ALBERTA TRANSPORTATION
GEOHAZARD ASSESSMENT PROGRAM
PEACE REGION (PEACE RIVER DISTRICT)
2021 INSPECTION

THURBER ENGINEERING LTD.

Site Number	Location	Name	Hwy	km
PH034	Judah Hill	Fence Slide	744:04	59.177
Legal Description		**UTM Co-ordinates**		
SE¼ 29-083-21 W5M		11V E 482792	N 6230946	

	Date	PF	CF	Total
Previous Inspection:	10-June-2020	14	5	70
Current Inspections:	6-July-2021	14	5	70
Road WAADT:	600		**Year:**	2020
Inspected by:	Tyler Clay, TEL Ed Szmata, TRANS Max Shannon, TRANS		Don Proudfoot, TEL Kristen Tappenden, TRANS Erwin Kurz, TRANS	
Report Attachments:	☑ Photographs ☑ Plans		☐ Maintenance Items	

Primary Site Issue:	An approximately 50 m wide slide, with its backscarp within the road, was repaired in 2005 by excavating the slide mass (including some old stone columns) and rebuilding the highway with geogrid reinforced fill. Since repairs, settlement and cracking of the pavement have occurred and cracks have extended further south and north of the original slide.	
Dimensions:	Main slide is about 60 m wide at the road shoulder. Additional areas of pavement distress and cracking extend 80 m to 100 m north and south of the main slide.	
Maintenance:	Cracking and dips in pavement were patched in 2008 and again in 2011. Patching has occurred intermittently following these repairs and both the guardrail and posts were replaced in 2009. Highway was closed between May 2013 and December 2013 due to the occurrence of the Sunshine Landslide at km 58.2 further to the south.	
Observations:	**Description**	**Worsened?**
☑ Pavement Distress	Near km 59.1 (near SI10-12), subsidence within the SBL near the guardrail is up to 150 mm. No significant expansion or change from 2020. (Photo 1) Existing cracks in the SBL shoulder near km 59.13 did not change significantly since 2020. At the main repair area (km 59.14) the cracks in the SBL shoulder are worse and are open up to 100 mm. The depression has a differential drop up to 350 mm with a sharp differential edge in the ACP that is worse from the previous inspection in 2020. (Photos 2 and 3) Pavement condition at km 59.2 had no significant change from 2020. (Photo 6)	☑
☑ Slope Movement	At main slide repair area: the previously observed shallow slump and skin failure in the	☐

	clay cap that was constructed over the sideslope during the 2005 repairs had no changes. Except for surficial erosion, slope appears similar to 2020 condition. (Photo 4) A shallow and dry earth slide was noted below SI10-15 on the west sideslope (km 59.25). (Photo 7)	
☑ Erosion	Increased rill erosion is present in the upper sideslope at the main slide repair area (km 59.18).	☑
☐ Seepage		☐
☐ Bridge/Culvert Distress		☐
☑ Other	Geogrid installed as part of the 2005 repair has been previously observed becoming exposed on the embankment downslope resulting in a further reduction of its anchoring capacity.	☐

Instrumentation:

SI05-15	Slope inclinometer installed in 2005 at the top of the hill in the ATCO gas utility right of way above the Fence Slide, approximately 30 m elevation above the road, has not shown any consistent trend of movement since installation.
SI10-12 and 15	The Spring 2020 readings for SI10-15 showed a rate of movement of 5.1 mm/yr over 2.4 m to 5.5 m depth. The rate of movement in the SI decreased by 5.7 mm/yr compared to the fall of 2020 readings (the previous reading in the fall of 2020 was the highest ever recorded for this instrument). SI10-12 sheared at 4.9 m depth in Fall 2019.
SI10-13 and 14	SI10-13 and SI10-14 are obstructed at depths of 6.4 m and 5.7 m, which correspond to the approximate elevation of the base of the upper clay fill of the 2005 repair.
PN10-12 and 15	Pneumatic piezometers PN10-12 and PN10-15 showed increases in groundwater level of 0.01 m and 0.14 m, respectively, since the fall of 2020 readings. Groundwater depth trends for both instruments have been relatively consistent since installation (March 2010) with PN10-15 showing between 2 m to 4 m depth and PN10-12 with a depth of approximately 18 m.
PN10-13 and 14	Non-Operational (Pinched or Blocked).

Assessment:

Cracking and settlement at the repair have continued, and cracking is re-appearing through the 2011 asphalt patch and continues to worsen along the road shoulder to the north and south of the main slide. The shearing or buckling of SI10-13 and SI10-14 indicate that slide movement or settlement is occurring at a steady rate in the clay backfill from the 2005 repair. SI10-12, located to the south outside the former landslide repair limits, showed a steady annual rate of movement of about 8 mm/yr up until it sheared off in Fall 2019. The movement measured at SI10-15, located north of the slide repair area, is at a rate of about 5 mm/yr (highest movement rate of 11 mm/yr was recorded in the fall of 2020).

It is postulated that the dipping in the highway pavement surface is the result of the clay fill settling and spreading over time. The shallow sloughing of the clay cap is considered due to the loss of cohesion as a result of weathering (wetting and desiccation cycles). The repaired sideslope is

over-steepened and lateral spreading of the clay fill is expected to continue. The shear depth of the SI's correlates with this assessment.

The development of additional cracks in the highway shoulder south and north of the Fence Slide (in the vicinity of SI10-12 and SI10-15) within the last few years are getting worse and likely indicate potential slope failures at these locations in the southbound lanes in the future. No toe bulge or other visible slide features have been apparent on the slope below the road in recent inspections.

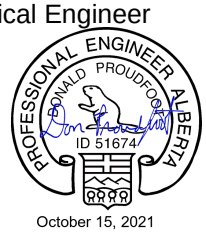
Rill erosion and scouring below the highway SBL resulting from the concentrated water runoff in the lower dipped sections also needs to be addressed as it can lead to progressively larger erosion gullies, skin failures and landslide features, which could eventually retrogress into the roadway.

Recommendations:	**Cost**
Winter road sand buildup at the edge of the pavement should be regularly cleaned to prevent the concentration of runoff flow into compromised sideslopes and/or erosion gullies. Consideration should be given to building an ACP berm at the shoulder that directs runoff to an armored discharge area along a sideslope outside the compromised areas below the highway.	Maintenance
A short-term solution for the shallow skin failures in the clay cap over the sideslope is to seed and cover the sideslope with Macmat and anchor it into the slope with Duckbill anchors. In addition to attenuating the dips at the landslide scarp in the roadway surface on-going milling and patching of the dipped pavement sections should be completed prior to the next anticipated asphalt resurfacing project.	$75,000
Mid-term to long term solutions would involve excavating and removing the upper clay backfill from the 2005 repair and rebuilding the highway embankment with granular fill reinforced with uniaxial geogrid, the reinstatement of the clay cap on the embankment sideslope and the placement of an overlying slope protection (Armormax anchored with Duckbill anchors).	$ 300,000
Long-term solutions to deal with the propagation of cracks to the north and south of the Fence Slide could consist of a realignment of the highway into the backslope (now that the natural gas pipeline is decommissioned), digging out weaker clay layers and rebuilding the slope with geogrid reinforced gravel (like the Fence Slide repair from 2015) or pile walls. The cost could range from $2,000,000 to $10,000,000. The realignment is likely the cheapest option but will only buy some time until further retrogression occurs whereas the pile wall option should be a more permanent solution.	$2M - $10M

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.

Don Proudfoot, P.Eng.
Principal | Senior Geotechnical Engineer



PERMIT TO PRACTICE
THURBER ENGINEERING LTD.
RM SIGNATURE: Don Proudfoot
RM APEGA ID #: 51674
DATE: October 15, 2021
PERMIT NUMBER: P005186
The Association of Professional Engineers and Geoscientists of Alberta (APEGA)

Tyler Clay, P.Eng.
Geological Engineer

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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.

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.

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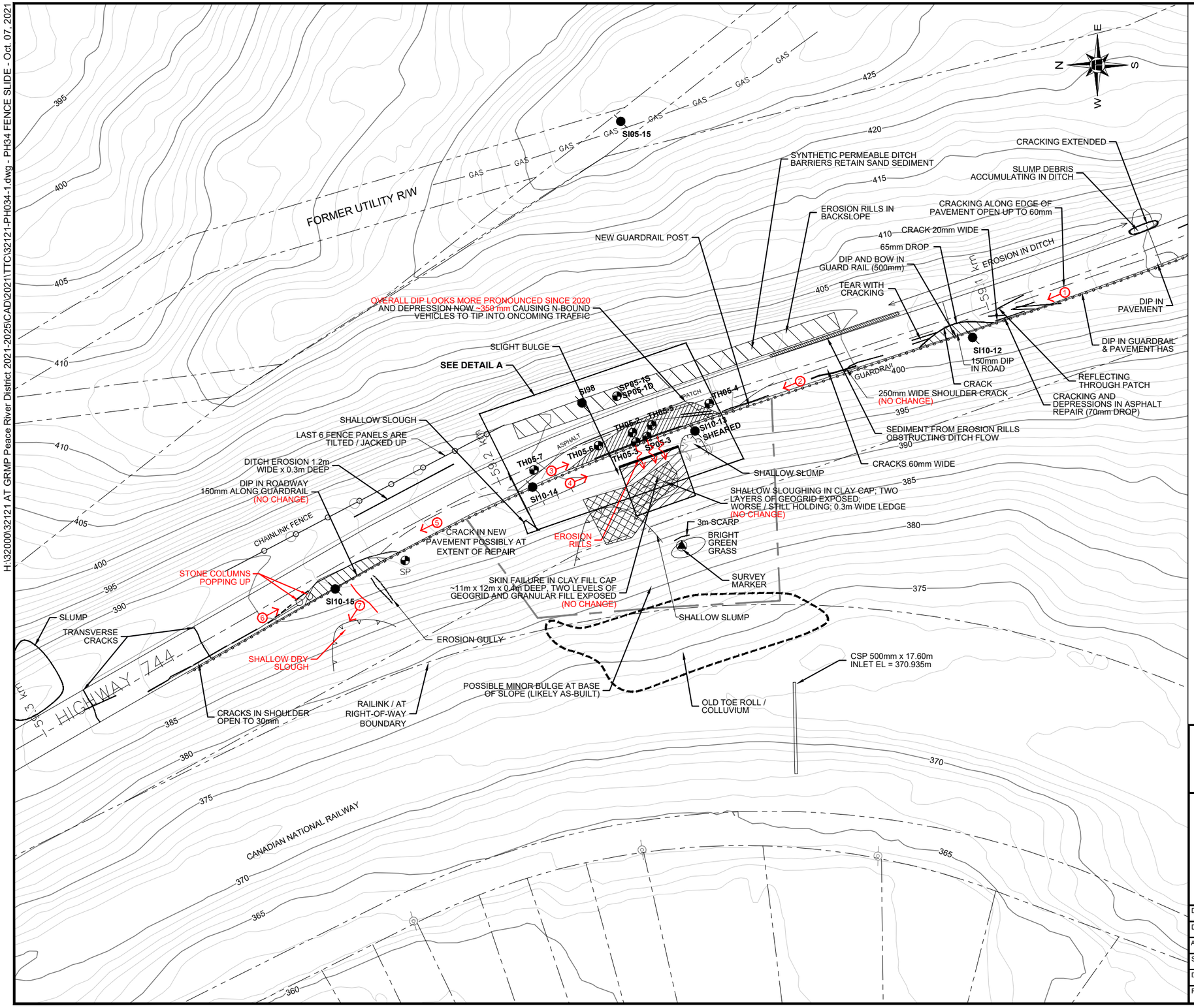
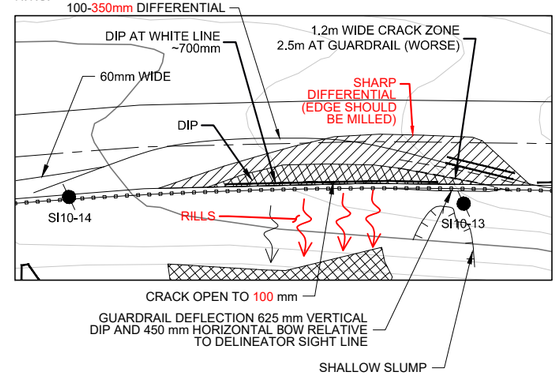
H:\32000\32121 AT GRMP Peace River District 2021-2025\CAD\2021\TTC\32121-PH034-1.dwg - PH34 FENCE SLIDE - Oct. 07, 2021



LEGEND

- TEST HOLE LOCATION
- SLOPE INDICATOR
- ① DIRECTION AND PHOTO NUMBER

DETAIL A
N.T.S.



NOTES:

1. LOCATION DATA RECORDED USING HANDHELD GPS RECEIVER. ALL LOCATIONS ARE APPROXIMATE AND ARE FOR ILLUSTRATIVE PURPOSES ONLY.
2. JULY 6, 2021 OBSERVATIONS SHOWN IN RED.

0 10 20 30 40 50m

SCALE 1:750

Alberta

PEACE REGION (PEACE RIVER DISTRICT)

PH034-1 JUDAH HILL FENCE SLIDE
2021 SITE INSPECTION PLAN

DWG No. 32121-PH034-1

DRAWN BY	ML
DESIGNED BY	TTC
APPROVED BY	DWP
SCALE	1:750
DATE	OCTOBER 2021
FILE No.	32121

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	**Photo 1.** Looking northwest from km 59.07 at the cracking and pavement distress along the downhill side of the road near SI10-12. No significant visual change in the pavement from the 2020 condition.
	**Photo 2.** Looking north from the south end of the Fence Slide repair at km 59.14. Slide damage extends into the NBL. Cracks in the SBL shoulder of the highway open to 100 mm and overall, the dip looks slightly more pronounced relative to the 2020 condition.

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	**Photo 3.** Looking south from the north end of the Fence Slide repair at km 59.18. Depression extends into the NBL, and differential drop up to 350 mm.
	**Photo 4.** Looking south from the west sideslope of Hwy 744:04 from km 59.18. The bow and vertical deflection in the guardrail are visible. ACP shoulder cracking is visible and there is increased rill erosion on the upper sideslope.

	**Photo 5.** Looking northwest from km 59.21 at the west sideslope below SI10-15. Minor rill erosion otherwise no major change from 2020.
	**Photo 6.** Looking southeast from km 59.25 along the SBL with dip up to 150 mm along the guardrail. No change from the 2020 condition.

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	**Photo 7.** Shallow dry slough below SI10-15 on the west sideslope below the highway near km 59.25.