ALBERTA TRANSPORTATION
GEOHAZARD ASSESSMENT PROGRAM
NORTH CENTRAL REGION – ATHABASCA & FORT MCMURRAY DISTRICTS
2022 SITE INSPECTION

THURBER ENGINEERING LTD.

Site Number	Location	Name	Hwy	km
NC103-2	Approximately 7.9 km north of Hwy 29 (North of Elk Point)	**KEHIWIN LAKE**	41:23	7.9
Legal Description		**UTM Co-ordinates (NAD 83)**		
9-25-58-07 W4		12 N 5988463.22 E 506745.73		

	Date	PF	CF	Total
Previous Inspection:	June 25, 2021	11	4	44
Current Inspection:	June 8, 2022	11	4	44
Road AADT:	1,250		**Year:**	2021
Inspected By:	José Pineda, Tarek Abdelaziz (Thurber) Arthur Kavulok, Rishi Adhikari, Amy Driessen (Alberta Transportation)			
Report Attachments:	☑ Photographs ☑ Plans ☐ Maintenance Items			

Primary Site Issue	A slump on the west side of the highway downslope of the NC103-1 pile wall location. The slump occurred above an existing 600 mm CSP centre line culvert. A sinkhole developed on the east side of the highway above the 600 mm CSP centre line culvert inlet.
Dimensions:	The slump on the west side of the highway is approximately 5.5 m wide, 20 m long, and about 1.6 m deep below the original ground surface. The sinkhole on the east side of the highway is about 3.3 m wide 2 m deep.
Site History/Maintenance:	The slump occurred in a section of the highway that is known for multiple landslides that have been repaired by AT using various configurations of pile walls on the west side of the highway. At the location of the west slump failure, a tied-back concrete pile wall was constructed in 2011 under AT contract No. 11165. The pile wall consisted of 15 m deep, 1.8 m diameter concrete piles, connected at the top using a 1.8 m deep concrete waler. Two rows of 200 mm diameter grouted anchors, 22 m long, were installed within the waler to further restrain the wall movement. At the location of the side slope failure, a centre line culvert was present prior to the construction of the pie wall. Hydrovac excavation was completed prior to the installation of the pile wall to expose the 600 mm CSP culvert. The top of the culvert was at an approximate elevation of 547.3 m (~6 m below the top of waler). The pile spacing at the culvert location was 3 m (i.e., 1.2 m clear space between concrete piles). Alberta Transportation noted that the slope failure occurred in 2019. The maintenance contractor attempted to expose the centre line culvert

	downslope of the pile wall locations in 2020. However, the hydrovac excavation was not advanced deep enough to expose the culvert. In May 2022 a hydrovac excavation and a CCTV inspection were conducted from the outlet of the centre line culvert under Thurber's supervision. The CCTV inspection revealed that the top of the culvert had collapsed and separated approximately 16 m from the outlet side. However, the condition and actual orientation of the culvert under the highway, between the identified break point and the inlet was unable to be inspected. Attempts were made to perform the CCTV inspection from the inlet side, but it was not possible due to a blockage in the culvert near the inlet.	
Observations:	**Description**	**Worse?**
☐ Pavement Distress		☐
☑ Slope Movement	Ongoing movement of the slump located on the west side of the highway caused the snow fence to collapse. The slump, halfway up the highway side slope, became 2.8 m wider. The slump flank cracks are about 2.0 m wide and 1.6 m deep. A scarp crack was noted on the east embankment side slope above the culvert inlet location; the crack is about 400 mm wide and 600 mm deep.	☑
☑ Erosion	The sinkhole located near the culvert inlet is about 3.3 m wide and 2 m deep (1 m wider and 1 m deeper since the 2021 inspection)	☑
☑ Seepage	Water ponding noted at the culvert outlet	☐
☑ Bridge/Culvert Distress	Culvert noted to be separated in 2021 at about 1 m from the inlet and at approximately 3 m from the inlet in 2022	☑
☑ Other	Approximately 600 mm of sediment accumulation at the culvert outlet	☐

Instrumentation Readings (1 Slope Inclinometer and 2 Piezometers**):**

SI11-4 installed in pile 60 adjacent to the slump on the west side of the highway showed a rate of movement of ~ 2 mm/yr in the spring 2022.

The maximum groundwater level recorded at PB10-1 and PB10-3 was 3.6 m and 0.5 m, respectively.

Assessment:

In general, the existing culvert is old, rusted and may have surpassed its design life span. The CCTV inspection of the culvert confirmed that the culvert is separated and collapsed approximately 16 m from the outlet location, consistent with Thurber's prior assumption regarding the intersection zone between the potential slump slip surface and the culvert alignment near the pile wall location.

Based on site observations and instrumentation results, the west side slope failure has not yet impacted the highway pavement surface condition, or the performance of the NC103-1 pile wall. The performance of the wall is not expected to be impacted since the design assumed complete loss of the downslope soil mass. However, the slump may become larger and deeper in the future, resulting in soil loss and formation of voids between the piles, and accordingly a dip or a sink hole on the highway surface.

The drop in ground surface downslope of the wall represents a significant hazard to motorists in this zone.

The upstream flow will continue to saturate the slump mass downslope of the wall location and the highway embankment fills. This may have an adverse impact on the overall stability of the highway, but it all depends on the discharge volume from the gully located on the east side of the highway.

The sinkhole located on the east side of the highway also appears to have developed in response to the culvert separation at the inlet location. The existing scarp crack on the east side, currently located about 7 m from the edge of the road, of the highway may eventually retrogress back and impact the highway condition.

Recommendations:

The site should be visited again in 2023.

In the short term, the roadway surface should be monitored for the development of new cracks or extension of existing cracks. Any open cracks should be sealed to prevent further rise in ground water levels. Additional warning signs (i.e., sharp shoulder signs) should be erected to warn motorists of the hazard. If AT is not planning to remediate this site soon, consideration should be given to placing guardrail to protect runaway vehicles form the existing hazard. The guardrail should extend a sufficient distance beyond the limits of the slump.

The depth of the waler is 1.8 m and the current drop in the ground surface along the face of the waler is about 1.6 m below the ground surface. The local MCI should frequently measure the drop along the face of the waler, and add minimal gravel wedge, as needed, to avoid exposure of the piles/gap below the underside of the waler.

Prior to the design of the long-term repair measure, it is recommended that the toe of the embankment southeast slope at the inlet location be excavated to remove the broken and corroded floor sections of the culvert to allow further culvert inspection from the inlet side of the pipe.

Based on the results of the partial investigation completed in May 2022, a feasible repair measure would consist of the following:

- excavate the west side slope to remove the slump material and expose the broken section of the pipe; use a deep trench box or possibly a short section of sheet pile to avoid disturbing the soil below the underside of the waler,
- excavate of the east side slope above the inlet location to remove existing scarp and the damaged/corroded section of the pipe,
- dispose of common excavation material and stockpile select clay at the base of the west side slope to provide a clay cap at final ground surface,
- remove the pipe section between break point and outlet location,
- line the existing culvert between the break point and the inlet location (assuming a further investigation reveals that the pipe is straight between the break point and inlet location),
- install a new pipe between the break point and outlet location
- backfill the excavation downslope of the wall with granular material and install a subdrain pipe within the gravel backfill replacement zone,
- backfill the east side slope with granular fill,
- place riprap at the at the culvert inlet and outlet locations, and daylight the subdrain pipe at the culvert outlet riprap location, and
- place a clay cap above the gravel replacement zone(s), and topsoil and seed all disturbed areas.

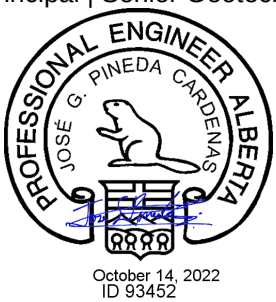
A hydrotechnical study should be conducted to assess the ability of the new lined pipe to handle the flow from the gully.

The ballpark cost to complete the repair measure listed above will be in the order of $400,000 (excluding engineering).

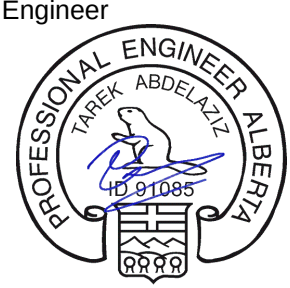
Closure:

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



October 14, 2022
ID 93452



October 14, 2022

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.
Senior 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.

IN ORDER TO PROPERLY UNDERSTAND THE SUGGESTIONS, RECOMMENDATIONS AND OPINIONS EXPRESSED HEREIN, REFERENCE MUST BE MADE TO THE WHOLE OF THE REPORT. THURBER IS NOT RESPONSIBLE FOR USE BY ANY PARTY OF PORTIONS OF THE REPORT WITHOUT REFERENCE TO THE WHOLE REPORT.

3. BASIS OF REPORT

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.

4. USE OF THE REPORT

The information and opinions expressed in the Report, or any document forming part of the Report, are for the sole benefit of the Client. NO OTHER PARTY MAY USE OR RELY UPON THE REPORT OR ANY PORTION THEREOF WITHOUT THURBER'S WRITTEN CONSENT AND SUCH USE SHALL BE ON SUCH TERMS AND CONDITIONS AS THURBER MAY EXPRESSLY APPROVE. Ownership in and copyright for the contents of the Report belong to Thurber. Any use which a third party makes of the Report, is the sole responsibility of such third party. Thurber accepts no responsibility whatsoever for damages suffered by any third party resulting from use of the Report without Thurber's express written permission.

5. INTERPRETATION OF THE REPORT

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.

6. RELEASE OF POLLUTANTS OR HAZARDOUS SUBSTANCES

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.

7. INDEPENDENT JUDGEMENTS OF CLIENT

The information, interpretations and conclusions in the Report are based on Thurber's interpretation of conditions revealed through limited investigation conducted within a defined scope of services. Thurber does not accept responsibility for independent conclusions, interpretations, interpolations and/or decisions of the Client, or others who may come into possession of the Report, or any part thereof, which may be based on information contained in the Report. This restriction of liability includes but is not limited to decisions made to develop, purchase or sell land.

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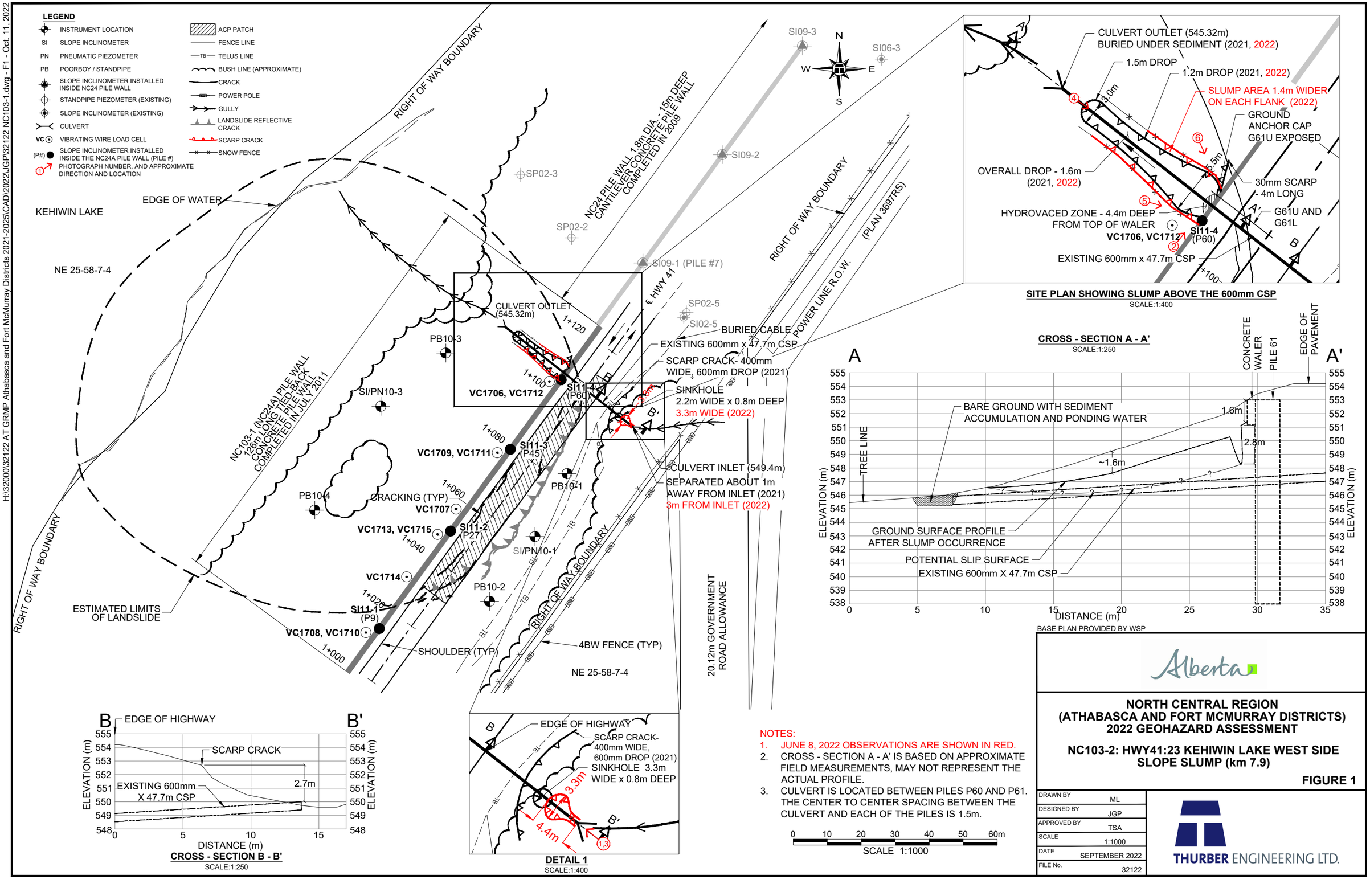
LEGEND

- INSTRUMENT LOCATION
- SI SLOPE INCLINOMETER
- PN PNEUMATIC PIEZOMETER
- PB POORBOY / STANDPIPE
- SLOPE INCLINOMETER INSTALLED INSIDE NC24 PILE WALL
- STANDPIPE PIEZOMETER (EXISTING)
- SLOPE INCLINOMETER (EXISTING)
- CULVERT
- VC VIBRATING WIRE LOAD CELL
- (P#) SLOPE INCLINOMETER INSTALLED INSIDE THE NC24A PILE WALL (PILE #)
- PHOTOGRAPH NUMBER, AND APPROXIMATE DIRECTION AND LOCATION
- ACP PATCH
- FENCE LINE
- TB TELUS LINE
- BUSH LINE (APPROXIMATE)
- CRACK
- POWER POLE
- GULLY
- LANDSLIDE REFLECTIVE CRACK
- SCARP CRACK
- SNOW FENCE



SITE PLAN SHOWING SLUMP ABOVE THE 600mm CSP
SCALE:1:400

CROSS - SECTION A - A'
SCALE:1:250

CROSS - SECTION B - B'
SCALE:1:250

DETAIL 1
SCALE:1:400

NOTES:
1. JUNE 8, 2022 OBSERVATIONS ARE SHOWN IN RED.
2. CROSS - SECTION A - A' IS BASED ON APPROXIMATE FIELD MEASUREMENTS, MAY NOT REPRESENT THE ACTUAL PROFILE.
3. CULVERT IS LOCATED BETWEEN PILES P60 AND P61. THE CENTER TO CENTER SPACING BETWEEN THE CULVERT AND EACH OF THE PILES IS 1.5m.

0 10 20 30 40 50 60m
SCALE 1:1000

BASE PLAN PROVIDED BY WSP

Alberta

NORTH CENTRAL REGION (ATHABASCA AND FORT MCMURRAY DISTRICTS) 2022 GEOHAZARD ASSESSMENT

NC103-2: HWY41:23 KEHIWIN LAKE WEST SIDE SLOPE SLUMP (km 7.9)

FIGURE 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 – 600 mm CSP culvert separated at 3 m from inlet. Note sinkhole developed above culvert separation

Photo No. 2 – Looking northeast at the observed slump downslope of the pile wall location. Snow fence collapsed due to ongoing movement of the slump.

Photo No. 3 – Scarp crack above the culvert inlet (400 mm wide, 600 mm drop)

Photo No. 4 – Looking east at the head scarp crack of the slump. Slump area approximately is 1.4 m wider on each flank.

Photo No. 5 – Looking at the northeast flank of the slump; the slump exposed a 5 m long section of the concrete waler

Phot No. 6 – Looking at southeast flank of the slump