ALBERTA TRANSPORTATION AND ECONOMIC CORRIDORS
GEOHAZARD ASSESSMENT PROGRAM
NORTH CENTRAL REGION – ATHABASCA & FORT MCMURRAY DISTRICTS
2023 SITE INSPECTION

THURBER ENGINEERING LTD.

Site Number	Location	Name	Hwy	km
NC071	1 km east of Colinton	Little Pine Creek Slide	663:04	6.98
Legal Description		**UTM Co-ordinates (NAD 83)**		
S.E.15&S.W.14& N.E.10-65-22-W4M		12 N 6054582 E 355785		

	Date	PF	CF	Total
Previous Inspection:	June 06, 2022	11	5	55 (For highway)
Current Inspection:	May 16, 2023	11	5	55 (For highway)
Road WAADT:	640		**Year:**	2022
Inspected By:	José Pineda, Tarek Abdelaziz (Thurber) Arthur Kavulok, Amy Driessen, Kristen Tappenden (TEC)			
Report Attachments:	☑ Photographs ☐ Plans ☐ Maintenance Items			

Primary Site Issue:	Slowly creeping deep-seated translational landslide, resulting in diagonal cracks and slight depression along both highway lanes; depression is more pronounced along the flanks of the slide.	
Dimensions:	Approximately 150 m wide (parallel to highway) by approximately 300 m long to the south of the highway.	
Site history:	The highway was constructed as a side-hill cut and fill section at this location; the road section was upgraded in the 70's and raised by 2 m; original landslide occurred prior to 1978 and extended from the uphill ditch of the highway to the existing bridge over the Little Pine Creek located approximately 300 m to the south of the highway; test holes (completed with 2 slope inclinometers and 3 standpipe piezometers) were drilled downslope of the highway prior to 1978; Drainage pipes were installed on May 12, 1980 to reduce ground water levels; slope inclinometers were sheared off in December 1980; slope inclinometers and piezometers were installed by Thurber in 2012.	
Maintenance:	TEC placed ACP patches at the flanks of the slide for a few years prior to 2019. In 2019 the highway surface was milled, and overlaid; re-grading of the north ditch, and the installation of a HTCB on the south side of the highway also took place in 2019; Culvert C3 was grouted by others and a new 760 mm diameter replacement pipe was auger bored 26.2 m from the original location. A 9 m long half pipe was welded to the culvert C3 outlet to convey the water down the side slope to the tree line. Riprap was provided around and at the outlet of the half pipe extension.	
Observations:	**Description**	**Worse?**
☑ Pavement Distress	A bit of twist on the highway surface near the flanks of the landslide; 10 mm dip on the eastbound lane by the eastern flank of the landslide; 50 mm dip on the highway WBL shoulder and driving lane upslope of the inlet of the C3 culvert	☐

☑ Slope Movement	Western flank crack is showing reflective cracks 10 to 20 mm wide; 20 to 30 mm wide cracks within the middle section of the landslide; eastern flank cracks are 20 to 25 mm wide with no drop.	☐
☑ Erosion	Erosion gully (18 m long x 1 m wide x 0.5 m deep) developed within the north ditch upstream of culvert C3; erosion rills along the highway side slope to the west of the access road; sink hole (800 mm long x 500 mm wide x 600 mm deep) to the west of C3 inlet location.	☐
☐ Seepage		☐
☑ Bridge/Culvert Distress	A void was noted under the half pipe extension of C3 outlet location; Culvert C1 is sagging, and water is ponding inside the culvert; 1.1 m crack within the north side slope immediately above the inlet of the C3 culvert.	☐
☑ Other	Highway north ditch: the highway side slope and the ditch to the west of the access road are bare of vegetation	☐

Instrumentation: (5SIs, 8PNs, 4 SPs)

Between the fall of 2022 and the spring of 2023: No discernible movement was noted in SI12-4 (located near the bottom of the slope); movement rates ranging from less than 1 to 12 mm per year in SI12-1, SI12-2, SI12-3, and SI12-9 (located to the south of the highway).

The operational piezometers showed a change in ground water levels ranging from -0.5 m to 0.1 m.

Assessment (Refer to attached Drawing)**:**

The site condition did not change significantly since the 2022 site visit.

The landslide will continue to cause progressive deterioration to the highway condition with time. The deterioration may take place quickly between the spring and the fall seasons since the landslide tends to move at high rates within this period based on historical data.

The existing twist on the highway surface near the flanks of the landslide still creates a rough ride to motorists.

The absence of vegetation in the highway north side slope and ditches, to the west of the access road, has resulted in the development of an erosion gully around and upstream of culvert C3 inlet location and erosion rills on the highway north side slope.

The sink hole and the crack developed in the vicinity of the inlet of C3 culvert replacement pipe reflect poor compaction of the reception pit, and this may result in stability issues of the slope and impact the performance of the new pipe.

It is suspected that a void exists below the highway's WBL/shoulder and the north side slope surface upslope of the C3 culvert inlet location. Inadequate grouting of old pipe is likely the main cause of the void and the dip noted in the highway surface. It is anticipated that the dip will become worse with time, due to the progressive collapse of the existing void, and this may cause a severe future distress on the highway WBL surface.

Culvert C1, located under the access road, is separated and hence this will likely impede the surface drainage within the north ditch, resulting in elevated groundwater levels within the landslide mass.

The void below the half pipe downstream of C3 outlet location is due to improper subgrade preparation. The surface flow around the pipe may undermine the subgrade, potentially resulting in the development of a severe erosion gully below and around the extension pipe.

Recommendations:

Short-Term

The local MCI should continue to monitor the site (particularly between the spring and the fall seasons) and seal any open cracks to reduce surface water infiltration into the highway fill. Consideration should be given in the future to placing an ACP patch near the flanks of the landslide to provide a smooth ride to motorists.

The following items should also be dealt with in the short-term:

- The north ditch to the west of the access road should be properly graded to eliminate gully erosion gully. The side slope should also be track-packed to fill erosion rills. After the ditch/side slope repairs are completed, all disturbed areas within the north ditch should be topsoiled and seeded. The ditch bottom should be covered with Type C TRM to reduce erosion potential.
- The area around Culvert C3 inlet should also be scarified, repacked, and contoured to eliminate the existing crack, and the sinkhole to the west of the culvert should be backfilled with compacted fill.
- Culvert C1 should also be replaced to reduce the amount of ponding water within the highway ditch.
- The dip developed on the highway WBL surface upslope of culvert C3 inlet location should be patched to eliminate existing hazard and provide a smooth ride to motorists. However, frequent patching of the highway should be anticipated to eliminate future dips. It is highly recommended that the distressed area be excavated, without damaging the new culvert, to locate the existing void. An excavator with a ripper tooth attachment may be needed to complete the excavation. Once the void is located, the base of the excavation should be inspected to remove damaged/collapsed section of the old pipe, debris, and soft /loose materials. Attempts should be made to re-grout the old pipe if the inspection reveals that the exposed section of the pipe has not been filled with grout. The excavation should then be backfilled with compacted crushed gravel to ground surface to re-build the highway surface and the side slope. The side slope should be capped with at least 300 mm of clay at ground surface. The closure of the highway WBL will likely be required to complete this repair.
- The void below the half pipe culvert, downstream of the outlet of the C3 culvert, should be filled with fillcrete.

Long-Term

In the long-term, the following options may be considered to remediate the landslide:

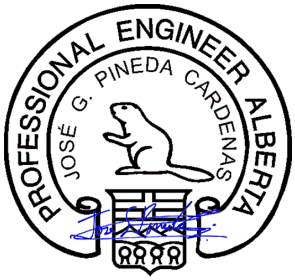
1. Unload the landslide through partial removal of highway fill, either by lowering the highway profile or replacing highway embankment fill with lightweight fill (e.g., EPS foam). The estimated cost of this option would range from $3,000,000 for the grade lowering option to $4,500,000 for the EPS foam replacement option.
2. Re-align the highway to the north of its current location outside the limits of the active landslide. The estimated cost of this option would be in the range of $2,000,000.
3. Reinforce the slip surface of the landslide by constructing a tied-back pile wall within the eastbound lane side slope. The estimated cost of a pile wall would be in the range of $9,000,000.

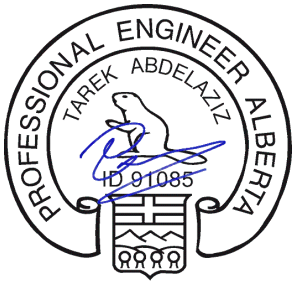
A geotechnical desktop study was completed in 2015 to investigate the feasibility of a new truck route around Athabasca. Two of the three investigated routes include a major realignment of the existing roadway to the north of its location at the landslide site. However, the final route has not been selected and the project timeline is still indeterminate.

Closure:

It is a condition of this letter report that Thurber's performance of its professional services will be subject to the attached Statement of Limitations and Conditions.

Yours very truly,
Thurber Engineering Ltd.
Tarek Abdelaziz, Ph. D, P.Eng.
Principal | Geotechnical Review Engineer





PERMIT TO PRACTICE
THURBER ENGINEERING LTD.
RM SIGNATURE: _____
RM APEGA ID #: 91085
DATE: July 10, 2023
PERMIT NUMBER: P005186
The Association of Professional Engineers and Geoscientists of Alberta (APEGA)

José Pineda, M.Eng., P.Eng.
Associate | Senior Geotechnical Engineer

H:\32000\32122 AT GRMP Athabasca and Fort McMurray Districts 2021-2025\CAD\2023 GEO HAZARD\JGP\32122 NC071-1.dwg - 1 - Jun. 22, 2023

TO COLINTON

THE DITCH AND THE SLOPES AND ARE BARE OF VEGETATION

DITCH BLOCK (2020, 2022)

SEE DETAIL NO. 1

SINK HOLE (800mm LONG, 500mm WIDE, 600mm DEEP)

760mm CSP CULVERT (C3)

OLD C3 GROUTED AND REPLACED WITH A 600mm SWSP (2022)

C3 OUTLET EXTENDED DOWN THE SIDE SLOPE TO THE TREE LINE WITH A HALF SMOOTH WALL CULVERT. RIPRAP PROTECTION PROVIDED AROUND AND AT THE OUTLET OF THE HALF PIPE. VOID WAS NOTED BELOW THE HALF PIPE EXTENSION A SILT FENCE WAS INSTALLED BEYOND THE RIPRAP LINING (2022)

SAME (2023)

1-2m DEEP SCOUR

SAME IN 2012, 2013, 2014

2.2m DEEP SCOUR IN 2020; HEAVY FLOW (NOT VISIBLE)

SAG POND

5-10mm WIDE CRACK, NO DROP

10-40mm WIDE (2017)

20-30mm WIDE (2018)

10-20mm WIDE (2022)

GRABEN FEATURE

BROKEN OUTLET AND NO FLOW

SAME IN 2012

NEW CRACK, 7m EAST FROM APPROACH 10-15mm WIDE, NO DROP

5-15mm DROP WITHIN PATCHED AREA

15-20mm WIDE CRACK, NO DROP

10-30mm WIDE, NO DROP (2017)

10-20mm WIDE, NO DROP (2018), 20-30mm WIDE (2022, 2023)

EROSION RILLS

PN12-8

SI/PN12-9

5mm WIDE, NO DROP (2016)

5-20mmWIDE, NO DROP (2017)

10-20mm WIDE, NO DROP (2018)

10-15mm WIDE (2022, 2023)

900mm CSP CULVERT (C2)

SI/2PN12-2

HAIRLINE CRACKS (2020)

5mm WIDE, NO DROP (2021)

10-20mm WIDE (2022, 2023)

PRIVATE LAND

HOMMOCKY TERRAIN

SI/2PN12-3

SI/2PN12-4

SP12-11 (20m)

R.R. 222

WATER FLOWING FROM C1 OUTLET TO C3 INLET - DRY IN (2021, 2023)

INLET PLUGGEDCULVERT (C2);

NOT VISIBLE IN 2020. THIS CULVERT MAY HAVE BEEN GROUTED OR COMPLETELY PLUGGED BY OTHERS AT THE INLET. - SAME IN 2021

600mm CSP CULVERT (C1)

WATER PONDING INSIDE THE CULVERT (2022, 2023)

SAGGING (2023)

CREST OF BACKSLOPE (APPROX.)

NORTH DITCH REGRADED BY OTHERS;

WATER DRAINING INTO C1 (2020) - DRY IN 2021, 2022, 2023

SILT FENCE

SI/2PN12-1

16° @ 9m HEIGHT

TRANSVERSE CRACKS 5-10mm WIDE, NO DROP - SAME

10-15mm WIDE, NO DROP (2022)

19° @ 9m HEIGHT

PN12-5

10-20mm WIDE, 5mm DROP

5-15mm, NO DROP (2021)

20-25mm WIDE, NO DROP (2022, 2023)

10-20mm WIDE, 5mm DROP

5-20mmWIDE, NO DROP (2021)

25-40mm WIDE, NO DROP (2022, 2023)

20-25mm WIDE, 5mm DROP

NOT VISIBLE (2020, 2021)

HWY 663:04

20° @ 7.5m HEIGHT

10mm DIP

20-25mm WIDE, 10mm DROP (2015)

20-30mm WIDE, 15mm DROP, SAME IN 2017

10-20mm, 15mm DROP (2018)

NOT VISIBLE (2020)

10-20mm WIDE, NO DROP (2022)

20-30mm WIDE, NO DROP (2023)

HTCB INSTALLED BY OTHERS IN 2019

PN12-6

5-30mm WIDE, NO DROP (2021)

20-25mm WIDE, NO DROP (2022)

SP1 (WATER @ 4m B.G.S.)

SI1 (SHEARED OFF IN 1980 @ 12.0m B.G.S.)

SP12-7

EASTERN FLANK OF LANDSLIDE

MORE PRONOUNCED DROP ACROSS CRACK (2014)

SP2 (WATER @ 3m B.G.S.)

SI2 (SHEARED OFF IN 1980 @ 9.5m B.G.S.)

GAP DEVELOPED ON THE TOP OF THE BRIDGE BEHIND THE ABUTMENT WALL - BRIDGE WAS OUT OF SERVICE (2012)

SAME IN 2013, SAME IN 2017

- GAP BECAME WIDER IN 2015 (2 TO 3m WIDE) (2015)
- GAP BECAME WIDER (4m WIDE) (2017)

SP3 (WATER @ 2.2m B.G.S.)

COULD NOT BE LOCATED

WOODEN BRIDGE - SOUTH FACING ABUTMENT WALL AND SUPPORTS ARE TILTED (2011)

DISTRESS OF ABUTMENT WALL AND FAILURE OF A FEW SUPPORTS (2012, 2013);

3 SUPPORTS FAILED ON EAST SIDE (2015, 2017);

BRIDGE DECK AND SUPPORTS REMOVED. FAILED HEADSLOPE REGRADED AND COVERED WITH EROSION CONTROL BLANKET. WILLOW STAKES INSERTED INTO REGRADED HEADSLOPES. SILT FENCES PLACE BY CONTOURED SLOPE. ACCUMULATED DEBRIS IN CREEK CHANNEL REMOVED (2019)

BEAVER DAM

TOE EROSION

LANDSLIDE SCARP (2012)

1.3m DROP (2015)

2.5m DROP (2017)

LANDSLIDE SCARP (2012)

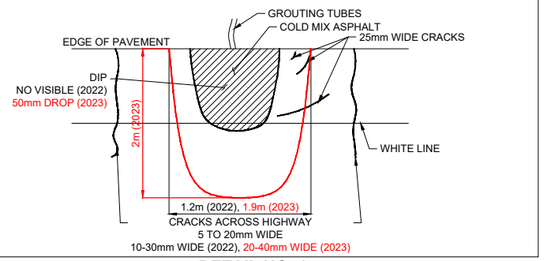
- BIGGER IN 2015, 600mm DROP ACROSS SCARP CRACK SURFACE

SAME IN 2017

LITTLE PINE CREEK

DITCH EROSION, 18m LONG, 1m WIDE, 0.5m DEEP (2022, 2023)

NEW CRACK, 40mm WIDE, 1.1m LONG AROUND CULVERT INLET LOCATION (2022, 2023)



DETAIL NO. 1

SCALE: 1:80

INSTRUMENT	GPS COORIDINATES (UTM ZONE 12)	
	NORTHING	EASTING
SI1	6054538	355878
SP1	6054544	355879
SI2	6054461	355838
SP2	6054481	355821

N

W E

S

LEGEND

- APPROXIMATE LOCATION OF2012 INSTRUMENTS
- SI — SLOPE INCLINOMETER
- PN — PNEUMATIC PIEZOMETER
- SP — STANDPIPE PIEZOMETER
- SP — STANDPIPE PIEZOMETER INSTALLED IN THE 1970's
- SI — SLOPE INCLINOMETER INSTALLED IN THE 1970's
- ACP OVERLAY
- SCARP CRACK
- POWER POLE
- P — OVERHEAD POWER LINE (APPROXIMATE)
- G — GAS LINE (APPROXIMATE)
- X — APPROXIMATE LOCATION OF FENCE LINE
- HIGH TENSION CABLE BARRIER (HTCB)
- BUSH LINE (APPROXIMATE)
- APPROXIMATE LOCATION OF EXISTING TRAILS
- ① PHOTOGRAPH NUMBER, AND APPROXIMATE DIRECTION AND LOCATION
- GROUND SURFACE SCARCE OF VEGETATION

NOTES

1. WATER LEVELS IN STANDPIPE PIEZOMETERS ARE BASED ON THE AVAILABLE INFORMATION PROVIDED BY TRANS
2. MAY 16, 2023 SITE OBSERVATIONS ARE SHOWN IN RED.

0 10 20 30 40 50 60m

SCALE 1:1000

Alberta

NORTH CENTRAL REGION (ATHABASCA AND FORT MCMURRAY DISTRICTS) 2023 GEOHAZARD ASSESSMENT

NC071: HWY 663:04 LITTLE PINE CREEK SLIDE (km 6.98)

DWG NO. 32122-NC071-1

DRAWN BY	ML
DESIGNED BY	JGP
APPROVED BY	TSA
SCALE	1:1000
DATE	MAY 2023
FILE No.	32122

THURBER ENGINEERING LTD.

Photo 1. Looking at reflective diagonal cracks on the highway surface from the western limit of the site.

Photo 2. Highway's north ditch to the east of the approach.

Photo 3. Looking north at a transverse crack (10 to 15 mm wide with no drop)

Photo 4. Looking northwest at the eastern flank reflective diagonal cracks (20 -25 mm wide with no drop).

Photo 5 Diagonal cracks located about 15 m east of the landslide western flank; 20mm – 30 mm wide with no drop.

Photo 6. Looking west at the regraded section of the ditch in 2019; side slopes and sections of the ditch bottom are bare of vegetation; note the presence of erosion rills along the side slope and a deep erosion gully in the ditch.

Photo 7. Looking southwest at the sinkhole previously developed within the northern edge of pavement of the highway above the original 600 mm diameter culvert (C3); Original pipe was grouted and a new 760 mm diameter SWSP was auger bored in 2021; cold mix patch placed on the highway surface, but cracks are still visible around the patched area; there is a 50 mm dip within the previously patched area.

Photo 8. C3 inlet; side slope is bare of vegetation; open crack around culvert inlet and erosion developing upstream of the inlet within the ditch.

Photo 9. A sink hole (800 mm long x 500 mm wide x 600 mm deep) developed to the west of C3 culvert inlet.

Photo 10. Looking inside culvert C3 outlet.

Photo 11. Outlet of culvert C3, installed in 2021. There is a void below the half pipe extension piece.