ALBERTA TRANSPORTATION
GEOHAZARD ASSESSMENT PROGRAM
PEACE REGION – SWAN HILLS
2020 INSPECTION

THURBER ENGINEERING LTD.

Site Number	Location	Name	Hwy	km
SH001-1 SH001A	North of Swan Hills	Swan Hills Retaining Wall	33:12	9.33-9.75 10.00-10.05
Legal Description		**UTM Co-ordinates**		
SE/NE05-67-09-W5M		11U E 607,545	N	6,070,516

	Date	PF	CF	Total
Previous Inspection:	10-Jun-2019	SH001-1: 9 SH001A: 7	4 3	36 21
Current Inspection:	1-Jun-2020	SH001-1: 9 SH001A: 7	4 3	36 21
Road AADT:	690		**Year:**	2020
Inspected By:	Rocky Wang, TRANS Ed Szmata, TRANS Rodney Johnston, TRANS Russell Romick, TRANS		Ken Froese, Thurber	
Report Attachments:	☑ Photographs ☑ Plans		☐ Maintenance Items	

Primary Site Issue:	SH001-1: Highway embankment placed over creek/gully obstructing seepage and mobilizing slide with creep movements at about 18 m to 20 m depth below the roadway. Pavement distress occurring behind and to the south of the floating pile wall. SH001A: Developing rotational landslide causing vertical displacement of highway surface.
Dimensions:	SH001-1: The pile wall is ~81 m in length. Pavement distress encompasses approximately 270 m of highway. SH001A: 50 m of highway affected by soft subgrade and slope movements.
Date of Remediation:	1970: Highway reconstructed about 30 m from original alignment which was buried by backslope failure. 1979: 9 – 50mm dia. slotted steel horizontal subdrains installed 3 m to 7.5 m below the roadway. Subdrain at 3 m depth installed in backslope ditch draining to four culverts. 1982: Backslope drains no longer functioning; 5 horizontal PVC drains installed from toe of north-facing embankment slope with lengths between 61 m and 73 m. 1989: Floating concrete pile wall 81 m long installed to depths of 6 m to 12 m below roadway surface. The 82 piles were 760 mm diameter installed at 1 m centre-to-centre spacing. 1991: Two rows of tie-back anchors install 1 m and 3 m below top of piles at 30° into clay shale at a length of 7.5 m. 1995, 1996: Backslope offloading undertaken. 2010: ACP curb installed directing surface water into two “T” drains; sideslopes regraded and tops of piles covered with gravel; guardrail installed.
Maintenance:	ACP patching as required to maintain surface (most-recent in 2015). 2014 and 2016: T-Drains cleaned out. 2016: Washed rock placed in erosion gullies on sideslope at east end of guardrail; patch placed to the west of the guardrail. 2018: Installation of three inclinometer/piezometers sets at SH001 and one set at SH001A.

Observations:	Description	Worsened?
☑ Pavement Distress	SH001-1: Cracking present over much of the length; dip south of the wall appeared Spring 2016 and second in 2019. Slight hump near west end of guardrail appeared in 2018 and second in 2019. Tension cracking continues to increase. Lack of maintenance leading to surficial deterioration (potholes). SH001A: dips have formed at both ends of patch and hump appeared in 2019; crack pattern is widening and becoming braided.	☑
☑ Slope Movement	SH001-1: Ongoing creep movement causing cracking and settling of highway surface at south end of pile wall. Slope may be pulling away from pile wall. SI south of wall sheared off in 2 years. SH001A: pavements cracks have developed into scarp pattern and are widening with vertical deformation.	☑
☑ Erosion	SH001-1: Some erosion noted on sideslope between and below piles. Deeper channels at west end of wall were infilled but are reforming Erosion in east ditch south of wall starting to revegetate; new gully forming in west ditch.	☑
☑ Seepage	SH001-1: Seepage observed in backslope area and wet zones noted below the pile wall. SH001A: Steady flow observed in east tree line and ditch.	☐
☑ Bridge/Culvert Distress	SH001-1: T-Drains outlets have been plugged with debris (partially accumulated since last cleaning) and one inlet is slightly damaged. Two sinkholes near the inlet of the culvert north of the pile wall are slowly growing and there are slumps near the outlet. SH001A: No apparent distress at culvert 130 m north of site.	☑
☐ Other		☐

Instrumentation (as of Fall 2020) – SH001:

SI-16, -18, -20	Has not shown a discernable movement pattern. Likely located outside of the main movement area.
SH18-4	Located southwest of pile wall. Sheared off at 16.8 m depth after Fall 2019 reading when the cumulative displacement was 37 mm since installation in March 2018 and was at the maximum historical movement rate of 51 mm/year.
SI18-5	Installed upslope of the southwest half of the retaining wall in March 2018. There is movement at about 8.6 m depth with current rate of 4 mm/year and a cumulative displacement of 7 mm.
SI18-6	Installed upslope of the northeast half of the retaining wall in March 2018. No discernable pattern.
PN-1, PN-2, PN-3, PN-4, PN01-2	Measured water levels have been relatively stable for about the last 10 years with minor seasonal variation (typically less than 1 m) noted at some of the piezometers. The exception are at PN-1 which remains elevated since Spring 2019 reading about 0.5 m above the historical trend. The 1 m rise at PN-3 has not sustained and it has dropped back to its historical level.
PN18-4A, 4B, 5A, 5B, 6A, 6B	Slight increasing trend at PN18-4B, -6A, and -6B since installation in March 2018 and the remainder have been relatively stable.

PN01-1	Not operational.
Instrumentation (as of Fall 2020) – SH001A:	
SI18-7	Sheared off at 8.5 m after Spring 2019 reading. Cumulative displacement was 50 mm from installation in March 2018.
PN18-7A & 7B	PN18-7A increased from about 2.3 m BGL at installation in March 2018 to 1.7 m AGL in Fall 2019 and is trending upward still but at a slower pace reaching 2.0 m AGL in Fall 2020; PN18-7B has been trending downward slightly since Fall 2018 and is now 11.0 m BGL.

Assessment:

At SH001-1, the highway embankment crosses two natural gullies which may have had prior instability. The additional weight of the embankment fill combined with blocking springs and natural drainage paths led to movements at this site. The floating pile wall appears to be adequately stabilizing the highway over its length; however, there is some ongoing creep movement and increasing amount cracking and distortion (dips and humps) of the highway at and beyond the southwest end of the wall. New inclinometers installed in March 2018 show movement of the slope south of the wall (SI18-4 has sheared off) and minor movement behind the south half of the wall (SI18-5) but no discernable displacement behind the north half (SI18-6). The drainage control measures implemented in 2010 (asphalt curb and T-down drains) had been functioning though the continued deterioration of the curb and plugging of the drains is currently limiting their functionality (although the drains are occasionally flushed). The piezometers installed in 2018 have identified that the water level behind the wall is approximately 5 m lower than in the unstable ground to the south of the wall.

Due to a reduced maintenance budget, there was noticeable deterioration of the highway surface in 2020 with several crack patches popped out, new potholes forming, and the unevenness at the south end of the wall more exaggerated than in past years. There continues to be minor increases in the crack length and frequency beyond both ends of the wall. The two sinkholes at the culvert inlet north of the wall have grown slightly; a new scarp was observed at the outlet with some indication that it might be located over an abandoned culvert outlet. Apparent movement of the soil downslope of the pile wall has opened up tension cracks between and below some of the piles. The absence of movement at SI18-6 would indicate that this movement is occurring below the wall rather than through it. Although the scarp features located northwest of SI16 through SI21 are not new (they are apparent on 2007 LiDAR), it was noted this year that there appeared to be recent movement on these features which will need to be observed in future visits. The SI's between the scarps and the highway do not yet indicate movement.

Site SH001A was first observed in 2013 after an FWD (falling weight deflectometer) program. The distress consists of cracking with associated dips in the pavement surface and has required patching in 2014 and 2015. It was initially suspected that the underlying issue was a soft/wet subgrade possibly associated with shallow groundwater flow. This is plausible as this location is on the flank of a small channel passing through a culvert (600mm diameter smooth-wall steel-lined at km 10.156) approximately 120 m to the northeast and the terrain to the northwest appeared to be wetter than surrounding areas. In 2017, the site inspection was conducted shortly after heavy rainfall and it was observed that there was significant flow (northeast toward a centreline culvert) in the east ditch but within the treeline which has continued to be the case in all subsequent visits. By 2018, the crack pattern across the highway had developed into a landslide scarp and the movement zone in the inclinometer (which sheared off after the Spring 2019 readings) confirmed there is slope movement at this location. The crack pattern lines up with the 0.5 m scarp feature observed to the west of the highway. Thus, the soft/wet subgrade may be a result of slope displacement and resultant modified groundwater flow regime. Like at SH001-1, the lack of routine maintenance has led to noticeable deterioration of the highway surface with most of the cracks becoming braided with increased vertical differential. The soil stratigraphy observed in SH18-7 consists of gravel and clay fill overlying native clay over a thin zone of clay till. The site is underlain by clay shale with sandstone layers. The movement zone appears to be at the contact between the clay till and clay shale. The high groundwater level measured in the clay till layer, which became artesian in Spring 2019, might be a trigger for the slide movements. The mechanism for the landslide occurring at this site has not yet been identified.

There is about 20 m of relief from the highway surface to the downslope creek but over a distance of about 190 m which is relatively flat (6°); however, remolded shale is expected to have a low friction angle.

Recommendations:

Short-Term:

- Road maintenance should continue as necessary to maintain the roadway surface and may consist of milling, patching, and crack sealing of the ACP.
- Re-establish the asphalt curb and clean the T-drains (this should be a periodic maintenance item).
- Re-grade, and augment with additional granular material if necessary, the sideslope below the pile wall as was partially undertaken since the 2016 inspection.

Medium Term

SH001A: An inexpensive option would be to install a subdrain in the upslope ditch to see if intercepting some of the groundwater might reduce the rate of movement. Although this is unlikely to remediate the site, it might extend the time before a full intervention is nececssary.

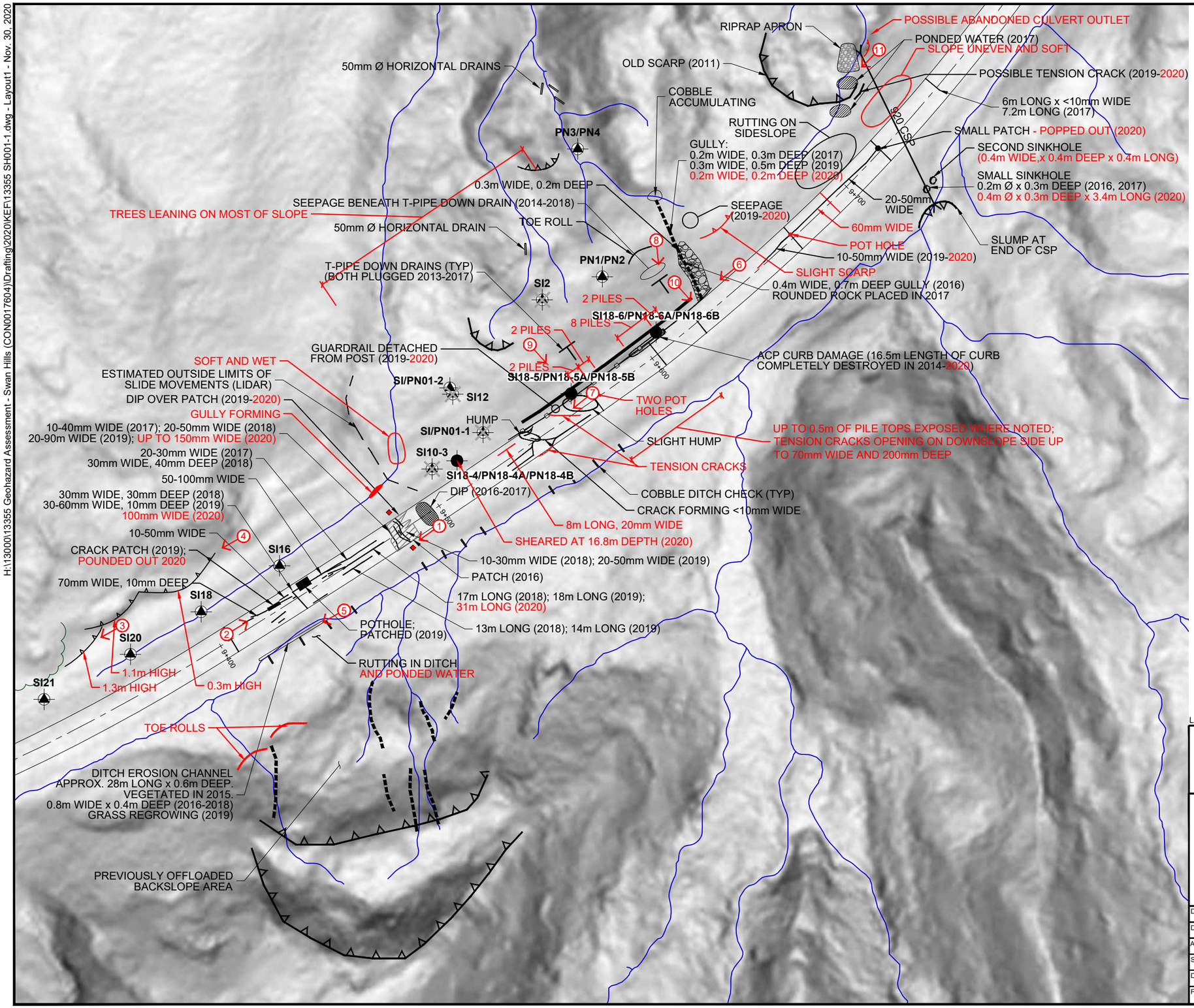
Long-Term:

SH001-1: Consideration should be given to placing additional horizontal drainage measures to further reduce groundwater levels in the highway embankment particularly to the southwest of the wall. This might also be accomplished with a subdrain or relief wells to the south of the highway. Consideration could also be given to extending the pile wall further southwest should ongoing maintenance become difficult and/or expensive.

SH001A: With confirmed movement at this site, it is recommended that a preliminary engineering assessment be undertaken to determine potential mechanisms and develop alternates for stabilizing this location. A LiDAR review should be included to try to better define the possible limits of the landslide.

Ongoing Investigation:

- It is recommended that the annual GeoHazard inspection should continue as scheduled.



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LEGEND

- SCARP (INTERPRETED FROM LIDAR)
- SLOPE INCLINOMETER (APPROXIMATE)
- DESTROYED SLOPE INCLINOMETER
- APPROXIMATE INSTRUMENT LOCATION (2018)
- PN — PNEUMATIC PIEZOMETER
- SI — SLOPE INCLINOMETER
- GULLY
- DRAINAGE PATHS (INTERPRETED FROM LIDAR)
- GUARDRAIL
- TREE LINE
- RED TEMPORARY HAZARD SIGN
- DIRECTION AND NUMBER OF PHOTO

NOTES

1. FEATURE LOCATIONS ARE APPROXIMATE.
2. LIDAR SHADED ACCORDING TO SLOPE FROM WHITE AT 0° TO BLACK AT 35° AND STEEPER.
3. PREVIOUS OBSERVATIONS SHOWN IN BLACK.
4. JUNE 2020 OBSERVATIONS SHOWN IN RED.
5. DRAWING UPDATED IN 2017 USING LIDAR, SATELLITE IMAGERY, AND A MEASURING WHEEL.

0 20 40 60 80 m
SCALE 1:1500

LIDAR PROVIDED BY ALBERTA TRANSPORTATION (FLOWN 2007)

Alberta

PEACE REGION (SWAN HILLS)

SH001-1: HWY 33:12
2020 SITE INSPECTION PLAN

DWG No. 13355-SH001-1

DRAWN BY	KLW
DESIGNED BY	KEF
APPROVED BY	DWP
SCALE	1:1500
DATE	NOVEMBER 2020
FILE No.	13355

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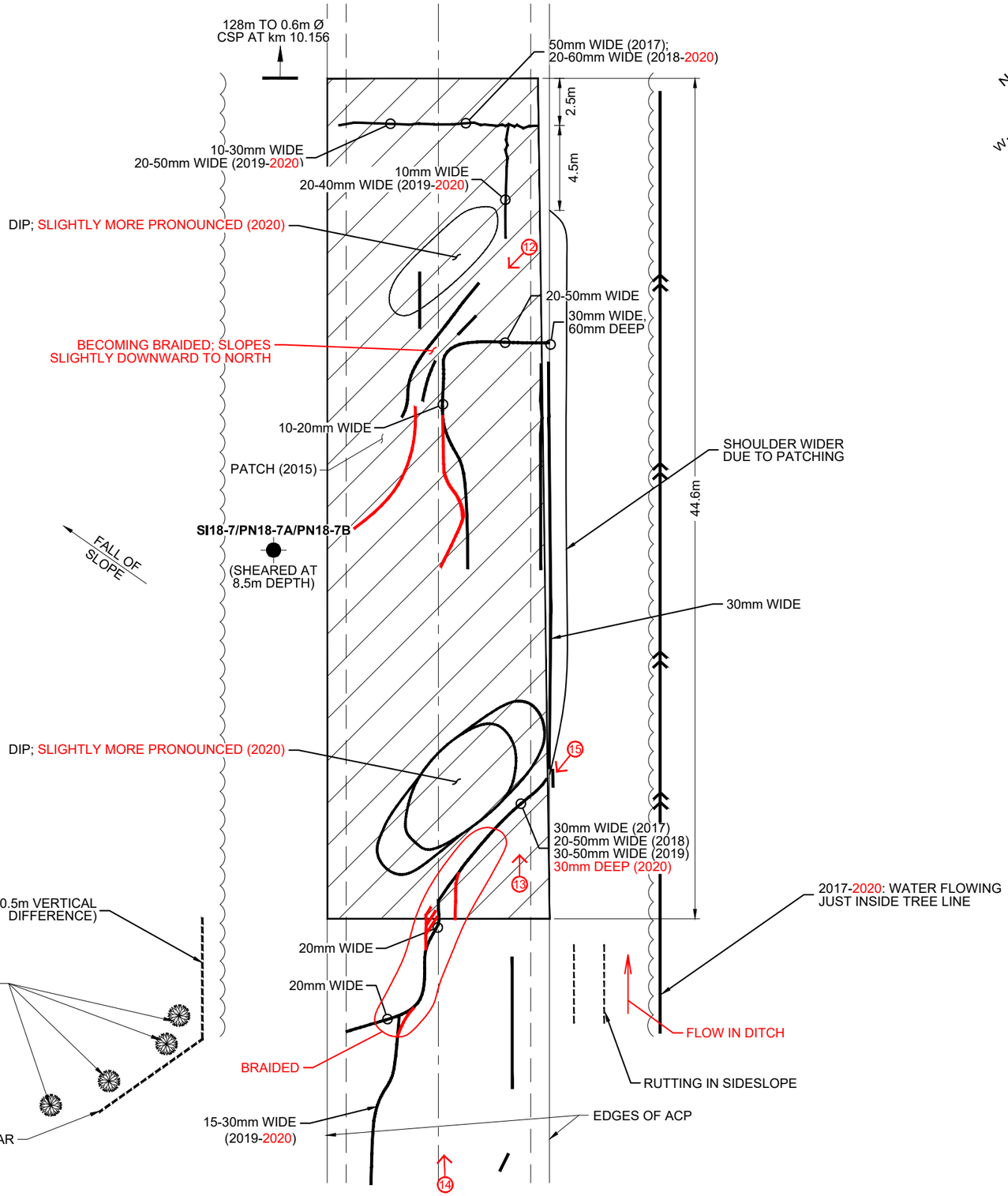

LEGEND

- CRACK
- WATER COURSE
- APPROXIMATE INSTRUMENT LOCATION (2018)
- PN PNEUMATIC PIEZOMETER
- SI SLOPE INCLINOMETER
- (1) DIRECTION AND NUMBER OF PHOTO

NOTES

1. FEATURE LOCATIONS ARE APPROXIMATE.
2. PREVIOUS OBSERVATIONS SHOWN IN BLACK (2013-2015 FROM AMEC FIGURE 1, PROJECT EG10030, PROVIDED BY ALBERTA TRANSPORTATION).
3. NO SIGNIFICANT CHANGES OBSERVED IN 2016.
4. CRACK PATTERN REMEASURED IN 2017 USING MEASURING WHEEL. PREVIOUS PATTERN REMOVED. DRAWING UPDATED USING HIGH RESOLUTION SATELLITE IMAGERY AND LIDAR (FLOWN 2007)
5. JUNE 2020 OBSERVATIONS SHOWN IN RED

0 2.5 5 7.5 10 12.5 15 m

SCALE 1:250

Alberta

PEACE REGION (SWAN HILLS)

SH001A-1: HWY 33:12
2020 SITE INSPECTION PLAN

DWG No. 13355-SH001A-1

DRAWN BY	KLW
DESIGNED BY	KEF
APPROVED BY	DWP
SCALE	1:250
DATE	NOVEMBER 2020
FILE No.	13355

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Photo 1 – Looking southwest at patch over cracks forming at the southwest end of the wall.

Photo 2 – Looking north at cracking in highway surface immediately south of the pile wall.

Photo 3: Looking southwest at scarp on slope below highway between SI20 and SI21.

Photo 4: Looking southwest at scarp below highway near SI18.

Photo 5 – Looking south at erosion in east ditch.

Photo 6 – Looking south at cobbles placed in gully at north end of guardrail.

Photo 7 – Looking southwest at cracked curb at south end of guardrail.

Photo 8 – Seepage out of slope below north-most T-drain.

Photo 9: Erosion and/or movement away from the piles around the southwest down drain.

Photo 10: Soil pulling away from the downslope side of piles near the northwest downdrain.

Photo 11 – 920 mm dia. centreline culvert outlet.

Photo 12 – Crack pattern at SH001A site.

Photo 13 - Looking northeast at second crack with slight pavement dip just beyond at SH001A site.

Photo 14 - Looking northeast at roadway crack and scarp (red line) at tree line at SH001A site.

Photo 15 - Looking west at cracks at south end of patch at SH001A site.