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

THURBER ENGINEERING LTD.

Site Number	Location	Name	Hwy	km
NC091-1 NC091-2	NBL - 5 to 6 Km south of Wandering River	**HWY 63-02 BACKSLOPE SLUMPS**	63:02	39.27 and 40.28
Legal Description		**UTM Co-ordinates (NAD 83)**		
NC091-1: **6 km** south of Wandering River		NC091-1 N6113146.92	E405688.87	
NC091-2: **5 km** south of Wandering River		NC091-2 N6112146.20	E405659.10	

	Date	PF	CF	Total
Previous Inspection:	June 24, 2020	11 11	3 3	33 (NC091-1) 33 NC091-2)
Current Inspection:	June 07, 2022	13 11	3 3	39 (NC091-1) 33 (NC091-2)
Road AADT:	3,970		**Year:**	2021
Inspected By:	Tarek Abdelaziz, José Pineda (Thurber) Arthur Kavulok, Amy Driessen, Rishi Adhikari (TRANS)			
Report Attachments:	☑ Photographs ☑ Plans ☐ Maintenance Items			

Primary Site Issue:	Active landslides toeing out in the highway east ditch, encroaching into private lands, but not impacting the highway
Dimensions:	**NC091-1:** The slide is 150 m wide (parallel to the highway), 26 m long (perpendicular to the highway), and the backslope is 8 m high (from the crest to the toe) and inclined at 3H:1V. **NC091-2:** The slide is 110 m wide (parallel to the highway), 35 m long (perpendicular to the highway), and the backslope is 7 m high (from the crest to the toe), and inclined at 3H:1V
Maintenance:	None

Observations:	Description	Worse?
☐ Slope Movement	**NC091-1:** Up to 3.5 m high head scarp crack in the farmer's field; seven fence posts hanging. The depth of the tension cracks within the landslide mass are 400 mm to 1.8 m deep and 300 mm to 700 mm wide. The toe roll is partially blocking the ditch and it is about 1 m high. **NC091-2: 1** Head scarp crack did not retrogress significantly during the 2022 inspection. The depth of tension cracks ranged between 200 mm and 2 m and the width ranged between 600 mm and 700 mm. The toe of the landslide is about 1.8 m high, and it is partially blocking the ditch.	☑
☑ Seepage	**NC091-1 and NC091-2:** wet landslide mass; ponding water within few locations of the landslide mass; toe roll partially blocking water flow along the ditch; catch water ditch near the crest of both slides was impacted by the landslide movement and water from the catch water ditch saturated the landslides.	☑

☑ Other	**NC091-1:** A severe erosion gully developed within the farmer's field; the gully is about 12 m long x 12 m wide with 1.3 m drop at the deepest location. **NC091-2:** Severe erosion around the half pipe and the riprap apron; erosion extended to the south of the catch water ditch into private land; half pipe got completely separated from culvert near the top of the slope; landslide mass became more vegetated than observed in 2020.	☑

Instrumentation (1SIs and 4PNs):

NC091-1: SI18-1 was installed near the toe roll, and SI18-2 near the crest of the landslide. SI18-2 was sheared off at about 3.0 m depth below ground surface a few months after installation. SI18-1 has a current rate of movement of 2 mm/yr at 1.4 m depth and the movement rate increased by 6.1 mm/yr since the previous readings in the spring of 2021.

Groundwater levels ranged between 8.2 m in PN18-2B to 9.0 m in PN18-1. The water levels did not change significantly since the previous readings. PN18-2A was damaged during the 2022 inspection, but the highest recorded groundwater level in PN18-2A was 1.1 m below ground surface in the spring of 2018.

NC091-2: SI18-3 was installed near the toe roll, and SI18-4 near the crest of the landslide. SI18-4 was sheared off at about 3.4 m below the top of casing a few months after installation. SI18-3 was damaged, likely by a lawnmower, and has not been read since the spring of 2019.

Groundwater levels ranged between 1.7 m in PN18-4A (near surface clay) to 12.7 m in PN18-4B (in the clay till). The water levels increased since the previous readings in the spring of 2021 by 0.1 m and 0.4 m in PN18-4B, and PN18-4A, respectively. PN18-3 was damaged during the 2022 inspection but the highest recorded groundwater level in PN18-3 was 5.1 m below ground surface in the fall of 2018.

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

The backslope landslides continued to be active, but NC91-1 appears to be moving at a higher rate than NC91-2 based on the site observations. Therefore, the Probability of Failure for the NC91-1 site was increased from 11 to 13.

The landslides are shallow and do not appear to extend below the highway ditch bottom. The soil within the backslopes consist of 3 to 4 m of soft to firm high plastic clay with occasional sand/silt pockets underlain by sand and clay till. A sand layer was however noted in the test hole near the crest of he NC91-1 site. The slip surface is within the high plastic clay at both sites. Piezometer readings indicate that groundwater levels in the clay are much higher than the underlying strata. It is likely that the slumps have been triggered due to ground water seepage (likely from the catch water ditch) into the clay though the sand/silt pockets resulting in softening of the clay and hence loss of its strength. The failure of half pipe at NC92-2 may have aggravated the situation. In addition, the backslopes appear to be relatively steep, when considering the high plasticity of the clay and the heights of the slope, and this may have been another contributing factor to the observed failures.

It is anticipated that both slumps will continue to be active and retrogress to cause further loss of private lands. Future prolonged heavy rainfall events are anticipated to increase groundwater levels in the landslides resulting in accelerated movements. In addition, the existing catch water ditches near the crest of both landslides have been impacted by the landslides and water is being discharged into both landslide masses. Surface water discharge into the landslide mass at both sites will continue to elevate groundwater levels in the slopes.

The presence of open wide cracks and erosion gullies within the private properties is a safety concern.

The landslide debris is partially blocking the highway ditch at both locations and hence impeding surface drainage in the highway ditch. This may result in elevated groundwater levels in the highway embankment and potential instabilities in the future.

Recommendations:

It is recommended to visit these sites again in 2024.

Short-Term

The owners of the land parcels located near the top of the backslope at both slump locations should be advised of the risk that exists at these locations.

The local MCI should consider the following:

(a) undertake slight grading of the highway ditch at the slump locations, as needed, to promote surface drainage. Excavated material from the ditch should be pushed back against the toe of the slope. Excessive removal of landslide debris from the toe of the slope could result in accelerated movement,

(b) seal open cracks in the slope surface to reduce surface water infiltration into the slide mass. A small track mounted equipment could be used to smoothen the slope surface and fill in any dips without causing significant changes in grade,

(c) place a snow fence around areas impacted by the landslide within the private lands or backfill these areas to eliminate existing hazard. However, this can only take place after consultation with the landowner(s).

Long-Term

There are two potential general approaches that could be considered for the repair of these sites:

1. Excavate and replace the slide material with imported low to medium plastic clay and reconstruct the slope at the original inclination (3H:1V). In this option, a gravel drainage blanket should be included along the back and at the base of the excavation to promote drainage. At least two subdrain pipes will need to be included along the base of the excavation within the drainage blanket to direct the flow into a controlled manner into the ditch; or

2. Excavate and reconstruct the backslope to 4H:1V or flatter. In this option, excavated materials will need to be reworked (moisture conditioned) before being recompacted, if the material is deemed suitable. A drainage blanket and closely spaced subdrains will need to be included in the reconstructed slopes to promote drainage. Acquisition of additional ROW will be required if it is decided to pursue this option.

For any of the above options, the subdrain pipes will need to daylight into the highway ditch. Riprap protection of the ditch will be needed within the repaired area to prevent future erosion issues.

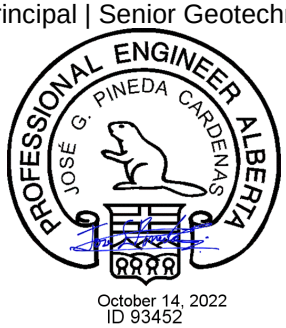
At both sites, the catch water ditch will need to be reconstructed using low to medium plastic clay, realigned to be a few meters away from the top of the slope in the vicinity of the landslides, and lined with an impervious barrier to prevent further erosion and saturation of the slopes. At NC091-2, it is possible to re-grade the catch water ditch to drain towards a centerline culvert located south of the site at approximate km 40.090. During construction, the catch water ditch flow will need to be temporarily diverted away from the slope repair area.

The estimated cost of repairing each site would range from $500K to $700K 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



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 | Geotechnical Engineer

THURBER

STATEMENT OF LIMITATIONS AND CONDITIONS

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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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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.

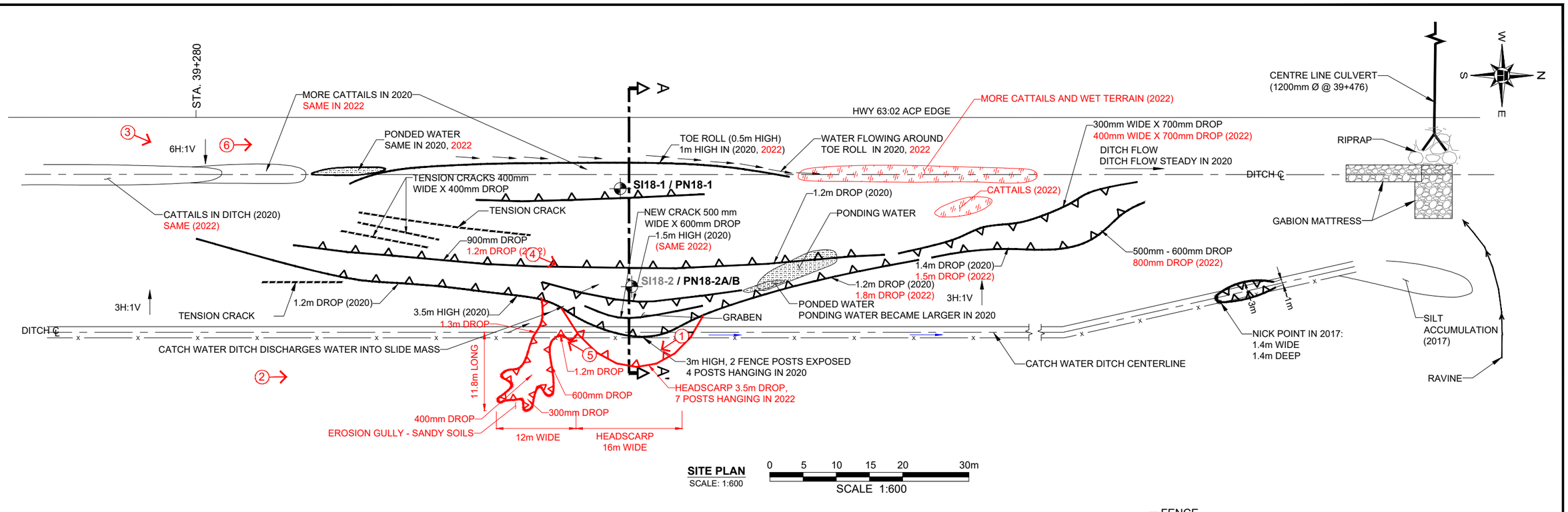
6. RELEASE OF POLLUTANTS OR HAZARDOUS SUBSTANCES

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

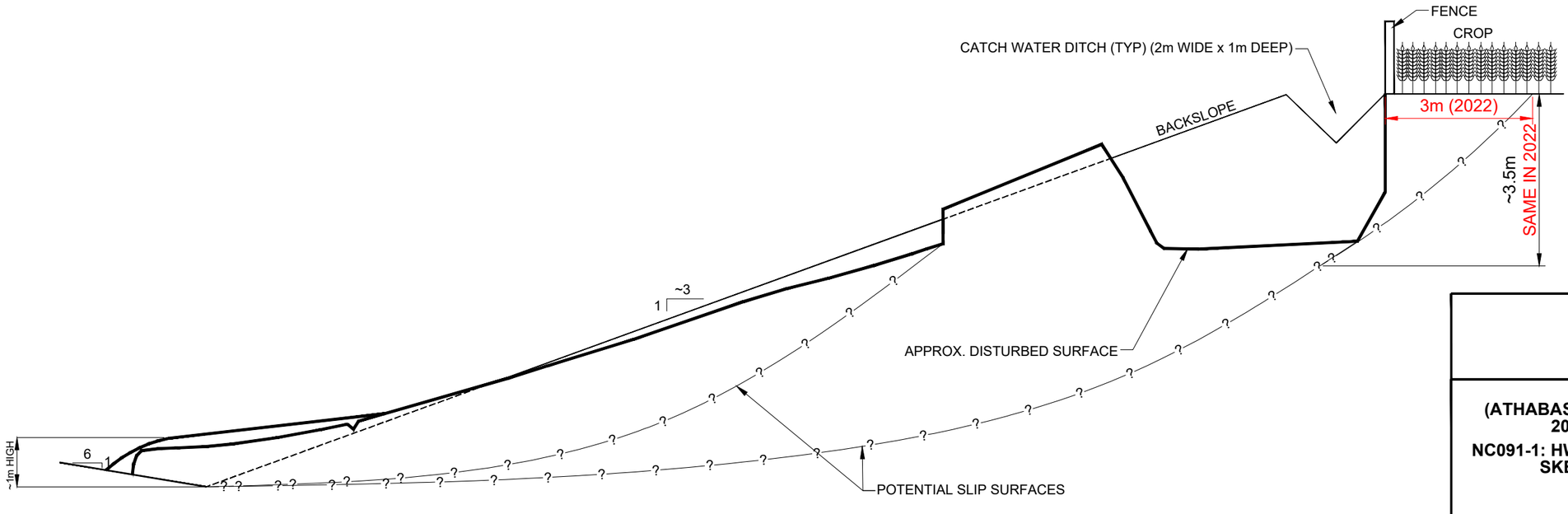
The information, interpretations and conclusions in the Report are based on Thurber's interpretation of conditions revealed through limited investigation conducted within a defined scope of services. Thurber does not accept responsibility for independent conclusions, interpretations, interpolations and/or 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.

H:\32000\32122 AT GRMP Athabasca and Fort McMurray Districts 2021-2025\CAD\2022\JGP\32122-NC091 FIGURE 1~2.dwg - 1 - Oct. 11, 2022



SITE PLAN
SCALE: 1:600

0 5 10 15 20 30m
SCALE 1:600



CROSS - SECTION A - A'
APPROX. SCALE: 1:100

NOTE:
1. CROSS - SECTION DRAWN BASED ON SIMPLE FIELD MEASUREMENTS AND MAY DEVIATE FROM THE ACTUAL GROUND PROFILE.
2. JUNE 7, 2022 SITE INSPECTION OBSERVATIONS SHOWN IN RED.

LEGEND
- APPROXIMATE INSTRUMENT LOCATION
- SCARP CRACK (APPROXIMATE)
- PHOTOGRAPH NUMBER, AND APPROXIMATE DIRECTION AND LOCATION

Alberta

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

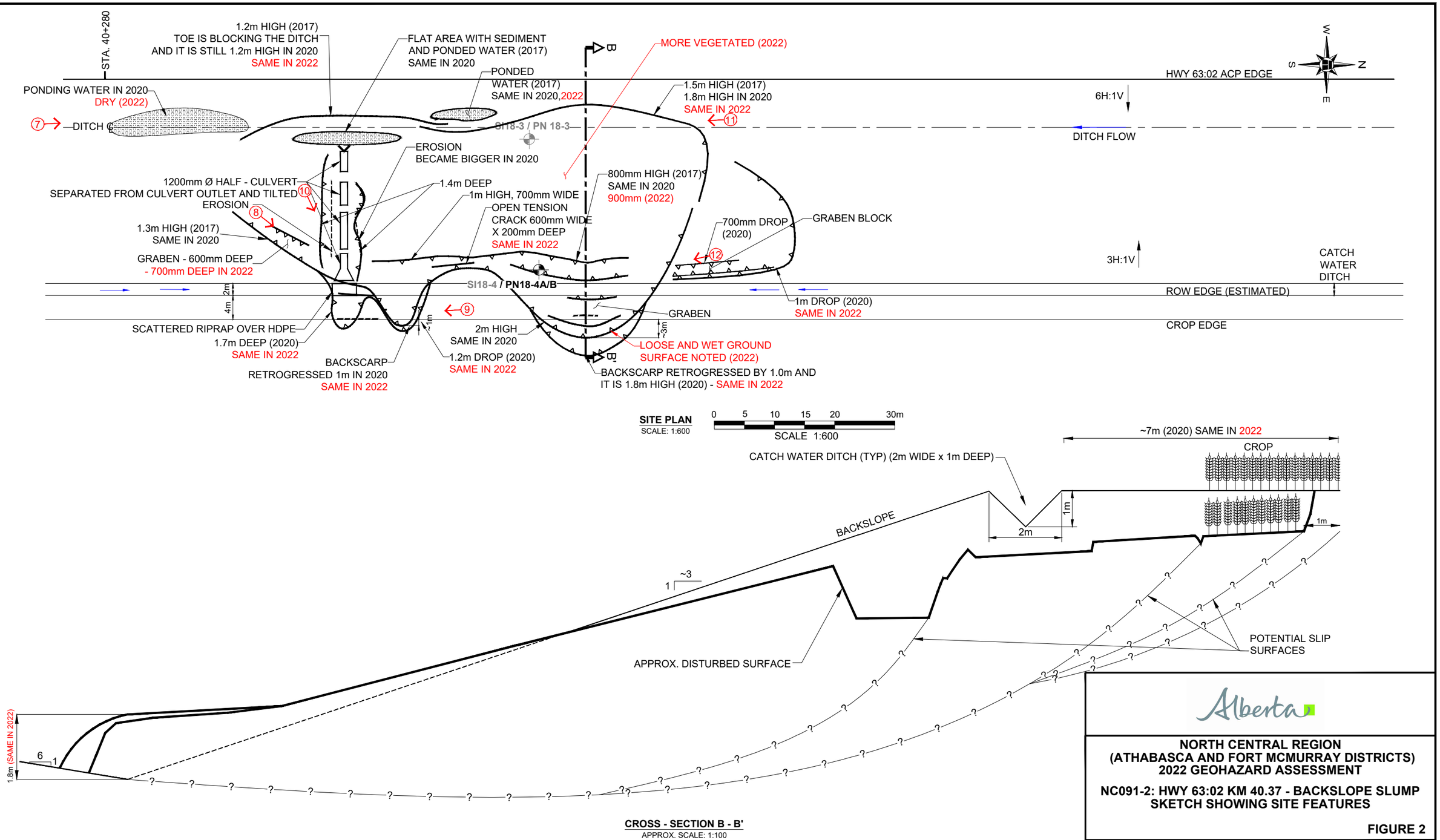
NC091-1: HWY 63:02 KM 39.35 - BACKSLOPE SLUMP
SKETCH SHOWING SITE FEATURES

FIGURE 1

DRAWN BY	ML
DESIGNED BY	JGP
APPROVED BY	TSA
SCALE	AS SHOWN
DATE	SEPTEMBER 2022
FILE No.	32122

THURBER ENGINEERING LTD.

H:\32000\32122 AT GRMP Athabasca and Fort McMurray Districts 2021-2025\CAD\2022\JGP\32122-NC091 FIGURE 1~2.dwg - 2 - Oct. 11, 2022



SITE PLAN
SCALE: 1:600

0 5 10 15 20 30m
SCALE 1:600

CROSS - SECTION B - B'
APPROX. SCALE: 1:100

LEGEND

- APPROXIMATE INSTRUMENT LOCATION
- SCARP CRACK (APPROXIMATE)
- PHOTOGRAPH NUMBER, AND APPROXIMATE DIRECTION AND LOCATION

NOTE:
1. CROSS - SECTION DRAWN BASED ON SIMPLE FIELD MEASUREMENTS AND MAY DEVIATE FROM THE ACTUAL GROUND PROFILE.
2. JUNE 7, 2022 SITE INSPECTION OBSERVATIONS SHOWN IN RED.

Alberta

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

NC091-2: HWY 63:02 KM 40.37 - BACKSLOPE SLUMP
SKETCH SHOWING SITE FEATURES

FIGURE 2

DRAWN BY	ML
DESIGNED BY	JGP
APPROVED BY	TSA
SCALE	AS SHOWN
DATE	SEPTEMBER 2022
FILE No.	32122

THURBER ENGINEERING LTD.

Photo No. 1- NC091-1: Looking southeast where the landslide cuts through catch water ditch; catch water ditch discharges water into the landslide mass

Photo No. 2- NC091-1: Looking north at a 12 m long erosion gully developed within the farmer's field; note the presence of sandy soils within the exposed surfaces of the gully walls

Photo No. 3- NC091-1: Looking northeast at the landslide mass; note the presence of multiple tension cracks in the slope and cattails in the highway ditch

Photo No.4 - NC091-1: Looking northeast at the north flank of landslide;3.5 m deep cracks and seven barbed wire posts hanging in 2022

Photo No. 5 - NC091-1: Looking southwest at the head scarp crack and the erosion gully developed within the farmer's field

Photo No. 6 – NC091-1: Looking north at a distinct toe roll in the ditch

Photo No. 7 – NC091-2: Looking north at the landslide mass; note the presence of a distinct toe roll in the ditch

Photo No. 8– NC091-2: Looking northeast at the southern flank of the landslide mass; note the presence of multiple tension cracks within the backslope

Photo No. 9 – NC091-2: Looking south at scarp crack developed within the crest of the backslope

Photo No. 10 – NC091-2: Looking northeast at a scarp crack through the riprap apron and into the adjacent field (south scarp)

Photo No. 11 – NC091-2: Looking south at landslide features; note the well-defined toe roll at the ditch and the presence of multiple tension cracks within the backslope; landslide appears to be more vegetated than in 2020

Photo No. 12 – NC091-2: Looking south at the northern flank of the landslide