ALBERTA TRANSPORTATION
GEOHAZARD ASSESSMENT PROGRAM
NORTH CENTRAL REGION – ATHABASCA & FORT MCMURRAY DISTRICTS
2022 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 23, 2021	11	5	55 (For highway)
Current Inspection:	June 06, 2022	11	5	55 (For highway)
Road AADT:	700		**Year:**	2021
Inspected By:	José Pineda, Tarek Abdelaziz (Thurber) Arthur Kavulok, Amy Driessen, Rishi Adhikari (Alberta Transportation)			
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:	AT 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	☑
☑ Slope Movement	Western flank crack is showing reflective cracks 10 to 20 mm wide; 20 30 mm wide cracks within the middle section	☑

	of the landslide; eastern flank cracks are 25 – 40 mm wide with no drop	
☑ Erosion	Severe erosion (18 m long x 1 m wide x 0.5 m deep) developed within the north ditch upstream of culvert C3	☑
☐ Seepage		☐
☑ Bridge/Culvert Distress	Culvert C2 was plugged or grouted by others in late 2019; Culvert C3 was replaced with a SWSP that was installed in 2021; A void was noted under the half pipe extension of C3; Culvert C1 separated approximate 5 m from the outlet; water is ponding inside Culvert C1 and at outlet	☐
☑ Other	Highway north ditch: scare vegetation near the crest of the side slope to the east of the access road; bare vegetation within the side slopes and the ditch bottom to the west of the access road; 11 m crack within the north side slope immediately above the inlet of the new C3 culvert replacement	☑

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

Between the Fall of 2021 and the Spring of 2022: No discernible movement was noted in SI12-4 (located near the bottom of the slope); movement rates ranging from less than 1.6 to 14 mm per year in SI12-1, SI12-2, SI12-3, and SI12-9 (located to the south of the highway).

The operational piezometers generally showed a change in ground water levels ranging from -0.3 to 1.8 m.

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

Further opening/re-appearance of cracks on the highway surface and the instrumentation readings indicate that the landslide is more active than 2021. Despite moving at a relatively slow rate, 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 be at high rates within this period based on historical data.

The existing twist on the highway surface near the flanks of the landslide 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 a severe erosion gully around and upstream of Culvert C3 inlet location.

It is likely that the crack developed above the inlet of Culvert C3 replacement pipe reflects poor compaction of the reception pit, and this may result in stability issues of the slope and impact the performance of the new pipe.

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 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 the gully located upstream of Culvert C3 inlet. The area around Culvert C3 inlet should also be scarified, repacked, and contoured to eliminate existing crack/depression. After 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.
- Culvert C1 should also be replaced to reduce the amount of ponding water within the highway ditch
- The void below the half pipe culvert should be filled with grout.

Long-Term

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

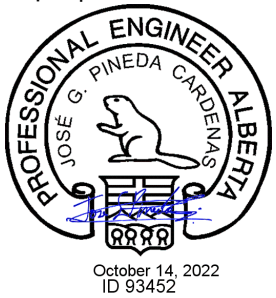
1. Unload the landslide through partial removal of highway fill, either by lowering the highway profile or replacing highway embankment fill with lightweight fill (e.g., EPS foam). The estimated cost of this option would range from $3,000,000 for the grade lowering option to $4,500,000 for the EPS foam 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 | Senior Geotechnical Engineer



PERMIT TO PRACTICE
THURBER ENGINEERING LTD.
RM SIGNATURE:
RM APEGA ID #: 91085
DATE: October 14, 2022
PERMIT NUMBER: P005186
The Association of Professional Engineers and Geoscientists of Alberta (APEGA)

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

THURBER

STATEMENT OF LIMITATIONS AND CONDITIONS

1. STANDARD OF CARE

This Report has been prepared in accordance with generally accepted engineering or environmental consulting practices in the applicable jurisdiction. No other warranty, expressed or implied, is intended or made.

2. COMPLETE REPORT

All documents, records, data and files, whether electronic or otherwise, generated as part of this assignment are a part of the Report, which is of a summary nature and is not intended to stand alone without reference to the instructions given to Thurber by the Client, communications between Thurber and the Client, and any other reports, proposals or documents prepared by Thurber for the Client relative to the specific site described herein, all of which together constitute the Report.

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The Report has been prepared for the specific site, development, design objectives and purposes that were described to Thurber by the Client. The applicability and reliability of any of the findings, recommendations, suggestions, or opinions expressed in the Report, subject to the limitations provided herein, are only valid to the extent that the Report expressly addresses proposed development, design objectives and purposes, and then only to the extent that there has been no material alteration to or variation from any of the said descriptions provided to Thurber, unless Thurber is specifically requested by the Client to review and revise the Report in light of such alteration or variation.

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a) Nature and Exactness of Soil and Contaminant Description: Classification and identification of soils, rocks, geological units, contaminant materials and quantities have been based on investigations performed in accordance with the standards set out in Paragraph 1. Classification and identification of these factors are judgmental in nature. Comprehensive sampling and testing programs implemented with the appropriate equipment by experienced personnel may fail to locate some conditions. All investigations utilizing the standards of Paragraph 1 will involve an inherent risk that some conditions will not be detected and all documents or records summarizing such investigations will be based on assumptions of what exists between the actual points sampled. Actual conditions may vary significantly between the points investigated and the Client and all other persons making use of such documents or records with our express written consent should be aware of this risk and the Report is delivered subject to the express condition that such risk is accepted by the Client and such other persons. Some conditions are subject to change over time and those making use of the Report should be aware of this possibility and understand that the Report only presents the conditions at the sampled points at the time of sampling. If special concerns exist, or the Client has special considerations or requirements, the Client should disclose them so that additional or special investigations may be undertaken which would not otherwise be within the scope of investigations made for the purposes of the Report.

b) Reliance on Provided Information: The evaluation and conclusions contained in the Report have been prepared on the basis of conditions in evidence at the time of site inspections and on the basis of information provided to Thurber. Thurber has relied in good faith upon representations, information and instructions provided by the Client and others concerning the site. Accordingly, Thurber does not accept responsibility for any deficiency, misstatement or inaccuracy contained in the Report as a result of misstatements, omissions, misrepresentations, or fraudulent acts of the Client or other persons providing information relied on by Thurber. Thurber is entitled to rely on such representations, information and instructions and is not required to carry out investigations to determine the truth or accuracy of such representations, information and instructions.

c) Design Services: The Report may form part of design and construction documents for information purposes even though it may have been issued prior to final design being completed. Thurber should be retained to review final design, project plans and related documents prior to construction to confirm that they are consistent with the intent of the Report. Any differences that may exist between the Report's recommendations and the final design detailed in the contract documents should be reported to Thurber immediately so that Thurber can address potential conflicts.

d) Construction Services: During construction Thurber should be retained to provide field reviews. Field reviews consist of performing sufficient and timely observations of encountered conditions in order to confirm and document that the site conditions do not materially differ from those interpreted conditions considered in the preparation of the report. Adequate field reviews are necessary for Thurber to provide letters of assurance, in accordance with the requirements of many regulatory authorities.

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Geotechnical engineering and environmental consulting projects often have the potential to encounter pollutants or hazardous substances and the potential to cause the escape, release or dispersal of those substances. Thurber shall have no liability to the Client under any circumstances, for the escape, release or dispersal of pollutants or hazardous substances, unless such pollutants or hazardous substances have been specifically and accurately identified to Thurber by the Client prior to the commencement of Thurber's professional services.

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H:\32000\32122 AT GRMP Athabasca and Fort McMurray Districts 2021-2025\CAD\2022\JGP\32122 NC071-1.dwg - 1 - Oct. 13, 2022

TO COLINTON

DITCH BLOCK (2020, 2022)
SEE DETAIL NO. 1

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)

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

PRIVATE LAND

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)

PN12-8

16° @ 9m HEIGHT

SI/PN12-9

5mm WIDE, NO DROP (2016)
5-20mmWIDE, NO DROP (2017)
10-20mm WIDE, NO DROP (2018)
10-15mm WIDE (2022)

TRANSVERSE CRACKS 5-10mm WIDE, NO DROP - SAME
10-15mm WIDE, NO DROP (2022)

900mm CSP CULVERT (C2)

SI/2PN12-2

HAIRLINE CRACKS (2020)
5mm WIDE, NO DROP (2021)
10-20mm WIDE (2022)

HTCB INSTALLED BY OTHERS IN 2019

WATER FLOWING FROM C1 OUTLET TO C3 INLET - DRY IN 2021

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)
C1 SEPARATED AT 5m FROM THE OUTLET. WATER PONDING INSIDE THE CULVERT

CREST OF BACKSLOPE (APPROX.)

NORTH DITCH REGRADED BY OTHERS;
WATER DRAINING INTO C1 (2020) - DRY IN 2021, 2022

SILT FENCE

SI/2PN12-1

10-20mm WIDE, 5mm DROP
5-15mm, NO DROP (2021)
20-25mm WIDE, NO DROP (2022)

10-20mm WIDE, 5mm DROP
5-20mmWIDE, NO DROP (2021)
25-40mm WIDE, NO DROP (2022)

20-25mm WIDE, 5mm DROP
NOT VISIBLE (2020, 2021)

PN12-5

19° @ 9m HEIGHT

10-30mm WIDE

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)

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.)

HOMMOCKY TERRAIN

EASTERN FLANK OF LANDSLIDE MORE PRONOUNCED DROP ACROSS CRACK (2014)

SP12-7

SI/2PN12-3

SI/2PN12-4

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

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

SP12-11 (20m)

R.R. 222

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)

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

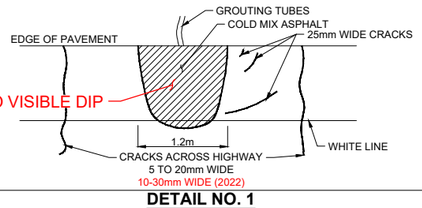
BEAVER DAM

TOE EROSION

LITTLE PINE CREEK

DITCH EROSION, 18m LONG, 1m WIDE, 0.5m DEEP

NEW CRACK, 40mm WIDE, 1.1m LONG AROUND CULVERT INLET LOCATION



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

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. JUNE 6, 2022 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)
2022 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	SEPTEMBER 2022
FILE No.	32122

THURBER ENGINEERING LTD.

Photo No. 1 – Looking at reflective diagonal cracks on the highway surface from the western limit of the site

Photo No. 2 – Looking at highway north ditch to the east of the approach; scarce vegetation on the highway side slope

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

Photo No. 4 – Looking northwest at the eastern flank reflective diagonal cracks (20 – 40 mm wide with no drop)

Photo No. 5 – Looking east at ditch regraded in 2019 by WSP; the north ditch has been regraded from culvert C1 outlet to culvert C3 inlet; culvert C2 appears to have been abandoned; side slopes and sections of the ditch bottom are bare of vegetation; erosion developed within the ditch

Photo No. 6 –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

Photo No. 7 – Looking south at new culvert C3 inlet; note bare vegetation, crack around culvert inlet and erosion developing upstream of the inlet within the ditch

Photo No.8 – Looking inside new culvert C3 outlet.

Photo No. 9 – Looking north at the outlet of culvert C3, installed in 2021. There is a void below the half pipe extension piece.