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

THURBER ENGINEERING LTD.

Site Number	Location	Name	Hwy	km
NC096	13 Km north of Wandering River	Wandering River Bridge (75731N)	63:04	2.85
Legal Description		**UTM Co-ordinates (NAD 83)**		
NW 12-73-17 W4		12 N6130357.92 E405776.13		

	Date	PF	CF	Total
Previous Inspection:	June 24, 2021	15	5	75
Current Inspection	June 7, 2022	15	5	75
Road AADT:	3,770		**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	Two slumps developed beside the NBL bridge south headslope. The west slump exposed NW wing wall and extended below bridge headslope.
Dimensions:	The slump on the east side of the bridge (Slump 1) is approximately 25 m wide (perpendicular to bridge alignment) and 13 m long (parallel to bridge alignment); the erosion gully to the east of Slump 1 is about 10 m wide, 20 m long, and up to 2.5 m deep. The slump on the west side of the bridge (Slump 2) is approximately 27 m wide (perpendicular to bridge alignment) and 19 m long (parallel to bridge alignment).
Site History / Available Information:	The existing bridge structure was first in service since 2014 as part of the twining of Highway 63 to Fort McMurray. As part of the bridge construction, the Wandering River was re-aligned by creating a bend that would allow a more perpendicular river flow under the new bridge. The new highway embankment was constructed by placing approximately 4 to 8 m of fill over the native ground on the south and north of the river alignment, respectively. The approach fill head slopes are inclined at 2H:1V and the north head slope also has a 2 m wide bench halfway up the slope. The side slopes of the approach fill are inclined at approximately 3H:1V on both sides of the highway. As part of the bridge construction, the wandering river channel was also realigned to the south. The three-span concrete girder bridge structure has a total length of 51 m. The abutment/wing walls are supported on driven steel H piles (310x125) and the piers are supported on 610 mm diameter x 12.5 mm thick closed end pipe piles filled with concrete. A geotechnical investigation was conducted by EBA in 2011 for the design of the existing bridge. During the 2011 geotechnical investigation, two boreholes were drilled as shown on Figures 1 and 2. Borehole BF3-2, drilled on the north highway embankment, showed that at least 0.6 m of peat were buried under approximately

	8 m of fill. Borehole BF3-1, drilled on the south highway embankment, did not encounter any peat. Both boreholes encountered clay till below either the peat or fill. The clay till extended to depths ranging between 15 to 17 m below the ground surface at the time of the investigation. BF3-1 and BF3-2 were terminated in sandstone at elevations of 541 m and 542 m, respectively. Groundwater was measured at an elevation of 561 m and 563 m on the north and south embankments, respectively. The bridge headslope was designed with a factor or safety of 1.3, which is less than typically recommended for bridge headslopes (i.e., a FOS of 1.5). Review of satellite images indicate that the highway NBL east ditch conveys surface drainage from a low-lying area about 135 m to the south of the bridge to the re-aligned creek channel; the images also show that a riprap lined channel was constructed at the mouth of the east ditch within the riverbank slope. Slumping of the riverbank by the bridge head slope was first noted by Alberta Transportation on August 28, 2020. A geotechnical investigation, consisting of drilling four test holes along with the installation of slope inclinometers and piezometers, was completed by Thurber in 2020. The test holes showed the soil conditions mainly consist of medium to high plastic clay fill over high plastic clay over clay till.

Maintenance /Repairs	**None**	
Observations:	**Description**	**Worse?**
☑ Pavement Distress	10 to 20 mm dip within the south approach slab; worse area within the western lanes	☐
☑ Slope Movement	A slump developing on each side of the bridge headslope. Slump 1 on the east side of the highway: head scarp cracks up to 1.5 deep and 1.5 m wide. Slump 2 on the west side of the highway: head scarp cracks up to 4 m deep and 1 m wide; multiple tension cracks within the Slump 2 slide area. The eastern flank of Slump 2 extends under the bridge by at least 2 m, but it is not exposing the abutment or pile supports. Slump 2 sheared off existing 150 mm diameter subdrain pipe and developed a 200 mm gap under the southwest wing wall. Both slumps 1 and 2 are toeing out into the river channel and are narrowing the river channel by approximately 1.2 m.	☐
☑ Erosion	Erosion developed east of Slump 1 at the mouth of the north facing riprap lined channel. Erosion became worse in 2022 and it is approximately 2.5 m deep and has distorted the existing riprap within the channel. Scattered and subdued riprap areas along the outside bend of the river channel	☑
☑ Seepage	Seepage along exposed scarp crack surfaces not observed during the 2022 inspection; ground within the landslide areas was dry. Beaver dam that used to block muskeg terrain drainage path located east of the highway southbound lanes was removed and did not	☐

	reappear in 2022	
☑ Bridge/Culvert Distress	Slumps 1 and 2 are getting larger; Slump 2 continues to impact the bridge northbound lanes headslope	☐
☐ Other		☐

Instrumentation Readings (Two SP and Four VW Piezometers):

SI20-1, installed within Slump 1 to the east of the bridge, sheared off at showed at a depth 1.5 m below ground surface. Prior to shearing off, SI20-1 showed a maximum rate of movement of 292 mm/yr. SI20-3, installed within Slump 2 to the west of the bridge, sheared off at 2.1 m below ground surface. Prior to shearing off, SI20-3 showed a maximum rate of movement of 103.1 mm/yr.

Standpipe piezometers SP20-2 and SP20-4 showed groundwater depths of 2.1 m and 4.0 m, respectively, corresponding to decreases in groundwater level of 0.4 m and 0.7 m since the piezometers were last read in October 2021.

Vibrating wire piezometers VW20-1A, VW20-1B and VW20-3A show current groundwater depths of 1.50 m, 1.03 m, and 1.08 m, respectively. VW20-3B currently shows an above-ground (artesian) groundwater level of -2.54 m. The vibrating wire piezometers showed increases in groundwater level of 0.1 m in VW20-1A and 0.5 m in VW20-A and decreases in groundwater levels of 0.47 m in VW20-1B and 1.02 in VW20-3B since the instruments were last read in October 2021.

Assessment (Refer to attached Figures and Photos)**:**

The site condition did not change significantly since the 2021 site inspection.

The placement of relatively steeply inclined deep high plastic clay fill (i.e., 2H:1V), elevated groundwater levels within the slope, potential winter construction of embankment fills, and ongoing toe erosion by the river are considered to be the triggering factors for the observed landslides. In addition, the existing riprap (mainly Class 1M) along the riverbank is relatively smaller in size than what is typically used to armour riverbanks in similar bridge projects.

The placement of geogrid layers within the south headslope was recommended in EBA's geotechnical report to achieve the target factor of safety. It is suspected that the geogrid layers were not placed outside the footprint of the bridge, and this may have been another contributing factor to observed instabilities. However, there are no detailed construction notes/records to confirm this hypothesis.

The presence of a beaver dam and ponding water to the east of the highway may have resulted in saturation of the highway embankment and riverbank slopes to the east of the bridge. Field observations from the 2020 inspection indicated that ponded water may have overtopped/breached the dam during a prolonged heavy rainfall event and high flow velocities may have caused the severe erosion to the east of the bridge and saturated the east slump (Slump1). Removal of the beaver pond helped reducing groundwater levels within the mass of Slump1.

The slumps did not appear to have yet impacted the integrity of the bridge and the highway. However, Slump 2 has exposed the base of the NW wing wall and its flank extended below the headslope of the bridge downslope of the abutment location. Slump 2 is considered more critical than Slump 1 in terms of its potential impact on the highway and the bridge conditions.

The landslides are very active, moving at very high rates and will continue to grow bigger in size. Future erosion of the toe of the landslides at the river location and/or rise in groundwater levels within the landslides may result in (a) failure of the majority of the headslope under the bridge deck, (b) distress of the wing walls and exposure of abutment seat and a few of the pile supports (particularity at Slump 2 location), and (c) possibly intolerable lateral movement of the bridge abutment, wing walls and piles. In addition, the complete failure of these closely spaced slumps, if occurs with time, may also restrict the width of the river channel and results in flooding of areas located upstream of project

area.

If the roadway/bridge fail at this location in response to the ongoing landslide movements, a major detour will be required. However, the SBLs may be used to accommodate traffic through this area.

Recommendations:

This site should be visited again in the spring of 2023.

The conditions of the landslides present a serious hazard (in particular Slump 2) that may impact the bridge structure if repairs are not addressed in the near future.

Short-Term Repair Measures

In the short term, consideration should be given for the following:

- Monitor the highway periodically for signs of distress and watch closely for the development of new cracks or widening of existing cracks.
- Monitor existing cracks under the bridge headslope and check for signs of movement of the headslope.
- Place heavy rock riprap (Min. Class 1) at the base of the slumps (near the river location) to provide additional buttress and erosion protection.
- Reshape the failed riprap-lined channel and add heavy rock riprap (Min Class 1) to armor the re-graded channel.
- Undertake slight grading to seal open cracks within landslide masses.
- Insert a flexible HDPE pipe into the void below the NW wing wall to convey as much flow as possible from the location of the sheared off subdrain pipe to the creek channel.

Long-Term Repair Measures

The long-term repair may include be one of the following options:

Option 1:

Dig and replace the landslide mass of slumps 1 and 2 using granular fill.

It should be noted however that the repair of Slump 2 could be tricky due it its proximity to the headslope and the feasibility of this option should be assessed during the detailed design. The other challenge associated with this option is excavating failed mass below the creek level (if needed), which may require the installation of a light sheet pile wall at the at the toe of the slope to provide a cut-off wall.

The ballpark cost of this option would be in the range of $900,000 (excluding engineering). If light sheet piles are used to provide a cut off for construction purposes, the estimated cost will increase by an additional $300,000.

Option 2:

- Install continuous pile walls (30 m long x 15 m deep each) approximately halfway down the failed slope, perpendicular to and on both sides of the highway embankment to stabilize the landslide movements.
- Regrade the slopes above and below the concrete pile wall.
- Undertake minor regarding of the impacted area under the bridge.

The ballpark cost for this option would be in the range of 1.5 Million (excluding engineering).

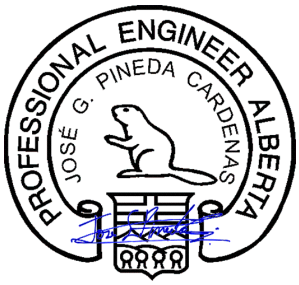
Any of the above measures will include re-shaping and armoring the eroded gully and failed banks with heavy rock riprap (at least Class 1), subject to the completion of a hydrotechnical study. The installation of soil nails under the bridge to enhance the FOS of the bridge headslope is also recommended. The additional cost to install and place soil nails (10 m deep, 1.5 m apart) will be in the range of $400,000.

Environmental approvals will be required to undertake the in-stream work, and Restricted Work Activity Period (RAP) in the stream will impact the schedule of the repair project.

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.

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 | 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.

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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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H:\3200\32122 AT GRMP Athabasca and Fort McMurray Districts 2021-2025\CAD\2022\JGP\32122 NC096 Drawings.dwg - 1 - Oct. 12, 2022

NW 12-73-17-4

CLASS 1M RIPRAP

REALIGNED CHANNEL

NEW CHANNEL

OLD CHANNEL

SUBDUED ZONE

2:1 (MIN)

R=50

WANDERING RIVER

DRAIN

DISTINCT TOE ROLL (SAME 2022)

SLUMP 1

CRACKS: 30mm WIDE X 10mm DEEP

100mm DEEP

2.5m DEEP (2022)

STRAW BALES

SEVERE EROSION ALONG RIPRAP ARMORED CHANNEL (MIX OF CLASS 1M AND CLASS 2 RIPRAP) DOWNSTREAM OF BEAVER DAM (SAME 2021)

1~2m DROP x 0.8m WIDE

45.00 NEW R/W

500mm DEEP (2022)

NEW GULLY, 900mm DEEP, 2.7m WIDE (2022)

WATER FLOWING IN DITCH (2021)
SLOWLY FLOWING IN 2022

DRAINAGE FROM LOW-LYING AREA

PONDING WATER (2022)

BEAVER DAM, REMOVED BY AT IN THE FALL OF 2020 (SOME DEBRIS LEFT IN PLACE AFTER REMOVAL OF BEAVER DAM)

DISTURBED / SCATTERED RIPRAP (WATER FLOWING UNDER RIPRAP) (SAME 2022)

0.8m DROP x 1m WIDE (2020)
1.5m DROP x 1.5m WIDE (2021, 2022)

SI20-1/ VW20-1A/ WV20-1B

15m SP20-2

SUBDRAIN PIPE (DRY IN 2021) (SAME 2022)

CRACK (50mm WIDE X 10mm DEEP) (SAME 2021, 2022)

CRACK (40-70mm WIDE X 40mm DEEP X NO DROP) (SAME 2022)

DRAIN TROUGHS

APPROACH SLAB: 10 TO 20mm DROP, THE DROP IS MORE DISTINCT ON THE WESTERN HALF BETWEEN YELLOW LINE AND EDGE OF PAVEMENT (SAME 2022)

1m WIDE x 0.7-2.2m DROP (2020), 1m WIDE x 0.8-3.8m DROP (2021)

1.1m DROP (2021)

GRABEN FEATURE (NOT VISIBLE IN 2021)

15m SP20-4

4.0m DROP (SAME 2022)

0.7m WIDE X 1m DROP

GABION MATTRES (10m WIDE): 4m BOTTOM AND 3m SIDESLOPES INCLINED AT 5H:1V ON BOTH SIDES OF THE CHANNEL

SHEARED AT 3.0m

SI20-3/ VW20-3A/ WV20-3B

1m DROP

2m DROP

150mm DIAMETER SUBDRAIN PIPE (FLOWING IN 2020)

DISTINCT TOE ROLL (SAME 2021, 2022)

SLUMP 2

600mm DROP

0.9m WIDE x 0.5m DROP (2020)
0.9m WIDE X 0.9m DROP (2021)

CRACK: 40mm WIDE X 30mm DEEP

CRACK: 100mm WIDE X 30mm DROP

CP690

EXISTING BRIDGE

APPROACH SLAB SETTLED AND CAUSED A HUMP AT END OF BRIDGE

ASCM 55112-7

APPROACH SLAB SETTLED AND CAUSED A HUMP AT END OF BRIDGE

GAP: 500mm WIDE X 500mm DEEP X 2m LONG (GAP EXPOSED THE 300mm THICK APPROACH SLAB)

SLUMP 3

SEVERE PAVEMENT DISTRESS WITH MULTIPLE POTHOLES CRACK, 200 - 250mm WIDE X 40 - 50mm DROP

CRACK: 60mm WIDE X 25mm DEEP

TH BF3-1

TH BF3-2

HWY 63 NBL

HWY 63 SBL

STA 58+370.00

58+500

58+450

58+400

58+350

58+300

13+350

13+300

13+250

13+200

3+300

3+250

3+200

3+150

15.7

7.5 TYP

55.00

50.00 R/W

A

A'

PP

LEGEND

- APPROXIMATE INSTRUMENT LOCATION (DEPTH (m))
- APPROXIMATE TEST HOLE LOCATION (BY EBA)
- ACTIVE HEADSCARP (APPROXIMATE)
- EXISTING RIPRAP (150 - 250mm)
- TREE LINE (APPROXIMATE)
- PHOTOGRAPH NUMBER, AND APPROXIMATE DIRECTION AND LOCATION
- SI SLOPE INCLINOMETER
- VW VIBRATING WIRE PIEZOMETER
- SP STANDPIPE PIEZOMETER

NOTE:
1. JUNE 7, 2022 OBSERVATIONS ARE SHOWN IN RED.

0 10 20 30 40 50m
SCALE 1:800

BASE PLAN PROVIDED BY ALBERTA TRANSPORTATION DRAWING 35349-P

Alberta

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

NC096: HWY 63:04 WANDERING RIVER BRIDGE (km 2.85) SITE PLAN SHOWING APPROXIMATE SITE FEATURES

FIGURE 1

DRAWN BY	ML
DESIGNED BY	JGP
APPROVED BY	TSA
SCALE	1:800
DATE	OCTOBER 2022
FILE No.	32122

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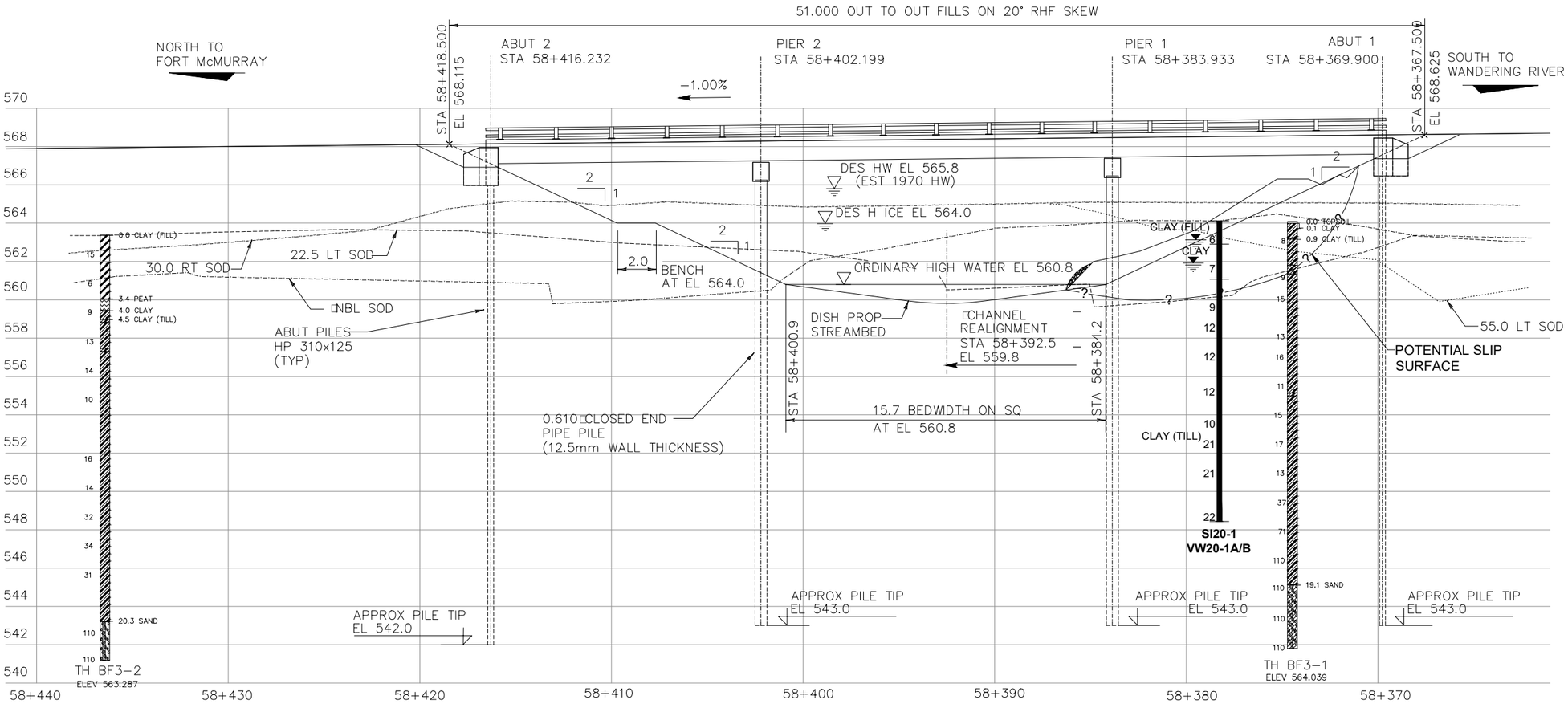

NOTES:

1. JUNE 7, 2022 OBSERVATIONS ARE SHOWN IN RED.
2. SLUMP 1 IS WITHIN THE RIVERBANK SLOPE TO THE EAST OF THE BRIDGE HEADSLOPE.

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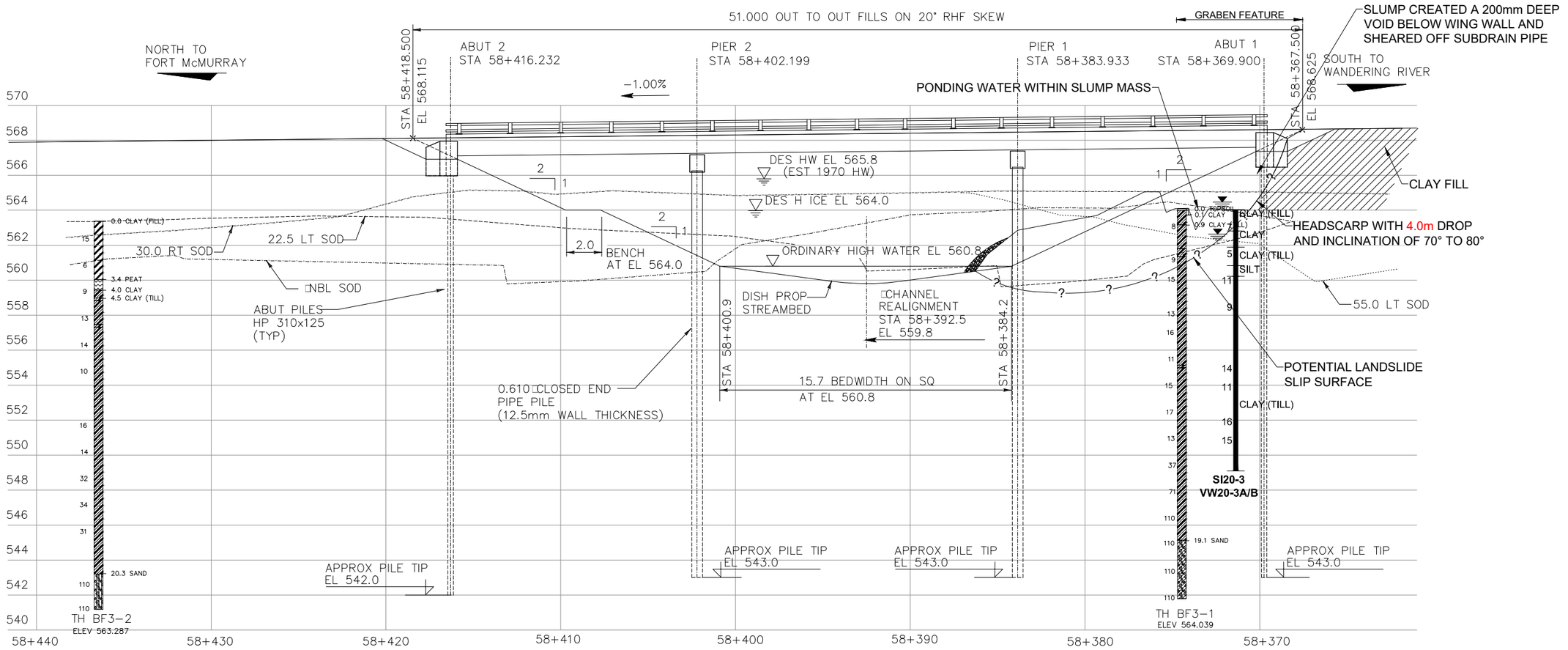
NORTH CENTRAL REGION
(ATHABASCA AND FORT MCMURRAY DISTRICTS)
2022 GEOHAZARD ASSESSMENT

CROSS - SECTION A - A'
SHOWING SLUMP 1 - EAST OF BRIDGE HEADSLOPE

FIGURE 2

DRAWN BY	ML
DESIGNED BY	JGP
APPROVED BY	TSA
SCALE	1:250
DATE	OCTOBER 2022
FILE No.	32122

THURBER ENGINEERING LTD.



NOTES:

1. JUNE 7, 2022 OBSERVATIONS ARE SHOWN IN RED.
2. SLUMP 2 IS WITHIN NORTHWEST APPROACH FILL TO THE WEST OF BRIDGE HEADSLOPE. THE EASTERN FLANK OF THE SLUMP EXTENDS INTO BRIDGE HEADSLOPE.
3. SLUMP 2 IS TOEING OUT NEAR THE MOST WESTERN BRIDGE PIER SUPPORT.

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

CROSS - SECTION A - A'
SHOWING SLUMP 2 - WEST OF BRIDGE HEADSLOPE

FIGURE 3

DRAWN BY	ML
DESIGNED BY	JGP
APPROVED BY	TSA
SCALE	1:250
DATE	OCTOBER 2022
FILE No.	32122

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Photo No. 1 – Looking northeast from the south side of the bridge at the low lying area within the bush. This area was flooded in 2020, but it is currently drained due to beaver dam removal by AT in the fall of 2020

Photo No. 2 – Looking south at the highway west ditch; water is draining towards the eroded ditch to the east of the bridge location

Photo No. 3 – Looking north at north facing riprap channel to the east of the bridge location. Note erosion along the channel.

Photo No. 4 – Looking southeast at the same area in Photo No. 3

Photo No. 5 – Looking west at river channel; Note slumping within the riverbanks to the east (slump 1) and the west (slump 2) of the south headslope location and the distinct toe rolls in the river channel.


Photo No. 6 – Looking southwest at Slump No. 2

Photo No. 7 – Looking east at the head scarp crack of Slump No. 2

Photo No. 8 – Looking southeast at Slump No. 2 flank. Note: (a) void developed under wingwall, (b) change in soil type between the area under the bridge and the area beyond (west of) the wing wall, and (c) eastern flank of slump extending below the bridge headslope

Photo No. 9 – Looking east at the portion of the head slope impacted by Slump No. 2

Photo No. 10 – Looking north at the bridge south approach slab; there is a slight dip in the highway surface, and it is more noticeable within the western half between the yellow line and the edge of pavement above Slump 2