ALBERTA TRANSPORTATION
GEOHAZARD ASSESSMENT PROGRAM
PEACE REGION (PEACE RIVER DISTRICT)
2022 INSPECTION

THURBER ENGINEERING LTD.

Site Number	Location	Name	Hwy	km
PH043A	Daishowa East Hill	Site A - Pile Wall	986:01	33.45
Legal Description		**UTM Co-ordinates**		
NE7-85-20 W5M		11V E 491380	N 6246075	

	Date	PF	CF	Total
Previous Inspection:	5-Jul-2021	6	4	24
Current Inspection:	26-May-2022	6	4	24
Road WAADT:	1080		**Year:**	2021
Inspected By:	Ed Szmata, TRANS Roger Skirrow, TRANS Max Shannon, TRANS		Don Proudfoot, TEL Tyler Clay, TEL	
Report Attachments:	☑ Photographs ☑ Plans		☑ Maintenance Items	

Primary Site Issue:	Roadway constructed across major landslide. Embankment originally stabilized by diverting unnamed creek on north side of roadway through a culvert within toe berm constructed across valley bottom. Embankment failed up to roadway requiring installation of a cantilever pile wall in 2004. Shallow slumping below the wall subsequently. Culvert outlet also became unstable and was eroding/ 'headcutting' through toe berm. Mitigation measures were completed between 2017 to 2019 that involved construction of a gabion drop structure and overflow channel to reduce rates of the creek erosion. The work also included the installation of a driven steel pile retaining wall to allow the construction of the drop structure; further regrading work across the embankment slope that slid during construction; and the construction of an armored swale to repair an erosion gully down the east edge (crotch) of the embankment fill sideslope.	
Dimensions:	Unstable roadway embankment was approximately 225 m in length. Distance from roadway to toe of slope approximately 110 m.	
Maintenance:		
Observations:	**Description**	**Worsened?**
☐ Pavement Distress		☐
☑ Slope Movement	During mitigation work a slide was initiated within the lower slope near the new drop structure that was mitigated via a driven steel pile wall. There is shallow slide activity with minor retrogression and expansion downslope of the west end of the older buried tangent pile wall (Photo 43-02). Previous cracking further east from this area have been graded during the mitigation work (Photo 43-01 and 43-04). No evidence of slope movement was observed upslope of the buried pile wall. Possible cracks related to sliding downslope and towards the east crotch riprap swale (near damaged	☐

	section) was noted (staked with lathe to monitor measuring 1.18 m offset to outside bottom).	
☑ Erosion	No change to erosion rills observed at the steel pile wall (Photo 43-03). Vegetation is more established relative to the 2021 inspection. At the culvert inlet (km 33+500) the south channel bank erosion was slightly worse with additional riprap fallen away. (Photo 43-06). The swale riprap at the east end of Site A with erosion damage from a 2019/2020 high flow event had increased damage, gullying was deeper and wider (Photo 43-13).	☑
☐ Seepage		☐
☑ Bridge/Culvert Distress	Gabion drop structure silt buildup at the base (Photo 43-03). Silt buildup at the culvert inlet (Photo 43-06).	☐
☑ Other	No significant beaver activity noted at the creek between Sites A and B.	☐

Instrumentation:

Spring 2022 measurements:
East end of Site A berm

- SI-4 – Movement at 2.1 mm/yr between 2.6 m to 6.3 m depth, 1.5 mm/yr between and 6.3 m to 8.1 m.
- SI-5 – Damaged (last reading June 2020).
- SI-6 –No discernible movement over 0.1 m to 5.0 m depth and a rate of movement of 3.7 mm/yr over 5.0 m to 6.8 m depth.

Buried Tangent Pile Wall

- SI04-1 – 14.1 mm/yr between 0.1 m to 2.6 m (127 mm cumulative above wall).
  2.6 mm/yr 1.9 m to 22.1 m (61 mm cumulative within wall)
- SI04-3 – 16.2 mm/yr between 0.1 m to 1.4 m (146 mm cumulative above wall).
  8.0 mm/yr between 1.4 m to 20.9 m (99 mm cumulative within wall)

Upslope of roadway

- SI03-6 – Creep (< 1.0 mm/yr) over 4.7 m to 6.0 m depth.

Groundwater

- Since the spring of 2021 readings, pneumatic piezometer PN03-1 showed an increase in groundwater level of 0.26 m and PN03-2 showed a decrease in groundwater level of 0.01 m.

Assessment:

Pile wall appears to be limiting sliding of area upslope of the wall and is protecting the west portion of Site A embankment. The erosion repair work should reinforce the embankment toe and reduce rates of soil loss from this area and the potential of destabilizing the upper embankment slope.
Slide activity in the lower part of the valley slope that was initiated during construction was mitigated via driven steel piles which appear effective. Instruments at the existing buried tangent pile wall indicated increased shallow slide movement rates but this is attributed to the lower slide activity during construction. There is ongoing slide activity directly below the west end of the old wall, but it appears shallow and not currently a direct threat to the highway. The embankment above the old pile wall has not exhibited signs of slide movement and slide related pavement damage has not been observed.
Erosion and sedimentation buildup was observed around the new erosion mitigation structures. Some maintenance work is required around the culvert inlet. The east crotch swale riprap requires repair to prevent expansion of the erosion damage. Due to the gradient in this area, it may need to have angular riprap or gabion mattress installed at a select points as check dams to offer containment and help reduce flow energy to reduce the risk of future washouts.
The apparent erosion gully or slide crack adjacent to the swale should be monitored for movement.

Recommendations:	Cost
Monitoring: Continue to monitor instruments twice yearly and undertake annual inspections.	-
Maintenance: Sediment buildup at the culvert should be monitored and cleaned out as required.	
Maintenance work required at the culvert inlet, swale riprap south channel bank requires shaping and additional riprap placement.	$30,000
Remove sand accumulation from side of roadway, which is causing channelization of surface runoff, resulting in erosion rills on embankment (maintenance).	$10,000
Repair the east crotch swale by backfilling the eroded base and replacing the riprap with gabion mattress	$25,000

ALBERTA TRANSPORTATION
GEOHAZARD ASSESSMENT PROGRAM
PEACE REGION (PEACE RIVER DISTRICT)
2022 INSPECTION

THURBER ENGINEERING LTD.

Site Number	Location	Name	Hwy	km
PH043B	Daishowa East Hill	Site B	986:01	33.74
Legal Description		**UTM Co-ordinates**		
NW8-85-20 W5M		11V E 491630	N 6245925	

	Date	PF	CF	Total
Previous Inspection:	5-Jul-2021	7	4	28
Current Inspection:	26-May-2022	11	5	55
Road WAADT:	1080		**Year:**	2021
Inspected By:	Ed Szmata, TRANS Roger Skirrow, TRANS Max Shannon, TRANS		Don Proudfoot, TEL Tyler Clay, TEL	
Report Attachments:	☑ Photographs ☑ Plans		☑ Maintenance Items	

Primary Site Issue:	An unnamed creek was diverted through a culvert located under a toe berm downslope of the roadway embankment. The culvert was undersized to handle the spring runoff, which overflowed and eroded the west sideslope of the toe berm. Between 2017 to 2019 mitigation was implemented that consisted of construction of a gabion drop structure, riprap berm, and armored culvert inlet within the creek area. The work also included construction of a swale to repair an erosion gully down the east edge (crotch) of the highway embankment sideslope and lining the highway ditch further east with gabion mattress and ECM.	
Dimensions:	Embankment is about 175 m long and extends 150 m below roadway to toe of slope.	
Maintenance:	.	
Observations:	**Description**	**Worsened?**
☐ Pavement Distress		☐
☑ Slope Movement	A landslide in the natural creek valley slope has moved and severed the CPP downpipe.	☐
☑ Erosion	South ditch erosion has been repaired with TRM near km 34+125 and is in good condition (Photos 43-09). Minor rills were slightly worse between the road and north ditch gabion armour at km 34+000 (Photo 43-10). Previous area of erosion rills at top of embankment at the east end of the site has been graded and TRM installed with vegetation regrowth starting (Photo 43-12). Where the TRM ends at the west end of the site there was increased rill erosion near km 33+650 (Photo 43-19)	☑

	Increased gully erosion was noted near the outlet of the CPP down pipe (33+800) due to a leaking joint caused by a local landslide movement (Photo 43-16). Minor rill erosion and poor vegetation noted in the overland flow area above the drop structure (Photo 43-07).	
☐ Seepage		☐
☑ Bridge/Culvert Distress	Culvert inlet at 33+800 is still damaged from high flow event and has severely reduced flow capacity. Additional riprap above the inlet had collapsed above it and slid down partially burying it (Photo 43-15). Piping erosion has formed a void in the previously damaged area and location where culvert joint and grouting repairs were made. The gabion baskets and mattresses in the bottom part of the drop structure have settled and tilted around the area of damage (Photo 43-08).	☑
☑ Other	Sediment and debris buildup near the culvert inlet indicative of flooding during a high flow event. (Photo 43-15)	☐

Instrumentation:

Spring 2022 Readings:

- SI-7 – No discernible movement measured.
- SI-8 –3.7 mm/yr over 0.3 m to 1.5 m depth, creep (< 1.0 mm/yr) over 1.5 m to 4.0 m depth.
- SI-9 –7.8 mm/yr over 0.3 m to 2.7 m depth.

Assessment:

The culvert and erosion control mitigation work should reinforce the embankment toe and reduce rates of soil loss from this area and the potential of destabilizing the upper embankment slope. Current erosion control measures appear mostly effective in controlling drainage at the site with the exception of the lower embankment culvert inlet (33+800) which has become damaged apparently during a high flow event. The culvert inlet requires repairs to restore full drain capacity. The end slope of the inlet should be cut steeper and shorter and possibly lined with a stronger SWSP (or reinforced within a concrete headwall) to resist hydraulic uplift forces. The riprap around the culvert needs to be reconfigured and should be "benched" into the slope as is practical to reduce displacement and sliding. The CPP downpipe requires repairs at a leaking joint, which was caused by a local landslide in the lower valley slope.

During the spring of 2018 a sinkhole developed beside the lower portion of the drop structure, caused by water flowing under pressure from a separated joint in the underlying C.S.P. culvert creating a subsurface void. The void was grouted, and the sinkhole backfilled, however distortions to the overlying gabion baskets/mattresses remain. It is believed the outlet of the C.S.P., which sits in the flow dissipation bowl, froze underwater and that the pressurized water eroded the sinkhole out the side of the pipe and drop structure. During the 2022 inspection further void formation as a result of piping erosion was observed to occur and cause displacement of the gabion drop structure and ongoing erosion damage. Repair of this area is required to prevent further damage to the drop structure and proper culvert function. The disturbed soils should be removed and then the sink hole and related erosion gully beside the gabion wall should be backfilled with Class 1 riprap over geotextile. The side of the gabion drop structure wall should be pushed back into vertical orientation as is practically possible during the riprap backfill activity. Maintenance and cleaning of the outlet to limit sediment and ice buildup prior to spring thaw will be critical to limit potential water backup and further damage. Consideration should be given to bypassing the compromised culvert joint by inserting a new internal reline pipe (e.g., expandable "slipline" or similar)

and grouting the annulus between the pipes. Alternatively, an internal band could be applied across the damaged joint using a combination of gaskets and sealing materials. Further pressure grouting would also be beneficial to reinforce the void area around the joint and limit further disturbance to the drop structure.

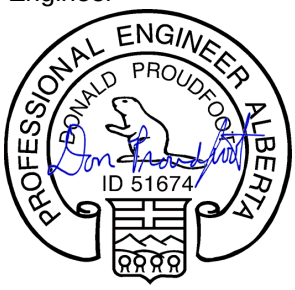
The current instrumentation indicates shallow movement (less than 3 m depth) at slow and steady rates (<10 mm/yr). No visual indicators of landslide movement are apparent on the slope. The SI closest to the highway (SI-7) has not measured movement.

Recommendations:	**Cost**
Monitoring: Continue to monitor instruments twice yearly and undertake annual inspections.	-
Maintenance: The outlet of the drop structure should be carefully cleared of excess ice and the outlet of the CSP steamed open in early Spring to limit further sinkhole expansion and damage. The void beside the drop structure should be backfilled with Class 1 rock riprap over geotextile to limit further damage.	$100k
Repairs required at the culvert inlet at the creek including, inlet replacement, riprap placement and reconfiguration, and joint repair at the CPP down pipe.	$150k
Remove sand accumulation from side of roadway which is causing channelization of surface runoff on embankments and highway ditch.	

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



October 17, 2022

PERMIT TO PRACTICE
THURBER ENGINEERING LTD.
RM SIGNATURE:
RM APEGA ID #: 51674
DATE: October 17, 2022
PERMIT NUMBER: P005186
The Association of Professional Engineers and Geoscientists of Alberta (APEGA)

Tyler Clay, P.Eng.
Geological 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

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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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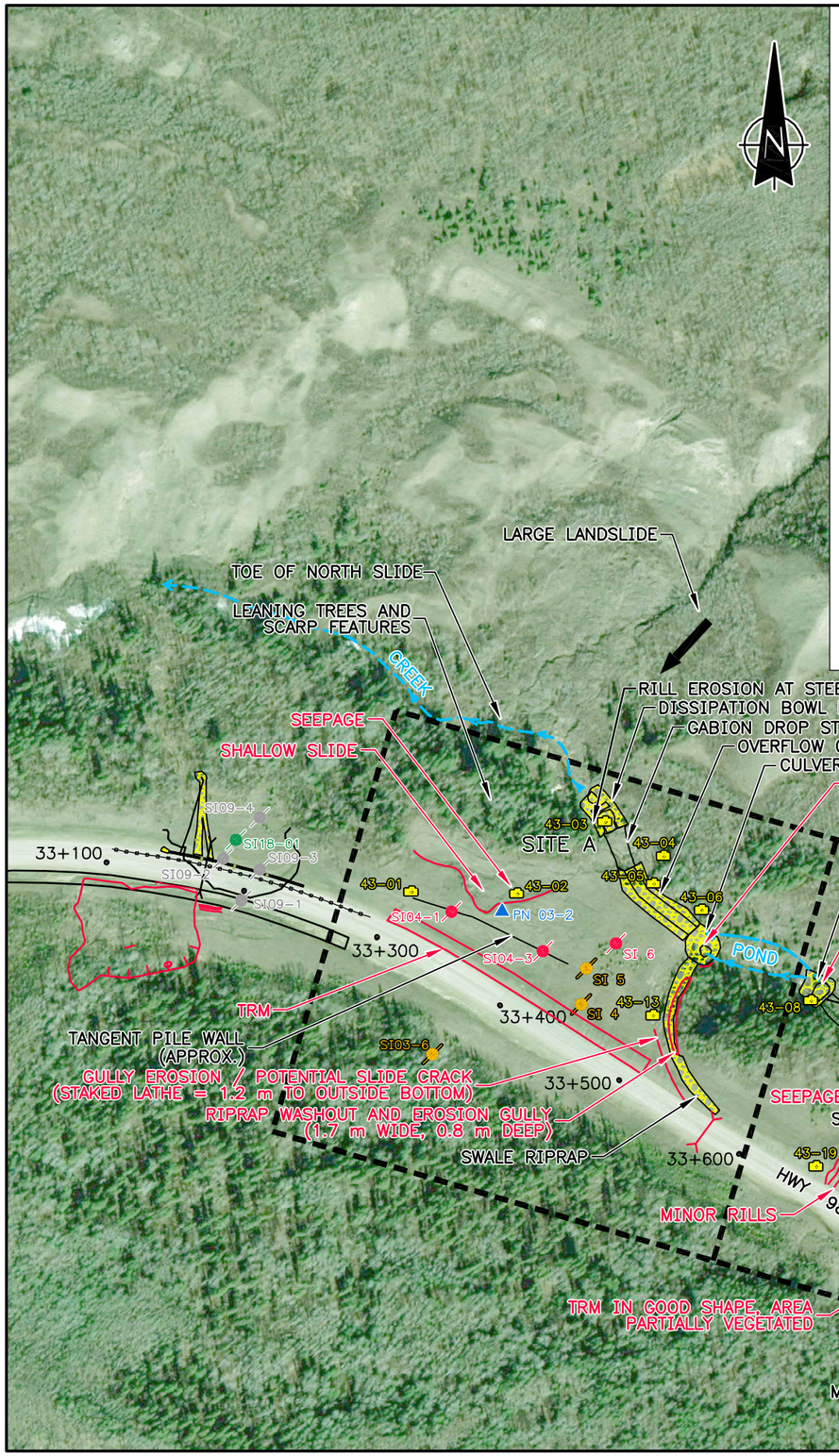

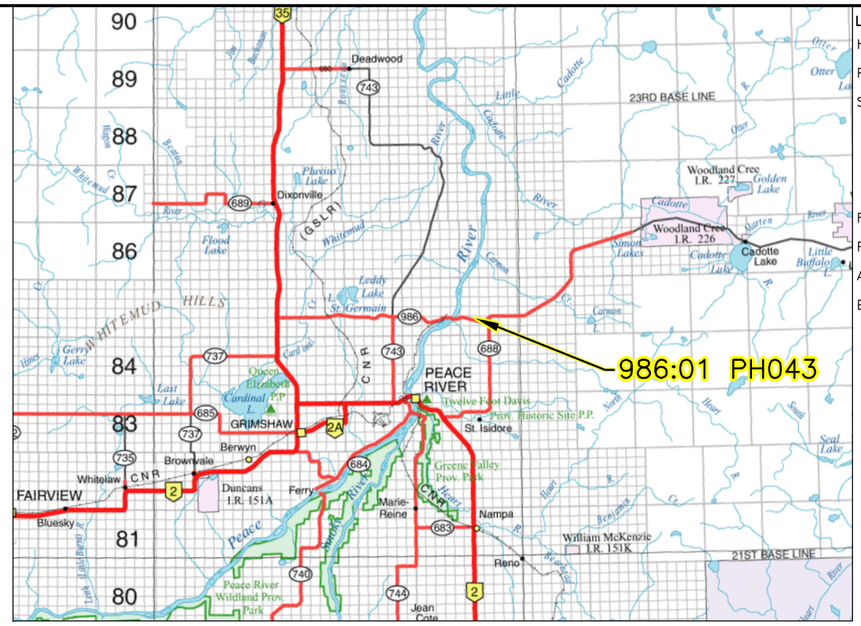

KEY MAP

SCALE 1:1 000 000

LEGEND:

- HORIZONTAL CHAINAGE — 32+100
- PHOTOGRAPH LOCATION — 43–01
- SLOPE INCLINOMETER
  - NO MOVEMENT — SI 64
  - CREEP — SI 82
  - MEASURABLE MOVEMENT (OR RECENTLY SHEARED) — SI 82
- PIEZOMETER — PN 004
- PH41 BOUNDARY
- ARMOURED CHANNEL
- EXTENT 2003 LANDSLIDE

NOTES:

1 DRAWING MUST BE USED IN CONJUNCTION WITH THE ATTACHED REPORT REFERENCE 32121 DATED OCTOBER 2022 AND IS SUBJECT TO THE STATEMENT OF LIMITATIONS AND CONDITIONS INCLUDED IN THE REPORT.

2 AIR PHOTO BASE FROM ESRI (DIGITAL GLOBE, 2016).

3 SLIDE FEATURES, PHOTOGRAPHS AND CHAINAGE ARE SHOWN APPROXIMATE ONLY.

4 BASED ON FIELD OBSERVATIONS ON MAY 26, 2022.

0 50 100 200 300 m

Alberta Transportation

PEACE REGION (PEACE RIVER DISTRICT)

DAISHOWA
HWY 986:01 (PH043)
LOCATION PLAN

FIGURE PH043-1

DRAWN BY	ICB
DESIGNED BY	TTC
APPROVED BY	DWP
SCALE	1:4 000
DATE	OCTOBER 12, 2022
FILE No.	32121–A5A

THURBER ENGINEERING LTD.

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	**Photo 43-01.** At the west edge of Site A near top of the buried pile wall looking northeast towards the overflow area and gabion drop structure. No major change from 2021.
	**Photo 43-02.** Main slide scarp of active shallow failure downslope of the buried pile wall (33+325) first observed in 2017. Area is vegetated and has shown only minor retrogression and expansion since the previous inspection.

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	**Photo 43-03.** Overflow gabion drop structure and dissipation bowl at the previous culvert outlet that had extensive erosion and gullying below Site A (33+430). Some rill erosion was noted within the fill areas that were still vegetating. Base of drop structure had a large amount of silt buildup. Minor change from 2021 condition.
	**Photo 43-04.** Looking southwest at the area of previous slumping associated with culvert erosion below pile wall (33+430). Area has since been graded and finished with straw matting.

	**Photo 43-05.** Standing at the top of the gabion drop structure looking east towards the overflow channel riprap (33+450). Vegetation has re-established.
	**Photo 43-06.** Looking south towards the culvert inlet riprap, riprap swale, and debris deflector (33+500). Note south channel bank erosion, silt buildup and erosion within the riprap swale. Slightly worse from the 2021 condition.

	**Photo 43-07.** Looking south towards the Site B highway embankment and overland flow area. Minor rill erosion is visible on the right top corner of the photo along the slope.
	**Photo 43-08.** View of the gabion drop structure and riprap dissipation bowl at the culvert outlet at Site B. (33+600). Additional erosion and gabion deformation due to piping erosion from leak in the culvert joint (left side).

	**Photo 43-09.** South ditch TRM installation at Site B to repair erosion damage and mitigate against future erosion (34+125). Ditch has well established vegetation.
	**Photo 43-10.** Looking west towards the north ditch gabion mattress installation at Site B.

	**Photo 43-11.** View of culvert inlet and riprap protection near 33+900 on north side of road.
	**Photo 43-12.** Looking west towards the TRM installation on the upper portion of the slope north of the road (33+700). Some vegetation growth has started.

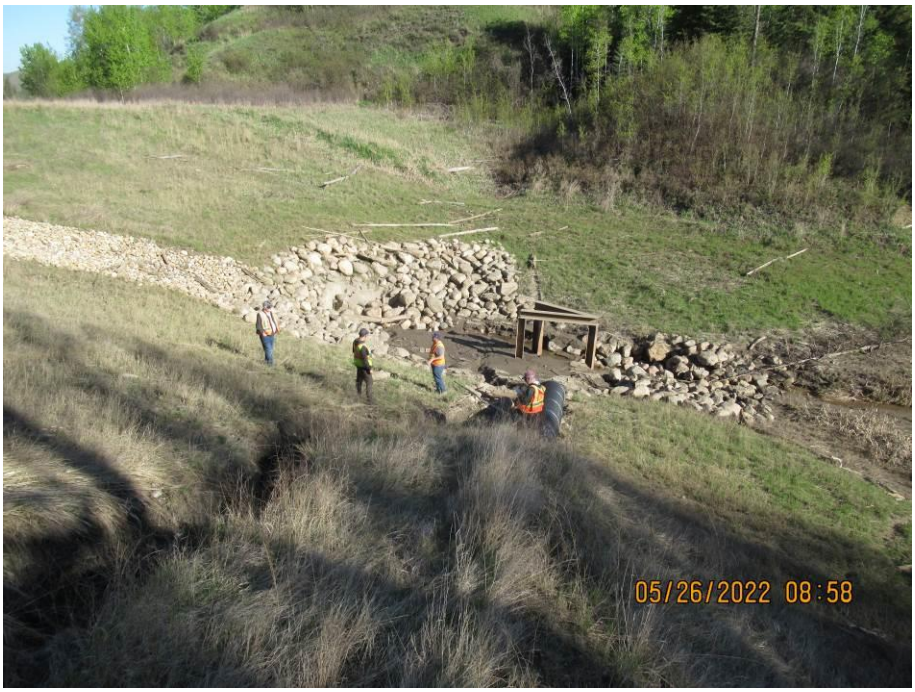
	**Photo 43-13.** Looking south, upslope towards washed out riprap and extensive erosion damage within the riprap swale at the east side of Site A (33+500), likely the result of a high-flow event in 2019/2020. Increased erosion damage since 2021.
	**Photo 43-14.** Site B culvert inlet with riprap protection and steel H-beam debris deflector. Inlet become severely damaged and blocked with fallen riprap during a high flow event in 2019/2020 (33+800). No major changes from 2021 condition. Increased erosion at gully on left side of photo. Repairs required in this area.

	**Photo 43-15.** Damage around culvert inlet due to a high flow event. Culvert pipe at the inlet was effectively pinched and twisted shut and was filled with woody debris. Riprap above the inlet had collapsed and slid down over it. No change to riprap damage or woody debris buildup. Increased silt buildup relative to 2021 condition. Repairs required in this area (33+800).
	**Photo 43-16.** Looking south towards the outlet of the CPP down pipe near the culvert inlet (33+800). Rill erosion was noted to be occurring upslope from the pipe outlet due to a leaking joint that requires repair. Increased gully erosion was noted on the right side of the pipe.

	**Photo 43-17.** Looking west towards the highway slope, overland flow area of Site B.
	**Photo 43-18.** View of the riprap berm located near the top of the gabion drop structure (33+650)

Photo 43-19.
View of the minor rill erosion near the top of the embankment of Site B (33+650) where TRM is not installed.