

**GEOHAZARD ASSESSMENT PROGRAM
NORTH CENTRAL REGION – ATHABASCA &
FORT MCMURRAY DISTRICTS
2021 SITE INSPECTION**



Site Number	Location	Name	Hwy	km
NC089	On the backslope of Hwy 63 to the south of King Street Interchange in Fort McMurray	Beacon Hill Backslope Slide	63:11	8.7
Legal Description		UTM Co-ordinates (NAD 83)		
SW-10-89-09-W4M		12 N 6284132.65	E	478495.60

	Date	PF	CF	Total
Previous Inspection:	June 25, 2020	11	3	33
Current Inspection:	June 24, 2021	11	3	33
Road AADT:	29,050		Year:	2020
Inspected By:	José Pineda, Tarek Abdelaziz (Thurber) Kristen Tappenden, Bernard Ching (Alberta Transportation)			
Report Attachments:	<input checked="" type="checkbox"/> Photographs <input checked="" type="checkbox"/> Plans <input type="checkbox"/> Maintenance Items			

Primary Site Issue	An active landslide toeing out immediately above the highway west ditch but not currently impacting the highway (2016 lower landslide block)
Dimensions:	About 75 m wide along the highway alignment and 55 m long perpendicular to the highway alignment (southern half of a 140 m wide ancient lower landslide block)
Site History:	<p>Beacon hill has experienced extensive landslide activities in ancient times. Multiple dormant landslide blocks are visible in the slopes above the highway alignment.</p> <p>Landslide movements occurred within the hill above Hwy 63 at other locations in the past. The backslope repairs consisted mainly of slope regrading and drainage improvement. The northern half of the active landslide is the vicinity of the southern flank of a repaired landslide.</p> <p>This landslide was first noted in the fall of 2016 after the August 2016 callout inspection of the ditch erosion. The landslide grew bigger in size between 2016 and 2017.</p> <p>Geotechnical instruments were installed during the winter of 2018.</p>

Observations:	Description	Worse?
<input checked="" type="checkbox"/> Slope Movement	2016 landslide block: 1.75 m deep and 2.0 m wide exposed head scarp crack; tilting trees; distinct toe roll (0.6 m high) located 9.5 m away from the edge of the highway	<input type="checkbox"/>
<input checked="" type="checkbox"/> Seepage	Standing water and seepage areas about the same as observed during the previous inspection	<input type="checkbox"/>
<input checked="" type="checkbox"/> Other	Vegetation grew within the landslide mass; sink hole (1.3 m long x 0.8 m wide x 0.6 m deep) developed in 2020 approximately 20 m north of the landslide toe was not visible; severe erosion developed at the inlet of the C6 pipe	<input type="checkbox"/>

Instrumentation: (2SIs, 14PNs)

SI17-2, located within the local landslide block, showed a rate of movement of 11.6 mm/yr over 1.8 m to 3.6 m depth between the fall of 2020 and the spring of 2021. SI17-3, SI17-4, and SI17-5 were all blocked at a depth of 1.2 m below ground surface. SI17-7, located in the upper landslide block, also showed a rate of movement up to 2.2 mm/yr at a depth of 1.6 m to 3.4 m up by 1.6 mm/yr since the previous readings.

Pneumatic piezometers PN17-1A, PN17-1B, PN 17-2A, PN17-5A, PN17-5B, PN17-6A, PN17-6B, PN17-7A, and PN18-7C showed increases in groundwater levels of ranging between 0.01 to 0.5 m since the piezometers were last read in the fall of 2020. Pneumatic piezometers PN17-2B, PN17-3A, PN17-3B, PN17-4, and PN17-7B showed decreases in groundwater ranging from 0.15 to 0.4 m since they were last read in the fall of 2020.

Assessment (Refer to attached Figures):

The site condition remained relatively unchanged since the 2020 site inspection visit.

The 2016 lower landslide block (i.e., southern half of the ancient landslide block), toeing above the highway ditch, is about 7 m deep, 75 m wide, 55 long and extends midway up the hill side. The landslide is visible on recent and previous LiDAR images and constitutes the southern portion an ancient landslide block, which is about 140 m wide (parallel to the highway).

It appears that the southern half of the ancient landslide block was re-activated in response to elevated groundwater levels. It is likely that the lack of vegetation, due to the 2016 forest fire, resulted in an increase in surface water runoff and elevated groundwater infiltration rates into the slope surface. The situation appears to have been aggravated at this location due to the presence of an existing gully that directs surface water into the landslide block.

The instrumentation readings indicate that the 2016 landslide block is typically moving at high rates between the spring and the fall seasons due to the increase in groundwater level within the landslide mass. However, and based on site observations, the landslide appears to have generally become more stable than in 2016 due to progressive growth of vegetation over time.

The northern half of the ancient block is relatively active, based on the previous readings of SI17-5. Hence, abrupt movement may also take place as previously occurred within the southern half of the block in response to loss of vegetation and/or development of elevated groundwater levels within the colluvium deposits.

Although the local backslope landslide does not currently appear to affect the highway ditch, landslide debris may quickly spill over the existing shallow ditch and possibly spread over the highway shoulder/lanes in response to an accelerated seasonal movement.

The ditch erosion will need to be addressed to reduce the risk of local instability which could trigger accelerated movement of the landslide block.

It is possible that the sinkhole developed 20 m north of the landslide toe, noted during the 2020 inspection, is the result of the C6 culvert rupture or separation.

Recommendations:

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

In the short term, the landslide should be regularly monitored, particularly after a prolonged rainfall event, and the ditch bottom should be touched to be cleared of the landslide debris as needed (without significantly changing grades) to improve surface water drainage. Excavated landslide debris (if any due to future movement) from the highway ditch should be pushed back into the toe of the slope.

The severe erosion noted at the C6 culvert inlet location should be repaired as part of the ditch maintenance work to prevent further loss of support at the toe of the landslide. It appears that the sinkhole developed 20 m north of the landslide toe was repaired.

An intermediate remedial measure, consisting of the construction of a riprap-lined channel to drain the standing water within the landslide mass to the highway ditch, has been designed as part of the highway ditch drainage improvement work. This measure aims to reduce groundwater levels within the landslide mass and hence landslide movement rates.

The long-term remedial option to retain the southern half of the lower landslide block would include the installation of a 100 m long concrete cast-in place pile wall along the west side of the highway (between the existing tree line and the ditch) to retain the landslide. The location of the pile wall will need to consider existing highway widening plans (if any). The ballpark cost of this option would be in the range of \$3.5 Million (excluding Engineering). If it is required to extend the wall to retain the entire lower landslide block, the cost would be in the range of \$6.5 Million (excluding engineering).

The decision to when to implement the long-term remedial option should consider the impact of landslide movement on the proposed ditch improvement work. It is ideal, subject to financial constraints, to implement the landslide and the ditch improvement remedial projects concurrently to avoid throwaway costs. This would be the case if the ditch repairs fail in response to a sudden landslide movement.

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

José Pineda, M.Eng., P.Eng.
Senior Geotechnical Engineer



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.

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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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- 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.
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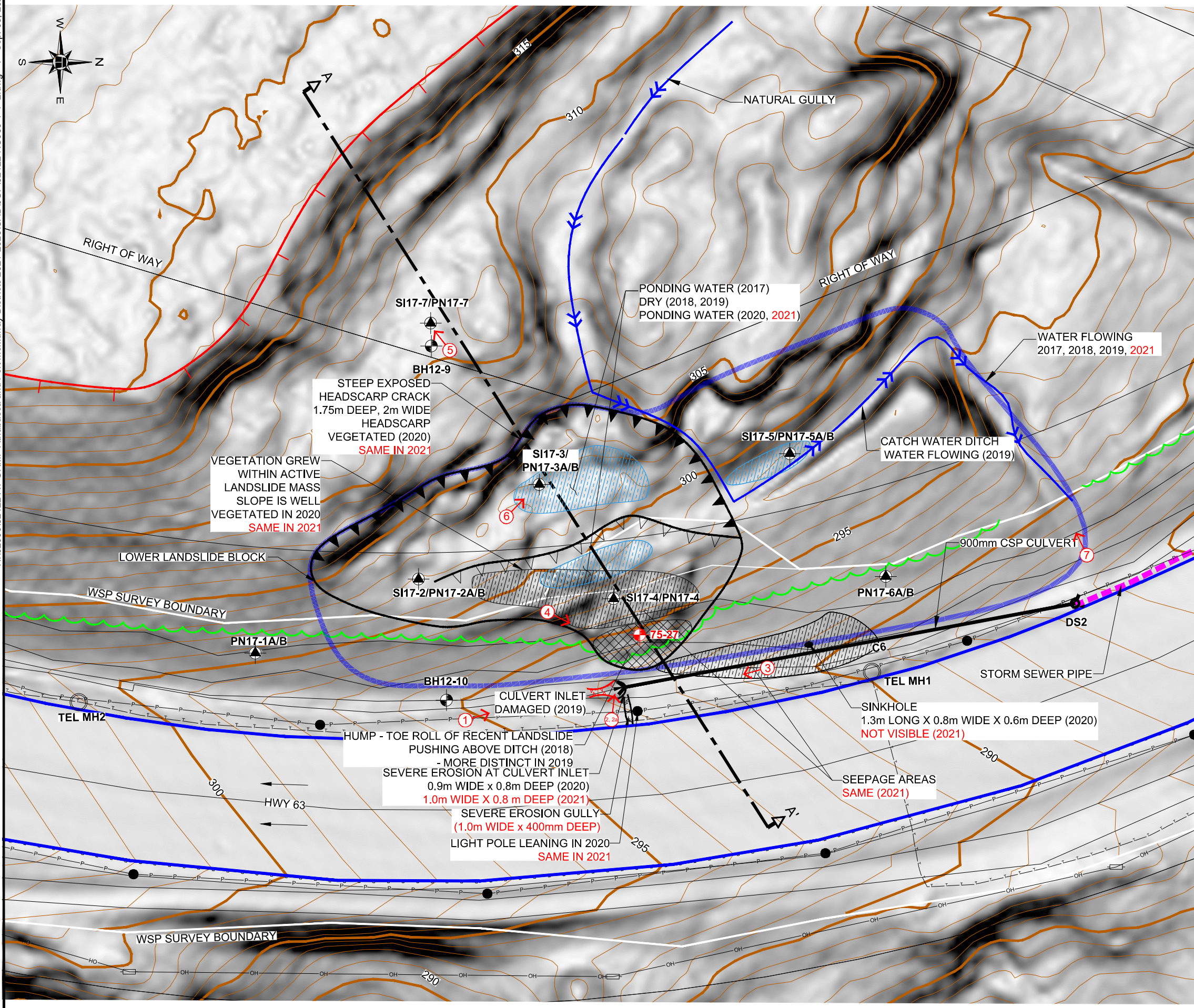
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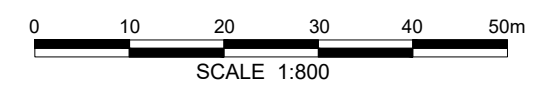
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LEGEND

- APPROXIMATE LOCATION OF SLOPE INCLINOMETER (SI) / PNEUMATIC PIEZOMETER (PN)
- APPROXIMATE LOCATION OF PREVIOUS TEST HOLE
- HEADSCARP CRACK
- TENSION CRACK
- APPROXIMATE BOUNDARY OF ANCIENT LANDSLIDE BLOCK (LIDAR)
- APPROXIMATE BOUNDARY OF RECENT ACTIVE LANDSLIDE (SOUTHERN HALF OF ANCIENT BLOCK)
- APPROXIMATE VALLEY CREST
- TREE LINE
- GUARDRAIL
- OVERHEAD POWER LINE
- UNDERGROUND POWER LINE
- UNDERGROUND TELUS CABLE
- LIGHT STAND
- TELUS MANHOLE
- POWER POLE
- DROP STRUCTURE (DS#)
- STANDING WATER
- WATER FLOW
- PHOTOGRAPH NUMBER, AND APPROXIMATE DIRECTION AND LOCATION

- NOTES:**
1. LIMITED SURVEY IN THE VICINITY OF THE HIGHWAY WAS CONDUCTED ON AUGUST 30, 2017 BY WSP.
 2. BACKSLOPE CONTOURS ARE BASED ON 20016 LIDAR DATA.
 3. JUNE 24, 2021 OBSERVATIONS ARE SHOWN IN RED.
 4. GRADING WORK TO INSTALL THE INSTRUMENT IN THE WINTER OF 2018 MASKED LANDSLIDE FEATURES.



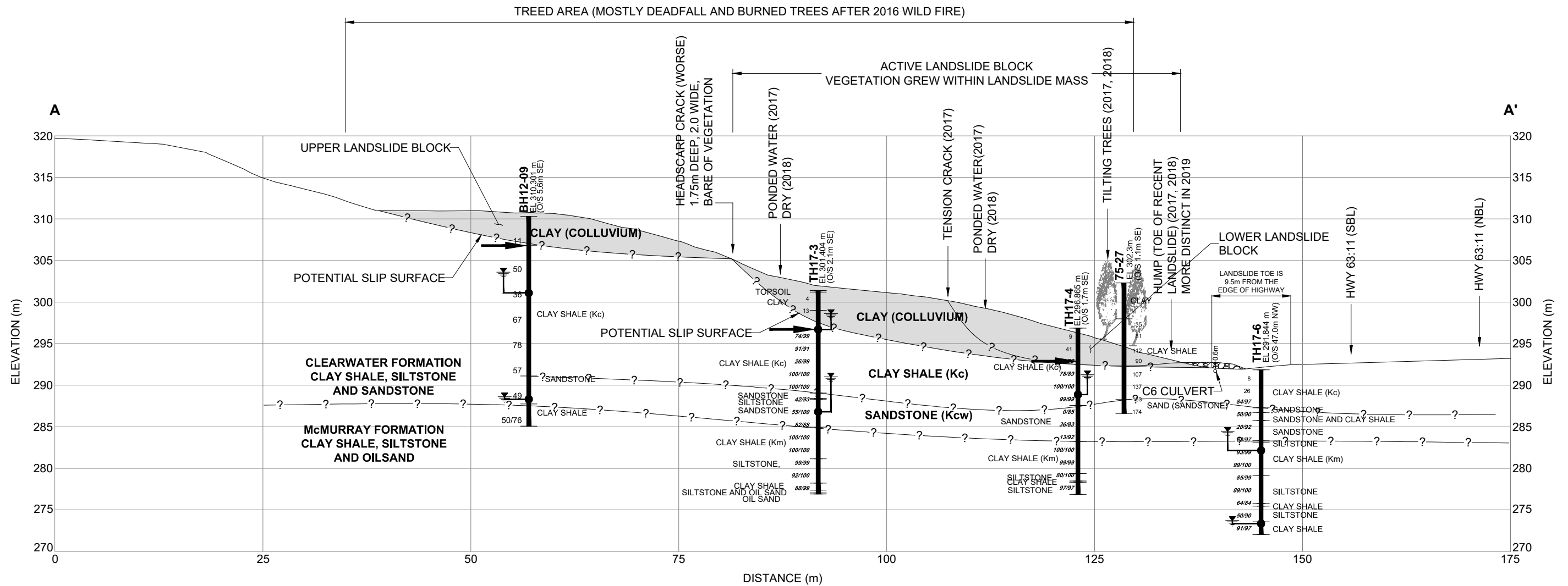
**NORTH CENTRAL REGION
(ATHABASCA AND FORT McMURRAY DISTRICTS)
2021 GEOHAZARD ASSESSMENT**

**NC089: HWY 63:11 BEACON HILL
BACKSLOPE SLIDE (km 8.7)
SITE INSPECTION PLAN**

FIGURE 1

DRAWN BY	ML
DESIGNED BY	JGP
APPROVED BY	TSA
SCALE	1:800
DATE	AUGUST 2021
FILE No.	32122

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LEGEND

- RQD / RECOVERY %
- SPT N VALUE
- WATER LEVEL IN PIEZOMETER (OCTOBER 18, 2017 AND FEBRUARY 21, 2018)
- PNEUMATIC PIEZOMETER TIP
- POTENTIAL ZONE OF MOVEMENT IN SLOPE INCLINOMETER

NOTE:

1. CROSS-SECTION A-A' IS BASED ON THE 2016 LIDAR DATA.
2. JUNE 24, 2021 OBSERVATIONS ARE SHOWN IN RED.

**NORTH CENTRAL REGION
(ATHABASCA AND FORT McMURRAY DISTRICTS)
2021 GEOHAZARD ASSESSMENT
NC089: HWY 63:11 BEACON HILL
BACKSLOPE SLIDE (km 8.7)
CROSS - SECTION A - A'**

FIGURE 2

DRAWN BY	ML
DESIGNED BY	JGP
APPROVED BY	TSA
SCALE	1:500
DATE	AUGUST 2021
FILE No.	32122

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Photo No.1 – Looking north at the toe of the landslide; the landslide is toeing out above the ditch near culvert C6



Photo No.2 – Erosion gully downslope of the toe of the landslide at culvert inlet location (Looking West)



Photo No.2a – Severe erosion gully on the highway side slope to the east of the culvert inlet location (Looking east)



Photo No.3 –Looking south at the toe of the landslide; note tilting trees within the landslide mass



Photo No.4 –Looking north at S117-4; landslide mass is well vegetated



Photo No.5 – Looking west at the valley crest near S117-7



Photo No.6 –Looking northwest at backscarp; note cattails and lush vegetation due to seepage near SI17-3



Photo No.7 –Looking west at the north flank of the lower ancient landslide block; note lush vegetation due to seepage and minor water flow