

SITE NUMBER AND NAME: NC014 – North of Fort Assiniboine	HIGHWAY AND KM: 661:02, km 1.8	PREVIOUS INSPECTION: May 31, 2023	CURRENT INSPECTION: June 13, 2024
LEGAL DESCRIPTION: NW-01-62-06-W5	NAD83 COORDINATES: UTM11U 6023391N, 644779E		RISK ASSESSMENT: PF: 8 CF: 10 Total: 80
AVERAGE ANNUAL DAILY TRAFFIC (AADT): 220 (2023)		CONTRACTOR MAINTENANCE AREA (CMA): 508	

<p>SUMMARY OF INSTRUMENTATION: Six standpipes functional and being monitored. No land access agreement for 2 slope inclinometers and 7 standpipe piezometers.</p> <p>LAST READING DATE: May 14, 2024</p>	<p>INSPECTED BY: Stantec: Leslie Cho and Sonja Pharand TEC: Kristen Tappenden and Tim Germyn</p>
<p>PRIMARY SITE ISSUE: Slope creep movements causing pavement distress to a side hill alignment due to seasonal high groundwater levels; a localized active landslide causing a severe deterioration of the highway southbound lane (SBL) within the mid-hill slope section.</p>	
<p>APPROXIMATE DIMENSIONS: About 250 m long (midslope section)</p>	
<p>DATE OF ANY REMEDIAL ACTION: No remediation undertaken. Maintenance work includes spray patch and manhole cleaning in 2014; patching of mid hill slope section in 2017. A dewatering pilot test was conducted in 2018 to assess the effectiveness of a gravity well to drain the upper sand aquifer to a lower sand and gravel aquifer. The pilot test was unsuccessful due to high clay and silt content in the upper aquifer as well as difficulty developing the well in the upper aquifer. The entire site was milled and paved in Fall 2023, with deficiencies addressed in late Spring 2024. The guardrail on the downslope side of the highway was also extended further southeast. 50 km/hr sign placed near midslope for traffic travelling northwest.</p>	

ITEM	CONDITION EXISTS		DESCRIPTION AND LOCATION	NOTICEABLE CHANGE FROM LAST INSPECTION	
	YES	NO		YES	NO
Pavement Distress	X		Multiple non-landslide related cracks throughout (recently patched) pavement.		X
Slope Movement	X		Mid-hill slope section: 10 mm wide reflective crack. Creep movement with open cracks to the north and south of mid-hill slope section. Upper slope section of the hill (north of mid-hill slope section): uneven guardrail; head scarp crack and graben feature downslope of the highway. Small dormant slump along highway backslope.		X
Erosion	X		Erosion along east highway shoulder.		X
Seepage		X			
Bridge/Culvert Distress		X			

Other	X		Two sinkholes in ravine, three new sinkholes northwest of ravine. Two sinkholes observed in east ditch of highway.	X	
COMMENTS					
<ul style="list-style-type: none"> • Cracks were observed to be reflecting through the recently milled and paved highway surface along the mid hill slope and upper slope sections where landslide activity is apparent (Photos 1, 3 and 4). • The water level in MH#1 was at ground surface. Water from the drainage channel adjacent to the MH appeared to be ponding and flowing into MH#1 (Photo 2). Siltation may be a problem at MH#1. • The mid hill slope section (Photo 3) had one 10 mm wide reflective crack. The dip towards the southwest observed during the past inspections was not observed in 2024, possibly due to the recent mill and pave. • At the upper slope section (Photo 4), the guardrail appeared to be slightly sagging and shifting laterally. Pavement cracks upslope from the graben were up to 10 mm wide. The slight dip in the pavement towards the west, observed during the 2023 inspection, was not observed. • A head scarp and graben were observed downslope of the guardrail (Photo 5). • Both functional SIs are located above the highway backslope and outside the landslide area. Both instruments showed no movement. Readings on these SIs have stopped since land access permissions have not been agreed upon with the private landowner since Spring 2021. • The piezometers show water levels have been relatively consistent with Spring 2024 readings ranging from 2.4 m bgs to 26.3 m bgs. A slight trend of increasing water levels seems to be developing in most piezometers since 2006. • Numerous sand outcrops were observed downslope of the upper slope landslide graben. The depressions up to 0.5 m deep in the two small sand outcrops closest to the ravine were observed to be relatively unchanged since the last inspection in 2023. • The gully with exposed sand starting south from the upper slope section near the sand outcrops, down to the bench was observed to be slightly more vegetated in comparison to the 2023 inspection (Photo 7). • The two sinkholes in the ravine downslope of the highway between the upper and mid slope appear to have changed in size since the 2023 site inspection. The north sinkhole was measured to be 500 mm deep by 600 mm in diameter (decreased depth), and the south sinkhole was measured at 700 mm deep by 1 m in diameter (increased depth) (Photo 6). • The two sinkholes observed in the east ditch near the mid-hill landslide area during the 2023 inspection were observed. The northernmost sinkhole was approximately 0.5 m deep, 0.7 m wide and 1.0 m long. The other sinkhole, southeast from the utility box, was measured to be 0.9 m deep, 1.2 m wide and 1.5 m long (Photo 8). It is possible that these sinkholes are related to the subdrains. • The perforated subdrain observed at surface along the east ditch during the 2023 inspection was not observed during the current inspection. • Several homes exist near the base of the landslide representing a public safety issue along with potential loss of privately owned structures. As such, the Consequence Factor remains at 10. 					
RECOMMENDATIONS					
<ul style="list-style-type: none"> • All pavement cracks should be sealed to reduce surface water infiltration into the landslide mass. • All culverts and manholes should be inspected to reduce the risk of water seeping into the slope. This could consist of cleaning and flushing to promote water flow. • The sinkholes should be backfilled and capped with clay to reduce further erosion and surface water infiltration into the slope. • Slope inclinometers within the slide mass are no longer functioning. Slope movement can be monitored by installing replacement inclinometers and/or considering InSAR or LiDAR change detection methods. • Preliminary remediation options may include: <ul style="list-style-type: none"> – Constructing a concrete pile wall from the upper slope section to the mid-hill section, approximately 160 m long. The high-level cost for a concrete pile wall is \$3.2 million to \$4.2 million, excluding engineering. – Reconstructing the highway with lightweight fill such as EPS geofoam or lightweight cellular concrete. The high-level cost for this option is \$730,000 to \$1.1 million excluding engineering. – Installing a new subdrain along the east ditch. The high-level cost for this option is \$400,000 to \$500,000 excluding engineering. – Maintenance, monitoring and surveillance approach: Given the low volume and low speed nature of this highway, it may be preferential for TEC to continue maintaining the highway by placing asphalt patches and sealing cracks as well as maintaining the existing manholes and subdrainage system. This approach carries some risk in that the rate of slope movement can suddenly increase. If this approach is adopted, 					

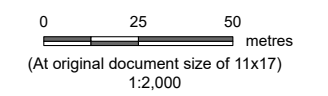
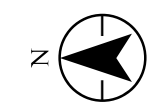
increased monitoring of the site is recommended consisting of additional slope inclinometers below the landslide headscarp, which can be fitted with near real-time monitoring using shape-accelerometer arrays (SAAs), and/or near real-time GPS monitoring (Geocubes) and/or InSAR satellite imagery to determine historical/present ground deformation rates. Adopting a surveillance and monitoring program to threshold values would provide asset protection of the site and allow suitable timing for remediation.

- The site should continue to be inspected annually.
- Instrumentation monitoring should continue annually in the spring and fall.

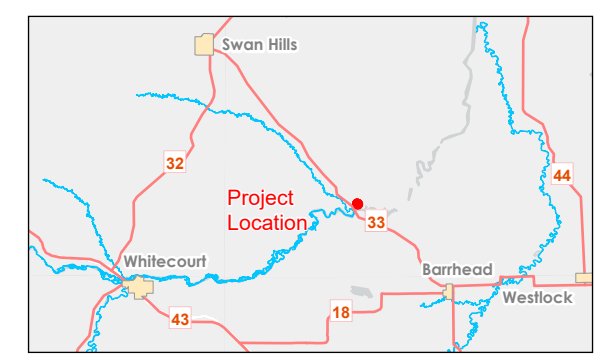
PREPARED BY: Sonja Pharand, P.Eng.	REVIEWED BY: Xiteng Liu, M.Sc., P.Eng., PMP	PERMIT TO PRACTICE



- Non-Operational Instrument
- Operational Instrument
- Photo and Direction
- Previous Observation/ Site Detail
- 2024 Observation
- Ground Elevation Contours (m AMSL)⁴
- Quarter Section



Notes
 1. Coordinate System: NAD 1983 CSRS UTM Zone 11N
 2. Data Sources: Geogratis, ©Department of Natural Resources Canada, All rights reserved.
 3. Background: Light Gray Base: Esri Canada, Esri, TomTom, Garmin, FAO, NOAA, USGS, EPA, NRCan, Parks Canada
 Google Satellite: © OpenStreetMap (and) contributors, CC-BY-SA
 4. Reference: Thurber Project No. 15-16-258, August 2011 (original Scale 1:2000).

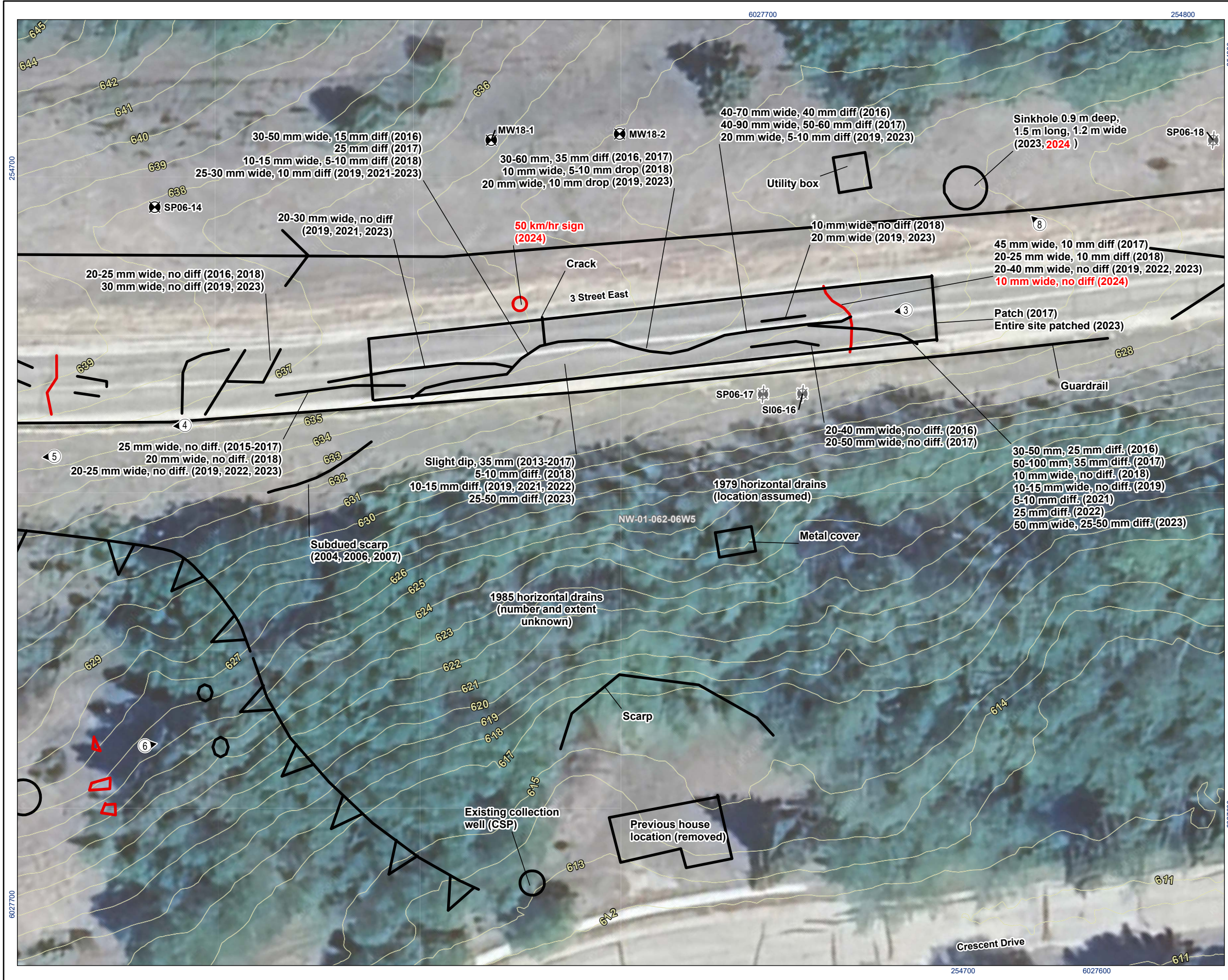


Project Location
 SW-28- and SE-29-056-08W5, Alberta
 Prepared by SP on 2024-09-30
 TR by LC on 2024-09-30
 IR by XL on 2024-09-30

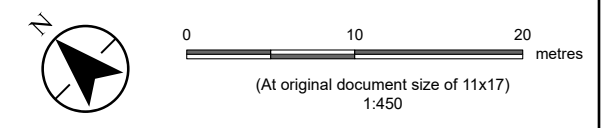
Client/Project
 Transportation and Economic Corridors
 Geohazard Monitoring Program
 NC014-1: HWY 661:02 Fort Assiniboine (km 1.8)
 123315222

Figure No.
 1
Title
 Site Plan

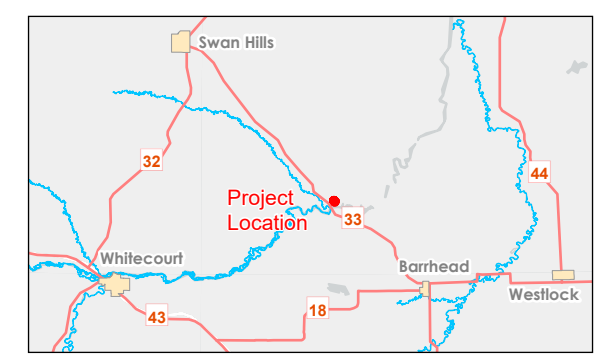
I:\cd\1001-c20\workgroup\123315222\03_6222\03_dialgis_cad\figures\annual_inspection_figure_fig_1_site_plan_11x17.ncf14-1 Rev:sect. 2024-10-07 By: spharand



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Figure No.
2

Title
Site Detail

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2024 Site Inspection Photos at NC014



Photo 1: Pavement condition southeast of mid-hill landslide. Looking northwest.



Photo 2: Pooling/flowing water adjacent to MH#1. Water entering culvert at ground surface. Looking northeast.

2024 Site Inspection Photos at NC014



Photo 3: Cracks reflecting through pavement repair at south extent of mid-slope landslide. Looking northwest.



Photo 4: Pavement cracking north of mid-slope landslide. Looking northwest.

2024 Site Inspection Photos at NC014



Photo 5: Landslide at uphill section. Looking northwest.



Photo 6: Two sinkholes in ravine. Looking southeast.

2024 Site Inspection Photos at NC014



Photo 7: Erosion channel heading downslope to the bench. Looking southwest.



Photo 8: Sinkhole southeast from the utility box in the east ditch near the mid-hill landslide area. Looking north.

2024 Site Inspection Photos at NC014



Photo 9: Site overview, taken by drone. Darker pavement patches are deficiency repairs, approx. 2 weeks old at time of photo. Looking northwest.



Photo 10: Overview of slide areas on highway embankment. Looking northeast.