

July 14, 2023

Alberta Transportation and Economic Corridors 2nd Floor, 803 Manning Road N.E. Calgary, Alberta T2E 7M8

Alex Frotten, P.Eng. Construction Engineer – Delivery Services Division (Southern Region)

Dear Mr. Frotten:

CON0022161 Southern Region GRMP Instrumentation Monitoring Site S036; H800:02, km 9.05 Belly River Section C – 2023 Spring Readings

1 **GENERAL**

Two slope inclinometers (SIs) (SI11-1 and SI11-2) and six vibrating wire piezometers (VWPs) (VW10-6701, VW10-6706, VW12-7899, VW12-7983, VW12-7888, and VW7051) were read at the S036 site in Southern Region on June 14, 2023, by Mr. Bradley Lawson, E.I.T., of Klohn Crippen Berger Ltd. (KCB). These instruments were read as part of the Southern Region Geohazard Risk Management Program (GRMP). The site is located on Hwy 800:02 km 9.05, approximately 9 km south of the Village of Hill Spring, Alberta, on the east side of the Belly River, in the Blood Tribe 148 Reserve. A permit was issued by Blood Tribe Land Management to Mr. White before the instrumentation readings were completed. The approximate site coordinates are 5454362 N, 308507 E (UTM Zone 12, NAD 83), and the legal land description for the site is NW 18-03-27-W4. A site plan is presented in Figure 1.

The geohazard at the S036 site consists of a landslide approximately 200 m long on the outside (south) bend of the Belly River riverbank. Previous remedial actions at the site include:

- In 2010, a section of the slide (approximately 40 m to 50 m in length) was excavated to a
 1H:1V slope and two to three rows of soil nails (approximately 6 m long) were installed in the
 excavated slope face to temporarily stabilize the slide. The soil nails were installed with 1 m
 vertical and horizontal spacing. The total number of soil nails installed is unknown.
- In 2012, the site was repaired by armouring the riverbank and channel with riprap, constructing a flow control structure, improving drainage, rebuilding the embankment slope, and buttressing the slope with a toe berm.

In 2011 and 2012, geotechnical site investigations, which included installing instruments, were conducted at the S036 site by a previous consultant to support design, construction, and post-construction monitoring. The encountered stratigraphy has not been provided to KCB.

2023 S036 Spring Report.docx A05116A03



1.1 Instrumentation

KCB has been reading the instruments at this site since 2016. Instrumentation installation details are tabulated in Table 1.1. Instrument locations are shown in Figure 1. Any instruments not included in Table 1.1 or shown in Figure 1 are assumed to be inoperable and are not presented or discussed herein.

In 2011, two SIs and eight VWPs were installed at the site by a previous consultant to monitor movement and groundwater conditions, respectively. In 2012, four additional VWPs were installed to monitor the performance of the drainage system installed below the toe berm during 2012 construction. Some of the VWPs are now inoperable.

The instruments are protected by either a flush-mounted or an above-ground casing protector.

KCB changed the SI reading equipment in 2016 when KCB took over the readings from the previous consultant, and again in October 2021, after the previous equipment became inoperable. Currently, KCB is reading the SIs with a metric RST Digital MEMS Inclinometer System.

The operable VWPs were read using an RST VWP readout box.

			UTM Coordinates ² (m)		Ground	Stick			
Instrument ID	Instrument Type	Date Installed	Northing	Easting	Surface Elevation (m)	Up (m)	Depth ² (mbgs ³)	Condition	
SI11-01	SI	Mar. 2011	5454320	308550	1208.0	0.0	20.0	Operable	
SI11-02	SI	Mar. 2011	5454411	308585	1208.0	0.0	20.0	Operable	
VW10-6701	VWP	Mar. 16, 2011	5454314	308529	1208.0	N/A	10.8	Operable	
VW10-6703	VWP	Mar. 2011	Unknown	Unknown	Unknown	N/A	Unknown	Inoperable	
VW10-6706	VWP	Mar. 16, 2011	5454289	308507	1210.5	N/A	11.6	Operable	
VW10-6707	VWP	Mar. 2011	Unknown	Unknown	Unknown	N/A	Unknown	Inoperable	
VW10-6708	VWP	Mar. 2011	Unknown	Unknown	Unknown	N/A	Unknown	Inoperable	
VW10-6709	VWP	Mar. 2011	Unknown	Unknown	Unknown	N/A	Unknown	Inoperable	
VW10-6711	VWP	- Mar. 2011	Unknown	Unknown	Unknown	N/A	Unknown	Inoperable	
VW10-6715	VWP	Mar. 2011	Unknown	Unknown	Unknown	N/A	Unknown	Inoperable	
VW12-7899	VWP	Dec. 11, 2012	5454370	308589	1193.0	N/A	3.4	Operable	
VW12-7983	VWP	Dec. 11, 2012	5454355	308523	1199.0	N/A	8.3	Operable	
VW12-7888	VWP	Dec. 11, 2012	5454393	308527	1193.0	N/A	3.5	Operable	
VW12-7051	VWP	Dec. 11, 2012	5454385	308539	1198.0	N/A	3.3	Operable	

Table 1.1Instrument Installation Details

Notes:

¹ Instrument installation details taken from reports and data files prepared or provided by the previous consultant(s) or Alberta Transportation.

² Coordinates were obtained by KCB with a handheld GPS. The handheld GPS had an accuracy of ±5 m.

³ Meters below ground surface (mbgs).

2 INTERPRETATION

2.1 General

For the operable SIs, the cumulative displacement, incrementation displacement, and displacementtime data was plotted in the A-direction (i.e., in the direction of the A0-grooves) and in the Xdirection (i.e., the direction of maximum movement obtained at a skew angle from the A0-grooves). SI11-01 and SI11-02 have skew angles of 30° and 200°, respectively, measured clockwise from the A0grooves.

For the operable VWPs, the recorded porewater pressures were converted to an equivalent water/piezometric elevation and plotted relative to ground surface of each instrument's tip elevation. The VWP readings are taken from one central monitoring station located on the toe berm, where all the VWP cables have been trenched to.

Monthly precipitation data is also plotted with the piezometer data. The data was obtained from the Alberta Climate Information Service (ACIS) database, referencing legal subdivision TWP003-27-W4.

The SI and piezometer data plots are included in Appendix I, and a summary of the SI and piezometer data is provided in Table 2.1 and Table 2.2, respectively. The SI data plots only include data obtained by KCB.

2.2 Zones of Movement

Movement has been recorded in SI11-01 from an approximate depth of 7 m to 10 m below ground surface (approximately El. 1198 m to El. 1201 m). Shallow movement from ground surface to approximately 2 m below ground surface (El. 1206 m) was also recorded between June 2021 and July 2022.

Movement has been recorded in SI11-02 from an approximate depth of 16 m to 20 m below ground surface (approximately El. 1192 m to El. 1196 m).



Table 2.1Slope Inclinometer Reading Summary

	Date							Movement (mm)				Rate of Movement (mm/year)		
Instrument ID		Provious Maximum			Ground Surface Elevation (m)	Depth of Movement (mbgs ¹)	Direction of Movement ²	Maximum Cumulative		Incremental		Most	Change	
	Initialized (Re-initialized)	Cumulative Movement Recorded	Previous Reading	Most Recent Reading				Before Re- Initialization	After Re- Initialization	Total	Since Previous Maximum Cumulative	Previous Maximum	Recent Reading	from Previous Reading
SI11-01 M	May 5, 2011	May 15, 2020	Jul. 7, 2022	2 Jun. 14, 2023	1208	0.5 - 4.0	X-Direction, 30°	Unknown	5.6	5.6	1.4	2.7	0.0	0.0
	(May 27, 2016) ³	Oct. 21, 2018				7.0 - 10.0		16.0 ³	2.6	18.6	-1.7	20.6	0.1	-0.2
SI11-02	May 5, 2011	Sep. 15, 2016	Jul. 7, 2022	Jun. 14, 2023	1208	12.0 - 16.0	X-Direction, 200°	N/A	N/A	3.3	-1.1	4.2	0.1	0.7

Notes:

¹ Meters below ground surface (mbgs).

² Skew angle of X-direction measured clockwise from the A-direction.

³ SI11-01 was re-initialized in May 2016 when KCB took over the instrument readings from the previous consultant and changed the SI reading equipment. Movement recorded before 2016 was taken from reports prepared by the previous consultant.

Table 2.2 Vibrating Wire Piezometer Reading Summary

Instrument ID		Date		Cround Surface Flowation	Tip Depth (mbgs ¹)	Water Level			
	Installed	Previous Reading	Most Recent Reading	(m)		Previous Reading (mbgs ¹)	Most Recent Reading (mbgs ¹)	Change from Previous Reading (m)	
VW10-6701	Mar. 16, 2011	Jul. 7, 2022	Jun. 14, 2023	1208.0	10.8	9.3	9.5	-0.2	
VW10-6706	Mar. 16, 2011	Jul. 7, 2022	Jun. 14, 2023	1210.5	11.6	6.1	6.2	-0.1	
VW12-7899	Dec. 11, 2012	Jul. 7, 2022	Jun. 14, 2023	1193.0	3.3	0.3	0.5	-0.2	
VW12-7983	Dec. 11, 2012	Jul. 7, 2022	Jun. 14, 2023	1199.0	8.2	7.0	7.0	0.0	
VW12-7888	Dec. 11, 2012	Jul. 7, 2022	Jun. 14, 2023	1193.0	3.5	2.6	2.8	-0.2	
VW12-7051	Dec. 11, 2012	Jul. 7, 2022	Jun. 14, 2023	1198.0.	3.3	2.0	2.3	-0.3	

Notes:

¹ Meters below ground surface (mbgs).



2.3 Interpretation of Monitoring Results

Slope Inclinometers

Between March 2011 and October 2015, the previous consultant reported:

- movement in SI11-01 from an approximate depth of 7 m to 10 m below ground surface (approximately El. 1198 to El. 1201 m). This movement was attributed to construction activities at the site in 2012 and not continued movement of the slide mass.
- movement in SI11-02 from an approximate depth of 7 m to 10 m below ground surface (approximately El. 1198 to El. 1201 m). The amount of movement was small (less than 2.5 mm) and likely due to post-installation flexure of the SI casing and/or backfill.

Since KCB took over the instrument readings at the site, the rate of movement recorded in SI11-01 and SI11-02 has been slow (less than 1 mm/year overall) and is currently negligible. The negative rate of movement recorded in these instruments during some readings indicates the rate of movement is within the accuracy of the reading equipment.

The July 2022 data indicated a small amount of movement (less than 6 mm) had occurred in the upper 2 m of SI11-01 between fall 2021 and spring 2022; however, no additional movement was measured in the zone during the spring 2023 reading. This movement could be due to instrument noise or reading error, or an indication that the slide is retrogressing towards the highway. More data is needed to assess. Tightness and difficulty passing the SI probe at approximately 8 m has been noted over the past several years; during the spring 2023 readings it was noted again.

Overall, given the negligible movement that has been recorded in SI11-01 and SI11-02, it appears as though the stabilization work completed in 2012 was successful and is performing well.

Vibrating Wire Piezometers

VW10-6701 and VW10-6706 were installed outside of the active slide zone, between the head of the slide and the west (southbound) lane of the highway. A steady increase (up to approximately 3 m) in water level was recorded in VW10-6701 and VW10-6706 between March 2011 (when the instruments were installed) and May 2012. Without reviewing previous borehole records, construction records for the site, or installation details for the instruments, KCB is unable to assess the cause of the increase in water level at this time. KCB suspects the increase may be attributed to a delayed response to 2010 construction activities or post-installation instrument stabilization.

Following construction in 2012, water levels recorded in VW10-6701 remained relatively steady until a 1.4 m decrease was recorded between October 2018 and April 2019. The cause of the decrease is unknown. Since April 2019, water levels recorded in VW10-6701 have fluctuated from approximately 8.8 m to 9.4 m below ground surface.



Since May 2012, water levels recorded in VW10-6706 have slowly decreased, most likely due to excess porewater pressure dissipation following the 2012 construction. In total, a 1.9 m and 0.2 m decrease has been recorded since May 2012 and the June 2021 reading, respectively.

In 2012, four VWPs (VW12-7983, VW12-7888, VW12-7899, and VW12-7051) were installed within the active slide zone in drain material below the toe berm, as reported by the previous consultant, to monitor the performance of the drain below the toe berm fill. VW12-7888 and VW12-7899 were installed closer to the toe of the embankment, while VW12-7083 and VW12-7051 were installed closer to the head of the slide.

Water levels recorded in VW12-7888 and VW12-7899 have been relatively steady since installation between an approximate depth of 2.6 m to 3.1 m and 0.3 m to 1.1 m, respectively. Whereas water levels recorded in VW12-7051 and VW12-7983 have been increasing (approximately 1.0 m and 1.1 m overall, respectively), with some seasonal variations noted. The rate of increase recorded in VW12-7983 appears to be slowing or flattening as the recorded water level in the spring 2023 readings noted a decrease by approximately 0.3 m compared with the spring 2022 reading. The decreases noted in water levels measured could be attributed to a dry spring in 2023 relative to previous years.

Overall, the June 2023 readings of the VWPs were consistent with historical trends observed in these instruments.

3 RECOMMENDATIONS

3.1 Future Work

All operable instruments should continue to be read once per year (spring).

KCB and AT must continue to obtain permission from the Blood Tribe to access the slide area during the bi-annual site inspections and annual instrumentation readings.

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

3.2 Instrument Repairs and Maintenance

No instrument repairs or maintenance is required.

4 CLOSURE

This report is an instrument of service of Klohn Crippen Berger (KCB). The report has been prepared for the exclusive use of Alberta Transportation (Client) for the specific application to the Southern Region Geohazard Risk Management Program (Contract No. CON0022161), and it may not be relied upon by any other party without KCB's written consent.

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

Yours truly,

KLOHN CRIPPEN BERGER LTD.

Peter Roy, P.Eng. Civil Engineer

PR:kb

ATTACHMENTS Figure Appendix I Instrumentation Plots



FIGURE







APPENDIX I

Instrumentation Plots



Deflection (mm) Deflection (mm) 25 - 1208 -25 - 1208 -25 -- 1208 0 12.5 25 ____1208 LEGEND -12.5 -12.5 0 12.5 27 May 2016 Initial 15 Sep 2016 1206 1206 1206 1206 16 May 2017 25 Apr 2018 21 Oct 2018 1204 1204 × × 1204 1204 30 Apr 2019 5 Sep 2019 ரு 1202 1202 1202 1202 15 May 2020 24 Sep 2020 16 Jun 2021 1200 1200 1200 1200 7 Jul 2022 15 Jun 2023 1198 1198 1198 1198 Elev. Elev. ^(m) 1196 ^(m) 1196 1196 1196 1194 1194 1194 1194 1192 1192 1192 1192 1190 1190 1190 1190 Ref. Elevation 1208 m 1188 1188 1188 1188 12.5 -12.5 -25 -12.5 0 25 -25 0 12.5 25 **Cumulative Deflection Cumulative Deflection** Direction A Direction B

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S036; H800:02, Belly River, Inclinometer SI11-01

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Displ. (mm)

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Displ. (mm)

Klohn Crippen Berger Ltd. - Calgary, AB

S036; H800:02, Belly River, Inclinometer SI11-01

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S036; H800:02, Belly River, Inclinometer SI11-02

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Sets marked * include zero shift and/or rotation corrections.

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