities, (undated). "Note to File: Field Inspections – Subgrade Slippage Areas SR744:02 – NE of Little Smoky km 18 to km 21."

11. Alberta Research Council, 1980. "Earth Sciences Report 79-3, Hydrogeology of the Winagami area, Alberta." Included "Hydrogeological Map, Winagami, Alberta, 83 N."

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