

**ALBERTA TRANSPORTATION AND  
ECONOMIC CORRIDORS  
GEOHAZARD ASSESSMENT PROGRAM  
PEACE REGION (PEACE RIVER DISTRICT)  
2024 INSPECTION**



Site Number	Location	Name	Hwy	km
PH070	East Hill 33+850 to 34+050	East Hill – Retaining Wall Site	2:60	33.84
Legal Description		UTM Co-ordinates (NAD 83)		
SW27-083-21 W5M		11V E 485363	N 6230677	

	Date	PF	CF	Total
<b>Previous Inspection:</b>	May 17, 2023 Pile Wall	5	6	30 (Slide Risk Rating)
	West Slide (KM 34+50)	12	3	36 (Slide Risk Rating)
<b>Current Inspection:</b>	May 27, 2024 Pile Wall	5	6	30 (Slide Risk Rating)
	West Slide (KM 34+50)	12	3	36 (Slide Risk Rating)
<b>Road WAADT:</b>	3760	<b>Year:</b>	2023	
<b>Inspected By:</b>	Don Proudfoot, Tyler Clay, Cole Szakacs (Thurber). Rocky Wang, Robert Senior (TEC)			
<b>Report Attachments:</b>	<input checked="" type="checkbox"/> Photographs <input checked="" type="checkbox"/> Plans <input type="checkbox"/> Maintenance			

<b>Primary Site Issue:</b>	<p>Large deep-seated landslide was occurring below roadway at 34+050 with potential to adversely affect highway if retrogression or reactivation were to occur. Active landslide caused roadway settlement on the eastbound lane at 33+910 since January 2013.</p> <p>Further east at 33+875 an instability of fill within an infilled ravine was previously mitigated with a cantilevered, cast-in-place concrete pile wall reinforced with steel wide-flange with a concrete header beam. The fill slope below wall had ongoing downslope movement and piles were becoming exposed.</p> <p>A concrete, tied-back tangent retaining wall to mitigate the slide movement and support the roadway was installed from August 2016 to October 2017 (between 33+925 and 34+000). At the same time, a new concrete cantilever wall was also constructed immediately upslope of the old wall at 33+875, to replace it and stabilize the old ravine area.</p> <p>An old landslide scarp with increased movement is developing west and downslope of the pile wall near 34+050. The area was identified in 2018 as being potentially active within disturbed slide terrain present in the midslope (approximately 40 m below the highway). Since 2020 new tension cracks and scarp development becoming apparent 10 to 15 m upslope of the disturbed slide terrain.</p>
<b>Dimensions:</b>	<p>Landslide at 34+050 laterally continuous below roadway for approximately 100 m width extending approximately 200 m south to North Heart River.</p> <p>About 40 m of roadway experiences settlement due to slide activity on the eastbound lane at 33+910 (less apparent in recent years following pile wall installation).</p>

	Unstable ravine width at 33+875: 65 m Previous cantilevered wall length: 40 m New anchored tangent pile retaining wall length: 175 m		
<b>Date of any remediation:</b>	2016 - 2017 – retaining walls installed between 33+850 and 34+000		
<b>Maintenance:</b>	2022 – Highway was repaved and there were numerous ditch and culvert repairs along entire East Hill section (no ditch or culvert repairs within PH070 site extents).		
<b>Observations:</b>	<b>Description:</b>	<b>Worsened?</b>	
		<b>Yes</b>	<b>No</b>
<input checked="" type="checkbox"/> Pavement	Minor dip in guardrail and NBL along previously observed extents behind wall in eastbound lane near 33+900 was unchanged from the 2023 condition. Dip at guardrail is suspected to be the installed condition and not due to slide related settlement. Overall pavement section upslope from the wall was in good condition with no distress noted along previous damage extents since being repaved in Fall 2022. (Photos 70-07 and 70-08)	<input type="checkbox"/>	<input checked="" type="checkbox"/>
<input checked="" type="checkbox"/> Slope Movement	<p>The fill slope below the wall and area of previously observed movement has been regraded as part of the pile wall installation work. At the east end of the wall a previously identified scarp/tension crack developing along the extents o the east flank of the previous slide was unchanged from the 2023 condition. (Photos 70-01 and 70-03)</p> <p>No other visual indicators of slide disturbance were observed downslope of the pile wall. Piles at the west side of the wall were marked with pink paint along the base to monitor future soil drop. (Photos 70-01 to 70-04)</p> <p>Active slide area developing west and downslope of the pile wall at 34+050 has expanded with significant more downdrop at the scarp (up to 1.5 m) and extended tension cracks. New tension cracks were forming 0.3 to 1.0 m upslope from the main scarp. Width of the main slide scarp is now approximately 115 m and has a minimum offset approximately 15 m from the highway at the east end (unchanged from 2023). (Photos 70-09 and 70-10)</p>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
<input checked="" type="checkbox"/> Erosion	<p>Erosion gully at the end of the armored drainage outlet area at the west end of the pile wall was slightly worse but gully sidewalls were well vegetated. (Photo 70-06)</p> <p>Minor erosion in the north ditch between 34+000 and 34+100 was not significantly worse relative to the 2023 condition.</p>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
<input type="checkbox"/> Seepage		<input type="checkbox"/>	<input type="checkbox"/>
<input type="checkbox"/> Bridge/Culvert		<input type="checkbox"/>	<input type="checkbox"/>
<input checked="" type="checkbox"/> Other	Drain trough along top of wall was open with minor sediment and debris buildup. Drainage outlet	<input type="checkbox"/>	<input checked="" type="checkbox"/>

	armouring (34+000) was functioning as intended with no visible changes from the 2023 condition. (Photo 70-05)		
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**Instrumentation:**

The pile wall is instrumented with four slope inclinometers (SI's), one shape accelerometer array (SAA), thirty strain gauges and sixteen anchor load cells. In the site area around the pile wall there are three SI's, eight pneumatic piezometers and one standpipe piezometer.

Instruments were read on May 19, 2024 and the results are summarized below:

- No new zones of movement were measured in the Spring of 2023 readings. Movement rates in the two SI's upslope of the pile wall are below 1.5 mm/yr. A zone of movement first observed in 2020, over 17.4 m to 21.0 m during the 2020 readings had incremental movement of 0.9 mm (this is of significance since this zone is below the tips of the piles in Wall Section 2A – from approximately 33+935 to 33+975). SI14-4 located downslope of the wall sheared at 19.5 m depth in June 2023. The remaining operational SI located downslope from the pile wall (SI13-3) has not measured any discernible movement (it is expected this instrument is not deep enough to intercept the shear surface of the landslide).
- Within the pile wall the SI's have shown movement rates between 0 to 3.0 mm/yr. Total cumulative movements have varied in the downslope direction up to approximately 10 mm and in upslope direction up to 15 mm. The SAA in the wall has measured an average rate of movement below 1.5 mm/yr in the downslope direction and a total cumulative movement of approximately 6 mm in the upslope direction.
- The strain gauges generally showed small increases in negative (compressive) strain on the upslope pile face. On the downslope pile face, there was not a clear trend of overall increasing or decreasing strain; seven of the strain gauges on the downslope pile face were not functioning during the Spring 2024 readings which limited trend observations.
- The majority of the load cells on the tie-back anchors showed an increase in measured load compared to the spring of 2022 readings ranging from approximately 0.1 kN to 26 kN. Three anchors measured all-time high loads. Two anchors in Design Section 2 show loads up to 6 kN above SLS design load and a trend of increasing load. Two anchors in Design Section 4 show loads up to 57 kN above SLS design load; however, these anchors were intentionally locked off at a higher load during construction with the expectation they would release some load over time. Due to datalogger power issues, load cell data was missing between November 2023 to May 2024 (typically highest loads have been measured in during the Winter months).
- The piezometers have measured relatively stable groundwater levels for the past several years, apart from one instrument which had shown a trend of slowly increasing groundwater levels since 2019 but has dropped with the 2024 reading.

**Assessment (Refer to Drawing PH070-1):**

Large deep-seated landslides are widespread below roadway in this area and have potential to affect the highway if they retrogress. The pile wall system (tied back pile wall and new cantilever wall) appears to be mitigating the previously observed settlement and pavement damage issues related to the landslide movement between 33+850 and 34+000. The tied-back pile wall is designed to accommodate ongoing downslope movement of the slide mass downslope of the wall. Based on instrument data and site observations there is ongoing creep movement downslope of the wall and movement rates upslope of the wall have diminished significantly. However, SI14-4 located downslope of the tied-back pile wall was found sheared at 19.5 m depth below top of casing. A review of the surface conditions around SI14-2 and future readings is recommended as current trends show potential movement of a failure surface occurring below the pile tips.

The slide developing west of the tied-back wall has developed a very apparent scarp and is expected to considerably worsen over the next 5 years. Due to its current offset from the highway (approximately

15 m at the east end) it is not expected to have an immediate impact to the NBL; however, future retrogression could cause instability that reaches the road shoulder or further if left unmitigated. The progression of this slide area relative to any changes in the rate of creep movements below the west portion of the wall should be made following each annual inspection to determine if the two are related to a single larger slide movement (note two monitoring stakes were installed above the scarp in 2023 with locations marked on Figure PH070-1). Drainage into the disturbed slide terrain below this area is expected to be a factor as the slope loses toe support. Expansion and retrogression of the erosion gully forming downslope from the armored outlet for the pile wall drain trough could cause further destabilization at the east flank of the new slide due to soil loss.

## **Recommendations:**

### **Monitoring:**

Annual inspections should continue with the next inspection occurring in the Spring of 2025.

Continue to monitor instruments twice a year to ensure the mitigation is performing as designed and monitor development of the landslide block west of the wall.

Updated aerial imagery or drone photogrammetry survey completed every 2 to 4 years would be beneficial for tracking the rate of slide activity west of the wall and within the lower valley.

Consideration should be given to whether the camera monitoring system (installed by Queens University) for the area downslope of wall should be reinstated, or equipment moved to a different site.

The solar panel and battery requirements for the instruments with data loggers should be confirmed as the current panel appears to be insufficient. The battery charging system should be checked to ensure that the battery is charging from the solar panel. Additionally, a larger solar panel should be installed for the datalogger, to ensure that the battery stays charged.

### **Maintenance:**

- The erosion downstream of the drainage outlets should be monitored by regular visual inspection and if the condition significantly worsens, consideration should be given to extending the rock armoring or installing a drainpipe to prevent gully retrogression towards the road and potentially exacerbating landslide movement west of the tied-back pile wall.
- Drain trough along top of pile wall should be cleaned of sediment and debris every Spring.

### **Short-term Measures:**

- An investigation program should be considered for the slide at 34+050 if movement rates continue at the observed rates over the last several years. This would likely involve accessing the relatively flat bench between the current scarp and guardrail with tracked drill equipment from the highway approximately 250 m west (end of guardrail section) and drilling two to three test holes with slope inclinometers. This would allow monitoring for a potential slide surface undermining the highway and provide design input for future remediation if required. (\$100k - \$150k)

### **Long-term Measures:**

- Installation of an approximately 120 m, long tied-back pile wall if the slide at 34+050 retrogresses and undermines the highway. Depending on the extent and rate of landslide development (including results of any future investigation work) a cheaper cantilever retaining wall configuration may be a potential option that involves crest offloading/lightweight fill. If downslope movement rates progress at a slow enough rate this may provide support to the highway for 10 years or more. An option to add a future waler and tie-back anchors could also be considered in the cantilever design as downslope soil support is lost. (\$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

Tyler Clay, P.Eng.  
Geological Engineer



## 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.

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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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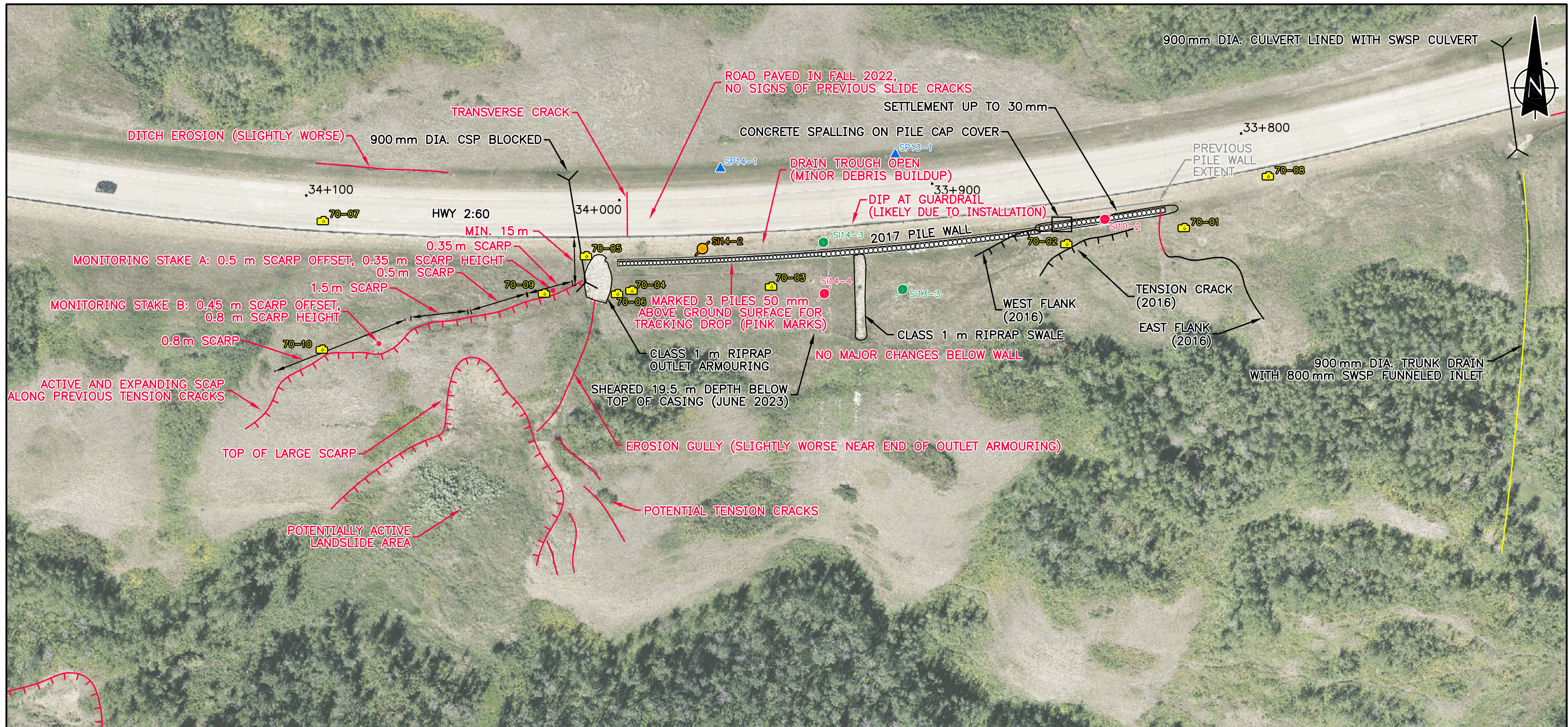
- a) Nature and Exactness of Soil and Contaminant Description: Classification and identification of soils, rocks, geological units, contaminant materials and quantities have been based on investigations performed in accordance with the standards set out in Paragraph 1. Classification and identification 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.

### 7. INDEPENDENT JUDGEMENTS OF CLIENT

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**LEGEND:**

HORIZONTAL CHAINAGE	● 33+900
PHOTOGRAPH LOCATION	📷 70-01
SLOPE INCLINOMETER	● SI 64
- NO MOVEMENT	📏 SI 82
- CREEP	📏 SI 82
- MEASURABLE MOVEMENT (OR RECENTLY SHEARED)	📏 SI 82
PIEZOMETER	▲ PN 004

- NOTES:**
- 1 FIGURE MUST BE USED IN CONJUNCTION WITH THE ATTACHED REPORT REFERENCE 32121 DATED MAY 2024 AND IS SUBJECT TO ANY LIMITATIONS DESCRIBED THEREIN.
  - 2 PHOTO BASE IMAGE COMBINED FROM 2012 AIR PHOTO (TARIN RESOURCES SERVICES LTD.), THURBER DRONE IMAGERY (2022), MACINTOSH PERRY DRONE SURVEY (2022).
  - 3 SLIDE FEATURES, PHOTOGRAPHS AND CHAINAGE ARE SHOWN APPROXIMATE ONLY.

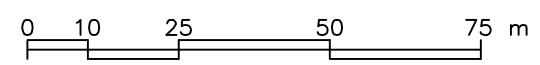
*Alberta* Transportation

**PEACE REGION (PEACE RIVER DISTRICT)**

**PEACE RIVER EAST HILL**  
**HWY 2:60 (PH070) STA. 34+200 TO 33+700**  
**LOCATION PLAN**

**FIGURE PH070-1**

DRAWN BY	ICB
DESIGNED BY	TTC
APPROVED BY	DWP
SCALE	1:1250
DATE	OCTOBER 10, 2024
FILE No.	32121-A7E





**Photo 70-01.**  
Looking west at  
concrete pile  
retaining wall at  
33+850. No major  
visible changes  
downslope from the  
wall since 2023.



**Photo 70-02.**  
Looking west from  
the east end of the  
2017 concrete pile  
retaining wall near  
33+875.





**Photo 70-03.**  
Looking east near the centre of the retaining wall with Class 1 riprap swale located near 33+950. East flank of the 2016 slide is visible in the background. SI13-3 is visible on the right side of the photo. No major changes were visible on the bench below the wall since 2023.



**Photo 70-04.**  
View east from the west end of the 2017 pile wall (34+000) on the downslope side. Similar appearance to the 2023 conditions.



**Photo 70-05.**  
View east from west end of pile wall (km 34+015) at armoured drainage outlet for the drain trough along top of wall. Trough drain was open and working as intended with some minor debris and sediment buildup. Overall no major changes from the 2023 condition.



**Photo 70-06.**  
Looking south at the top of the erosion gully at the downstream end of the armoured drainage outlet (34+015). Slightly worse but gully sidewalls have grass growth.



**Photo 70-07.**  
View along highway looking east above pile wall. No pavement disturbance was visible since the Fall 2022 repaving.



**Photo 70-08.**  
Looking west along highway above pile wall. Visible dip in guardrail (near 33+900) suspected from install and likely not related to slide related settlement that occurred prior to the pile wall. No cracking or other slide related distress was visible in pavement along previous damage extents since the highway was repaved in 2022.



**Photo 70-09.**  
Looking west from the east end of the active landslide scarp developing west of the pile wall (34+050). There was a more visible scarp with increased dropdown (up to 1.5 m deep) and the tension cracks have extended and opened up further relative to the 2023 condition.



**Photo 70-10.**  
Looking east at main scarp expansion west of the pile wall near 34+100 with increased movement since 2023. Dropdown of the scarp in this area was up to 0.8 m in height. Increase dropdown and lateral expansion along previously observed tension cracks. No major retrogression towards the highway was observed. Lower slide terrain has ongoing movement but no major visible changes.