January 11, 2019

Alberta Transportation
4th Floor, Provincial Building
4920 51 Street
Red Deer, Alberta
T4N 6K8

Tony Penney, P.Eng.
Construction Engineer

Dear Mr. Penney:

CON0017608 Central Region GRMP Instrumentation Monitoring
Site C070; H27:10, km 18.932 and 33.102 West and East Slides
Section C – 2018 Fall Readings
Second Draft

1 GENERAL

One slope inclinometer (SI17-C70W-01) and one vibrating wire piezometer (VW42619) were read at the the C070 – I site in the central region on September 6, 2018 by Mr. Ryan Gazley, E.I.T. and Ms. Cynthia Lee, E.I.T. of Klohn Crippen Berger Ltd. (KCB). These instruments were read as part of the central region geohazard risk management plan (GRMP). A site plan is presented in Figure 1. The C070 site consists of two sites:

- The "west slide" (C070 – I) located along Hwy 27:10, km 18.932, approximately 27 km southeast of Three Hills, Alberta. The site coordinates are 5723837 N, 363877 E (UTM Zone 12, NAD 83). A site plan is presented in Figure 2.
- The "east slide" (C070 – II) located in the westbound lane of Hwy 27:10, km 33.102, approximately 2 km southwest of Morrin, Alberta. The site coordinates are 5723487 N,377005 E (UTM Zone 12, NAD 83). A site plan is presented in Figure 3.

The geohazard at the two C070 sites consists of shallow slope failures in the highway embankment. The West Slide and East Slide are located on the south (eastbound lane) and north (westbound lane) side of Hwy 27:10, respectively. The west slide first occurred and was repaired in 2003, and subsequently remobilized in 2015. In 2015, the maintenance contractor attempted emergency repairs at both sites by pushing failed material back upslope, reshaping, and seeding. However, the west site failed again within two weeks of completion.

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In March 2017, KCB conducted a geotechnical site investigation at the two C070 sites. Drilling was completed by Mobile Augers and Research Ltd. The encountered stratigraphy summarized from ground surface to end of hole was as follows:

- high plastic lacustrine clay, overlying bedrock (siltstone) at the west site; and
- high plastic lacustrine clay, overlying clayey silt till at the east site.

1.1 Instrumentation

Instrumentation installation details are tabulated in Table 1.1. Instrument locations are shown in Figure 2 for the west slide and in Figure 3 for the east slide.

In March 2017, KCB installed two slope inclinometers (SIs) and two vibrating wire piezometers (VWPs) to monitor depth of movement and groundwater conditions, respectively. SI17-C70W-01 and VW42619 were installed in a borehole located on the west slide area, and SI17-C70E-01 and VW42618 were installed in a borehole located on the the east slide area. The instruments are protected by above-ground casing protectors.

During the Spring 2018 readings, the instruments at the east slide area (SI17-C70E-01 and VW42618) were found to be inoperable. It appears that a vehicle or other piece of equipment had collided with the above ground casing protector damaging the instruments (Photo 1).

SI17-C70W-01 was read using the same metric RST Digitial MEMS Inclinometer System that was used to read the SI since July 2017. Prior to July 2017, SI17-C70W-01 was read with an imperial Slope Indicator control cable, Digitilt probe, and Digitilt DataMate readout.

VW42619 were read using a Slope Indicator VW Data Recorder (Model No. 52613500).

Table 1.1 Instrumentation Installation Details

Instrument ID	Instrument Type	Site	Date Installed	Coordinates[1] (m)		Ground Surface Elevation (m)	Stick-up (m)	Depth Below Ground Surface (m)	Condition
				Northing	Easting				
SI17-C70W-01	SI	West	Mar. 23, 2017	5723496	377013	830.0	0.8	8.1	Operational
SI17-C70E-01	SI	East	Mar. 22, 2017	5723829	363898	827.0	0.8	13.9	Inoperable
VW42618	VWP	East	Mar. 22, 2017	5723496	377013	830.0	N/A	7.5	Inoperable
VW42619	VWP	West	Mar. 23, 2017	5723829	363898	827.0	N/A	4.0	Operational, but dry

Notes:
[1]Coordinates were obtained with a handheld GPS during installation.

2 INTERPRETATION

2.1 General

For SI17-C70W-1, the cumulative displacement and incremental displacement data was plotted in the A-direction (i.e., the direction of the A0-grooves). The A0-grooves in the SI are aligned approximately perpendicular to the highway and the direction of maximum movement, in the downslope direction.

The SI plots are included in Appendix I, and a summary of the SI data is provided in Table 2.1, respectively. Note that SI plots only include data recorded after July 2017 to eliminate the data shift that resulted from switching SI probes in July 2017 previously discussed in Section 1.1.

Data plots are not provided for the piezometers because the piezometers are either inoperable (VW42618) or have been dry since installation (VW42619).

2.2 Zones of Movement

Movement has been recorded in SI17-C70W-01 and SI17-C70E-01 at an approximate depth of 1.2 m below ground surface in the embankment fill.

No discernible foundation movements have been recorded in SI17-C70W-01 or SI17-C70E-01.

2.3 Interpretation of Monitoring Results

In the 2016 call-out report, it was KCB's opinion that the slides were rotational-embankment failures that were likely exacerbated by poor surface drainage. KCB understands that historic rural road construction practices in Alberta often included placing poor quality and/or uncompacted fill beneath the slopes of the embankment and also did not include foundation preparation. As a result, there is a relatively high likelihood that the embankment slopes are weaker due to lack of compaction, and more susceptible to failure due to weak layers (e.g., soft and/or organic soils) being left in the foundation. Additionally, construction of an uncompacted "sliver fill" on the embankment slopes during widening may have contributed to the movement observed at both sites.

The upper movements being recorded in SI17-C70W-01 and SI17-C70E-01 appear to be occurring within the previously failed embankment fill, and in the failed material that was pushed upslope to create an access ramp and pad for the drilling rig.

Both sites should be repaired and drainage improvements implemented to limit the potential for future instability (e.g., lateral expansion of the slide along the highway embankment, or retrogression of the backscarp onto the highway) and impacts on the adjacent farmland.

The instrumentation at the west slide (SI17-C70W-01 and VW42619) is installed at the base of the backscarp, and therefore is unable to monitor for movements under the highway embankment, which pose the greatest risk to the safety of the highway.

Table 2.1 Slope Inclinometer Reading Summary

Instrument ID	Date Initialized	Date of Previous Reading	Date of Most Recent Reading	Date of Previous Maximum Movement	Ground Surface Elevation (m)	Depth of Movement (mbgs[1])	Cumulative Maximum Movement (mm)	Incremental Movement Since Previous Maximum Movement (mm)	Rate of Movement (mm/year)		
									Previous Maximum	Current	Change from Previous Reading
SI17-C70W-01	Mar 30,2017	May 22, 2018	Sep. 6, 2018	N/A[2]	830.0	N/A[2]					
SI17-C70E-01[3]	Mar 30,2017	Sep. 7, 2017	N/A[3]	N/A[3]	827.0	N/A[3]					

Notes:
[1] Meters below ground surface (mbgs)
[2] No discernible foundation movements have been recorded in the SIs.
[3] SI17-C70E-01 is inoperable.

Photo 1 SI17-C70E-01 and VW42618 are inoperable after being damaged between September 2017 and May 2018.

3 RECOMMENDATIONS

3.1 Future Work

All operational instruments should continue to be read.

Repair options for both sites are currently being assessed by KCB and Alberta Transportation, and may include the excavation and reconstruction of the slopes with geosynthetic reinforced fill, with subsurface drainage.

The site should continue to be inspected by the Maintenance Contract Inspector (MCI) and as part of the central region GRMP Section B inspections.

3.2 Instrument Repairs

An attempt should be made to repair the instruments at the east slide area (SI17-C70E-01 and VW42618).

4 CLOSING

This report is an instrument of service of Klohn Crippen Berger Ltd. The report has been prepared for the exclusive use of Alberta Transportation for the specific application to the central region GRMP (Contract No. CON0017608). The report's contents may not be relied upon by any other party without the express written permission of Klohn Crippen Berger. In this report, Klohn Crippen Berger has endeavoured to comply with generally-accepted professional practice common to the local area. Klohn Crippen Berger makes no warranty, express or implied.

Please contact the undersigned if you have any questions or comments regarding this report.

KLOHN CRIPPEN BERGER LTD.

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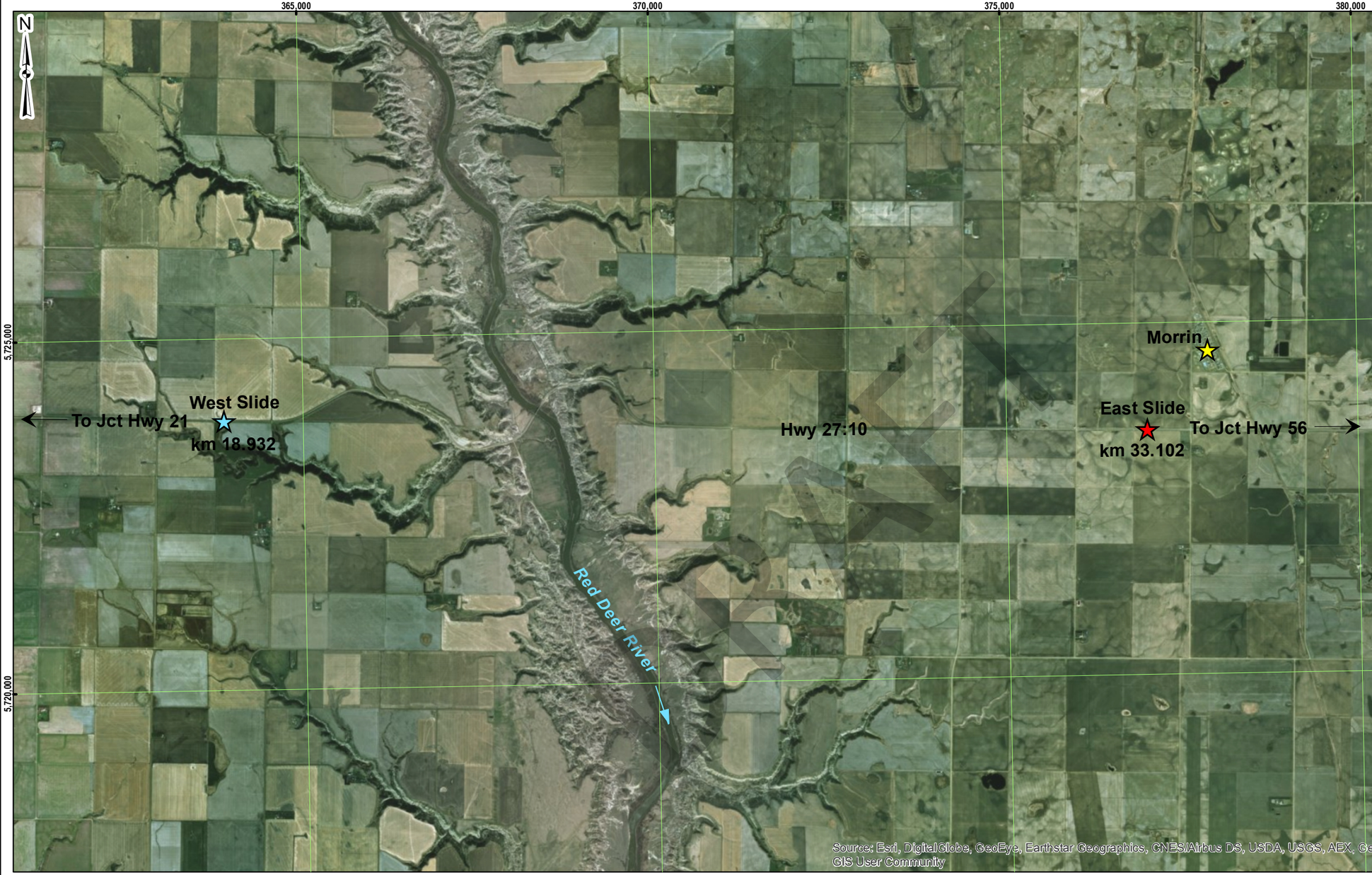
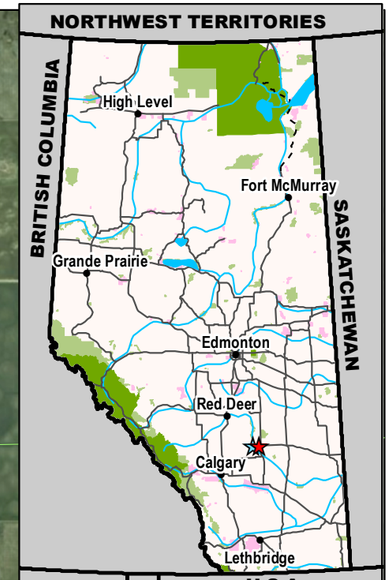
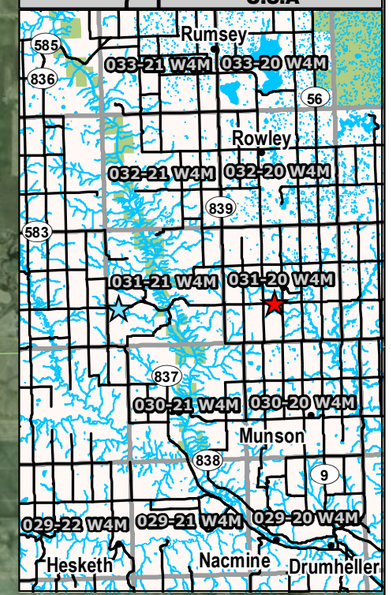
JL:kc

Attachment
Figures
Appendix I Instrumentation Plots

FIGURE







0 5 Kilometres

NOTES:
1. HORIZONTAL DATUM: NAD83
2. GRID ZONE: UTM Zone 12N
3. IMAGE SOURCE: World Imagery, ESRI ArcGIS Online. Image dated 2009/2010

CLIENT: Alberta

Klohn Crippen Berger

PROJECT: CENTRAL REGION GEOHAZARD RISK MANAGEMENT PROGRAM

TITLE: Site Location Plan
C070 - West and East Slides
Hwy 27:10, km 18.932 and 33.102

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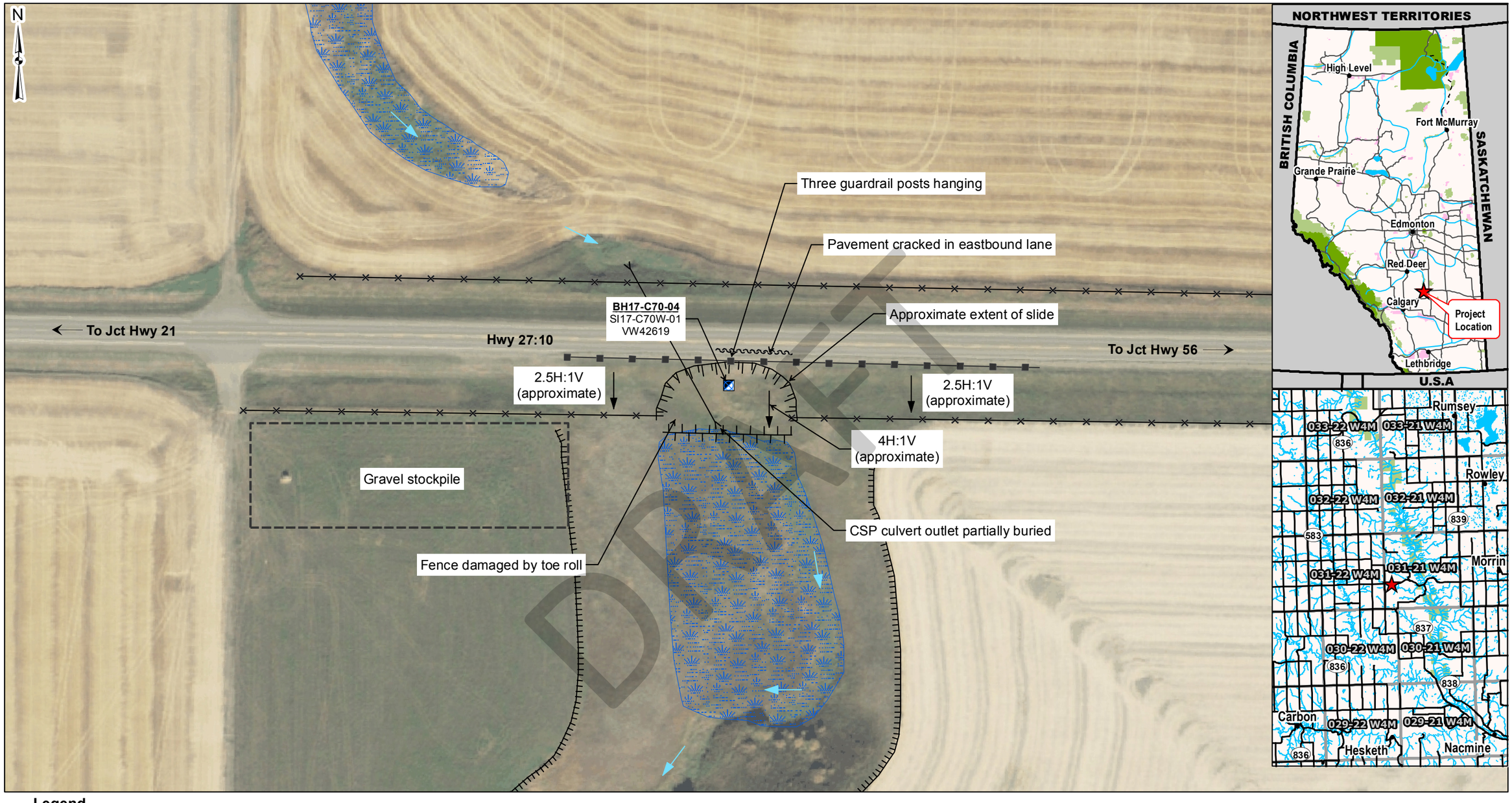

Legend

- Slope Inclinometer (SI)
- Vibrating Wire Piezometer (VW)
- Fence
- Guardrail
- Culvert
- Crack
- Scarp
- Toe of Slide
- Top of Slope
- Flow Direction
- Wet Area

Metres
0 50

NOTES:
1. HORIZONTAL DATUM: NAD83
2. GRID ZONE: UTM Zone 12N
3. IMAGE SOURCE: Abacus Datagraphics Ltd. Image dated July 5, 2011 to October 7, 2011
4. Location of instruments is approximate (not surveyed)

CLIENT: Alberta

Klohn Crippen Berger

PROJECT: CENTRAL REGION GEOHAZARD RISK MANAGEMENT PROGRAM

TITLE: Site Plan
C070 - West Slide
Hwy 27:10, km 18.932

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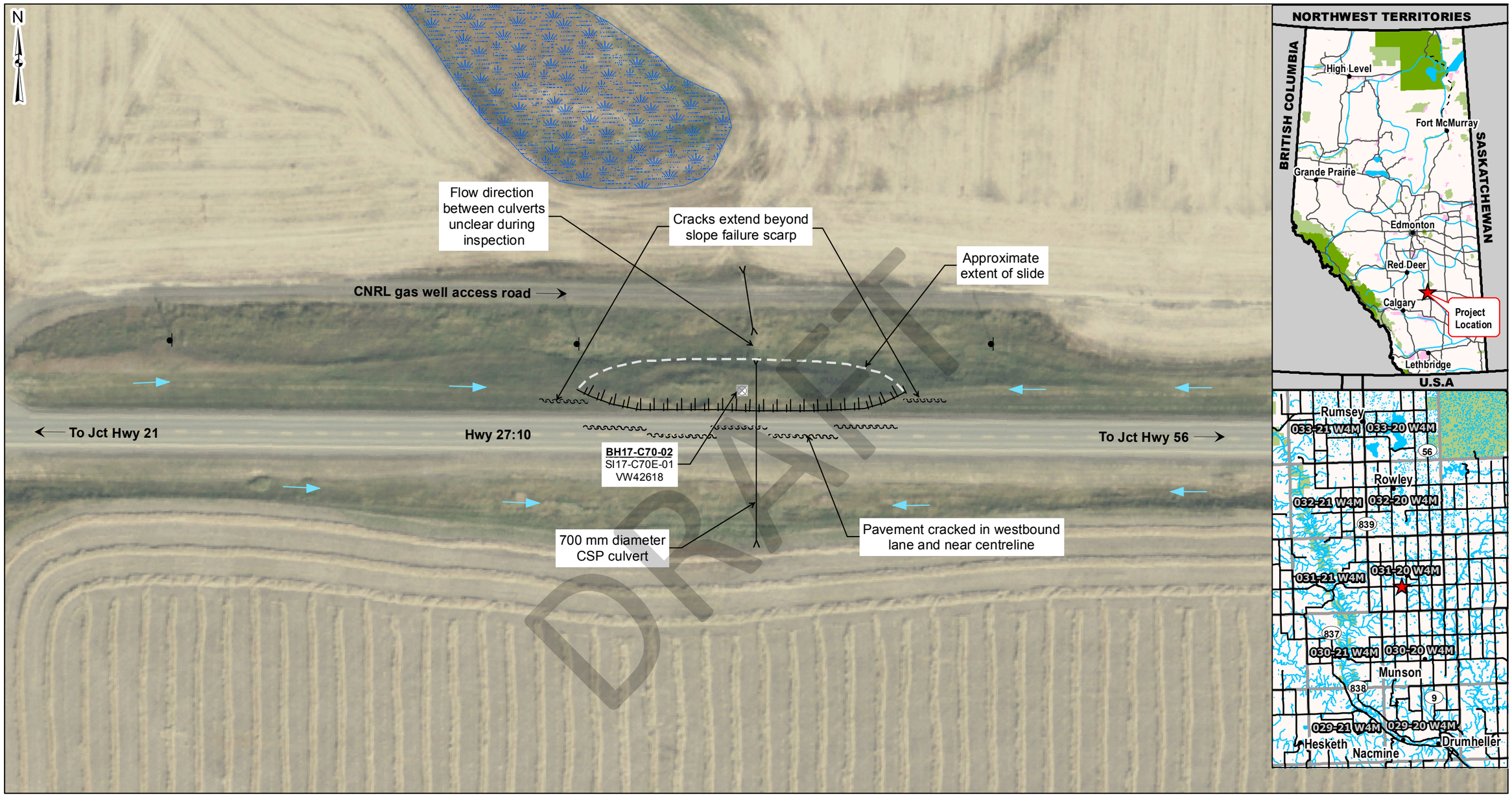

Legend

- Slope Inclinometer (SI) (inoperable)
- Vibrating Wire Piezometer (VW) (inoperable)
- Power Pole
- Culvert
- Crack
- Scarp
- Flow Direction
- Wet Area

Metres
0 50

NOTES:
1. HORIZONTAL DATUM: NAD83
2. GRID ZONE: UTM Zone 12N
3. IMAGE SOURCE: Abacus Datagraphics Ltd. Image dated July 5, 2011 to October 7, 2011
4. Location of instruments is approximate (not surveyed)

CLIENT: Alberta

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PROJECT: CENTRAL REGION GEOHAZARD RISK MANAGEMENT PROGRAM

TITLE: Site Plan
C070 - East Slide
Hwy 27:10, km 33.102

SCALE	PROJECT No.	FIG No.
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