

July 15, 2024

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

**Tony Penney, P.Eng.
Construction Engineer**

Dear Mr. Penney:

**CON0022160 Central Region GRMP Instrumentation Monitoring
Site C043; H619:06, km 12.206 Soil Nail Site
Section C – 2024 Spring Readings**

1 GENERAL

Two vibrating wire piezometers (VWPs) (VW46428 and VW46429) and two slope inclinometers (SIs) (SI21-C43-01 and SI21-C43-02) were read at the C043 site in the Central Region on May 14, 2024 by Aden Shipton, E.I.T. of Klohn Crippen Berger Ltd. (KCB). These instruments were read as part of the Central Region Geohazard Risk Management Program (GRMP). The site is located on Hwy 619:06, km 12.2, approximately 24 km southeast of Vermilion, Alberta. The approximate site coordinates are 5890276 N, 520018 E (UTM Zone 12, NAD 83). A site plan is presented in Figure 1.

The geohazard at the C043 site consists of an embankment slope failure on the north side of Hwy 619:06 and a backslope failure on the south side of Hwy 619:06.

In November 2017, KCB conducted a geotechnical site investigation at the C043 site. Drilling was completed by Mobile Augers and Research Ltd. The encountered stratigraphy was as follows: low to medium plastic silty clay till, overlying weathered clay shale. The encountered stratigraphy was consistent with the stratigraphy encountered during a 2013 drilling investigation.

In March 2021, a 12-m-deep, 63-m-long H-pile wall (H360X132) consisting of 106 piles was installed on the north side of the highway. Previous remedial actions include soil nails installed through the embankment slope failure on the north side of the highway in 2006.

1.1 Instrumentation

Instrumentation installation details are tabulated in Table 1.1. Instrument locations are presented in Figure 1.

In June 2013, KCB installed one SI (SI13-01) and one standpipe piezometer (SP) (SP13-01) in the north (westbound) lane of Hwy 619:06. The instruments were destroyed in 2014 due to ongoing road maintenance (i.e., pavement patching).

In November 2017, KCB installed two VWP (VW46428 and VW46429) to monitor groundwater conditions. The VWPs were installed in borehole BH17-C43-01, located in the south (eastbound) ditch of Hwy 619:06.

On March 23, 2021, KCB installed two SIs (SI21-C43-01 and SI21-C43-02) in steel pockets between the web and flanges of the 2021 H-piles to monitor deflection of the H-pile wall. SI21-C43-01 and SI21-C43-02 are located approximately one-third (21 m) from either end of the H-pile wall.

The VWPs are protected by an above-ground casing protector. However, the SIs do not have casing protectors (see Section 3.2).

The VWPs were read using an RST VW2106 vibrating wire readout.

The operable SIs were read using the same metric RST Digital MEMS Inclinator System that has been used to read the SIs since they were installed.

Table 1.1 Instrumentation Installation Details

Instrument ID	Instrument Type	Date Installed	UTM Coordinates ¹ (m)		Ground Surface Elevation ¹ (m)	Stick Up (m)	Depth (mbgs ²)	Condition
			Northing	Easting				
SI13-01	SI	Jun. 20, 2013	5890277	520006	607	-0.1	14.5	Inoperable ³
SI21-C43-01	SI	Mar. 23, 2021	5890285	520009	Unknown	0.1	10.9	Operable
SI21-C43-02	SI	Mar. 23, 2021	5890285	520024	Unknown	0.1	11.4	Operable
SP13-01	SP	Jun. 20, 2013	5890277	520008	607	0.0	14.5	Inoperable ³
VW46428	VWP	Nov. 20, 2017	5890266	520007	605	N/A	6.5	Operable
VW46429	VWP					N/A	12.3	Operable

Notes:

¹ Coordinates and ground surfaces elevations for the instruments installed in 2017 were obtained with a handheld GPS during installation.

² Meters below ground surface (mbgs).

³ SI13-01 and SP13-01 were destroyed in 2014 due to ongoing road maintenance (i.e., pavement patching).

2 INTERPRETATION

2.1 General

For the operable SIs, the cumulative displacement, incremental displacement, and displacement-time data was plotted in the A-direction (i.e., the direction of the A0-grooves). The A0-grooves in the SIs are aligned approximately with the direction of maximum movement, in the downslope direction.

For the VWPs, the recorded porewater pressures were converted to an equivalent water/piezometric elevation and plotted relative to ground surface elevation and the tip elevation for each instrument.

The SI and piezometer 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.

Table 2.1 Slope inclinometer Reading Summary

Instrument ID	Date				Ground Surface Elevation (m)	Depth of Movement (mbgs ¹)	Direction of Movement	Movement (mm)		Rate of Movement (mm/year)		
	Initialized	Previous Maximum Cumulative Movement Recorded	Previous Reading	Most Recent Reading				Maximum Cumulative	Incremental Since Previous Maximum Cumulative	Previous Maximum	Most Recent Reading	Change from Previous Reading
SI21-C43-01	Apr. 22, 2021	May 08, 2023	May 08, 2023	May 14, 2024	Unknown	0.7 – 10.7	A-Direction	7.3	1.8	11.7	1.8	0.8
SI21-C43-02	Apr. 22, 2021	May 08, 2023	May 08, 2023	May 14, 2024	Unknown	0.6 – 10.6	A-Direction	8.5	2.8	6.2	2.7	1.8

Notes:
¹ Meters below ground surface (mbgs).

Table 2.2 Vibrating Wire Piezometer Reading Summary

Instrument ID / Serial No.	Date			Ground Surface Elevation (m)	Tip Depth (mbgs ¹)	Water Level		
	Installed	Previous Reading	Most Recent Reading			Previous Reading (mbgs ¹)	Most Recent Reading (mbgs ¹)	Change from Previous Reading (m)
VW46428	Nov. 20, 2017	May 08, 2023	May 14, 2024	605	6.5	4.5	4.7	-0.2
VW46429	Nov. 20, 2017	May 08, 2023	May 14, 2024	605	12.3	5.4	5.6	-0.2

Notes:
¹ Meters below ground surface (mbgs).

2.2 Zones of Movement

Before the instrument was destroyed in 2014 due to ongoing road maintenance, movement was being recorded in SI13-01 at an approximate depth of 2 m below ground surface, at the interface between the silt and clay till.

Distributed movement is being recorded in the SIs installed in the H-pile wall, SI21-C43-01 and SI21-C43-02, from top of casing to approximate depths of 11 m and 8 m below ground surface, respectively. The H-pile wall is 12 m deep, and SI21-C43-01 and SI21-C43-02 are approximately 10.9 m and 11.4 m deep, respectively.

2.3 Interpretation of Monitoring Results

Previous assessments of the slope failure suggest that movement is likely occurring in response to periods of heavy or prolonged rainfall, resulting in higher groundwater conditions or a near surface zone of saturation within the north (westbound lane) embankment slope for short periods of time. However, this is not supported by the most recent piezometer data. The water levels recorded in the VWPs have been relatively steady (± 0.6 m) since the instruments were installed in 2017. It is possible that the reading frequency of the instruments (currently annually, previously bi-annually) does not capture short-term fluctuations (i.e., increases and decreases) in water level that are occurring in response to periods of heavy or prolonged rainfall or freshet infiltration. More frequent readings (i.e., installing a data logger) would be useful to assess how the groundwater responds to periods of heavy or prolonged rainfall.

Even after installation of soils nails in 2016, the slope continued to deform slowly (as indicated by pavement cracking and settlement) with the site requiring regular pavement patches. Subsequently, the H-pile wall was installed in 2021.

The distributed movement being recorded in SI21-C43-01 and SI21-C43-02 is from approximately ground surface to the base of the H-pile wall and from ground surface to 4 m above the base of the wall, respectively. The deflection recorded in SI21-C43-02 is approximately 2 m below the depth of movement recorded in SI13-01 before it was destroyed. Distributed movement along the length of the H-pile wall indicates that the failure surface has been intercepted, and is continuing to deflect, transferring load to depths below the failure plane as the piles stabilize the slide mass.

The May 2024 data obtained from the pile-wall SIs indicates that the top of the H-pile wall has deflected up to approximately 8.5 mm since installation. In the spring of 2021, shortly after construction of the H-pile wall, the maximum rate of movement recorded in these SIs was between approximately 6 mm/year and 12 mm/year. The rate of movement has since decreased and is now less than approximately 3 mm/year. KCB anticipated that the rate of movement shortly after installation would be highest and would decrease as the H-pile wall picked up load stabilizing the sliding mass.

Although the current rate of movement in the H-pile wall SIs is slow, increased movement may occur in response to periods of heavy or prolonged rainfall, resulting in higher groundwater conditions.

3 RECOMMENDATIONS

3.1 Future Work

All operable instruments should continue to be read once per year (spring) until movements attenuate, and all cracking and deformations of the pavement surface cease.

The site should continue to be inspected by the Maintenance Contract Inspector (MCI) and as part of the Central Region GRMP Section B inspections, until movement rates attenuate.

3.2 Instrument Repairs and Maintenance

Between the 2022 and 2023 spring readings, the above-ground PVC casing protector for SI21-C43-01 was damaged (most likely damaged during snow clearing activities). A replacement casing protector should be installed.

Photo 1 **Damaged PVC casing protector at SI21-C43-01. Photo taken May 8, 2023.**



4 CLOSING

This report is an instrument of service of Klohn Crippen Berger (KCB). The report has been prepared for the exclusive use of Alberta Transportation and Economic Corridors (Client) for the specific application to the Central Region Geohazard Risk Management Program (Contract No. CON0022160), and it may not be relied upon by any other party without KCB's written consent.

KCB has prepared this report in a manner consistent with the level of care, skill and diligence ordinarily provided by members of the same profession for projects of a similar nature at the time and place the services were rendered. KCB makes no warranty, express or implied.

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

Yours truly,

KLOHN CRIPPEN BERGER LTD.



James Lyons, P.Eng.
Civil Engineer

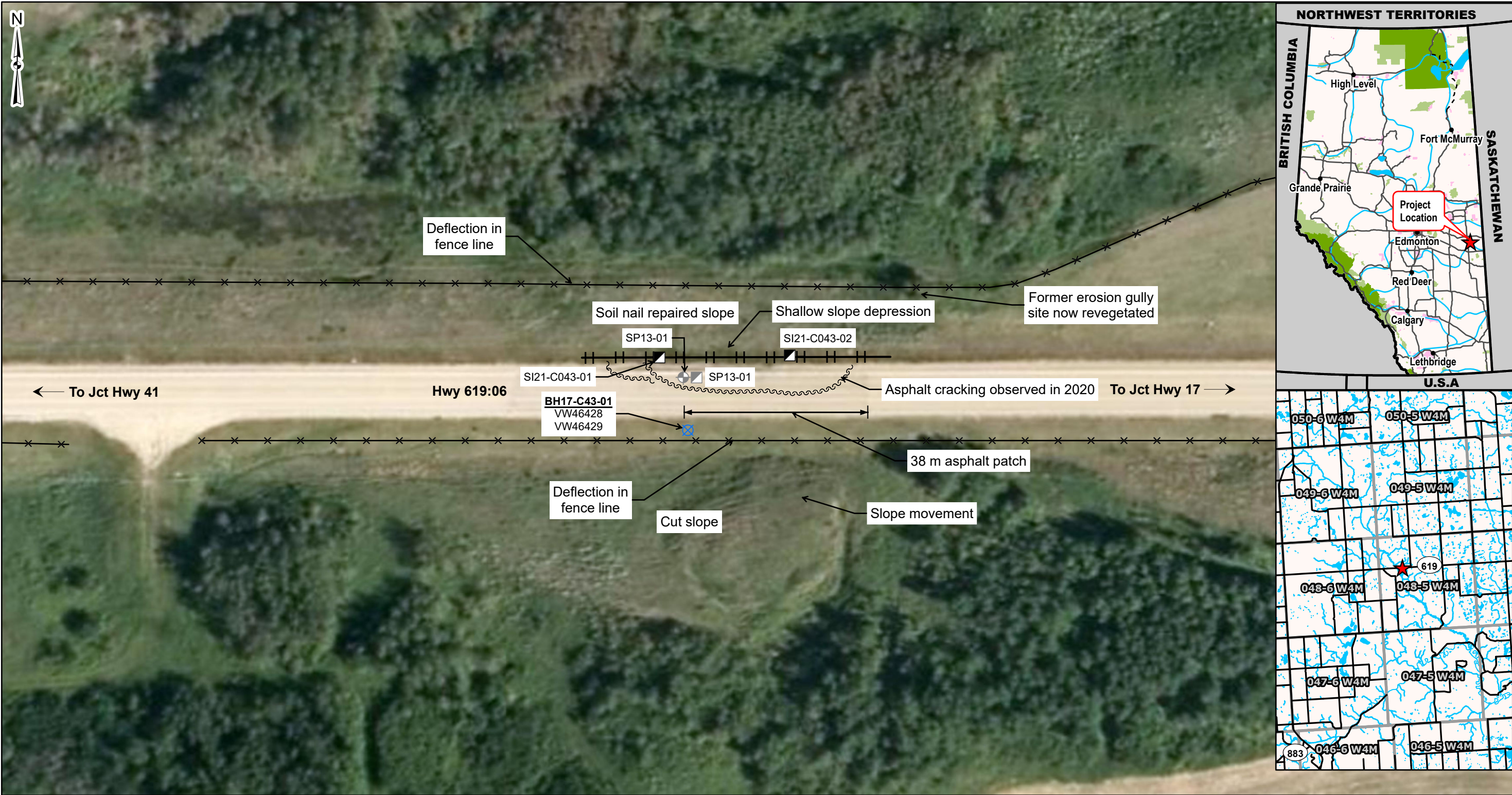
Aden Shipton, E.I.T.
Civil Engineer in Training

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
ATTACHMENTS

Figure
Appendix I Instrumentation Plots

FIGURE



Legend

-  Slope Inclinerometer
-  Slope Inclinerometer (SI) (inoperable)
-  Standpipe Piezometer (SP) (inoperable)
-  Vibrating Wire Piezometer (VW)
-  H-Pile Wall
-  Fence
-  Crack

NOTES:
1. HORIZONTAL DATUM: NAD83
2. GRID ZONE: UTM ZONE 12N
3. IMAGE SOURCE: ESRI, MAXAR, EARTHSTAR GEOGRAPHICS AND THE GIS USER COMMUNITY
4. INSTRUMENT LOCATIONS ARE APPROXIMATE (NOT SURVEYED)
5. H-PILE WALL INSTALLED IN MARCH 2021

CLIENT





PROJECT
CENTRAL REGION GEOHAZARD RISK MANAGEMENT PROGRAM

TITLE
Site Plan
C043 - Soil Nail Site
Hwy 619:06, km 12.206

SCALE
1:800

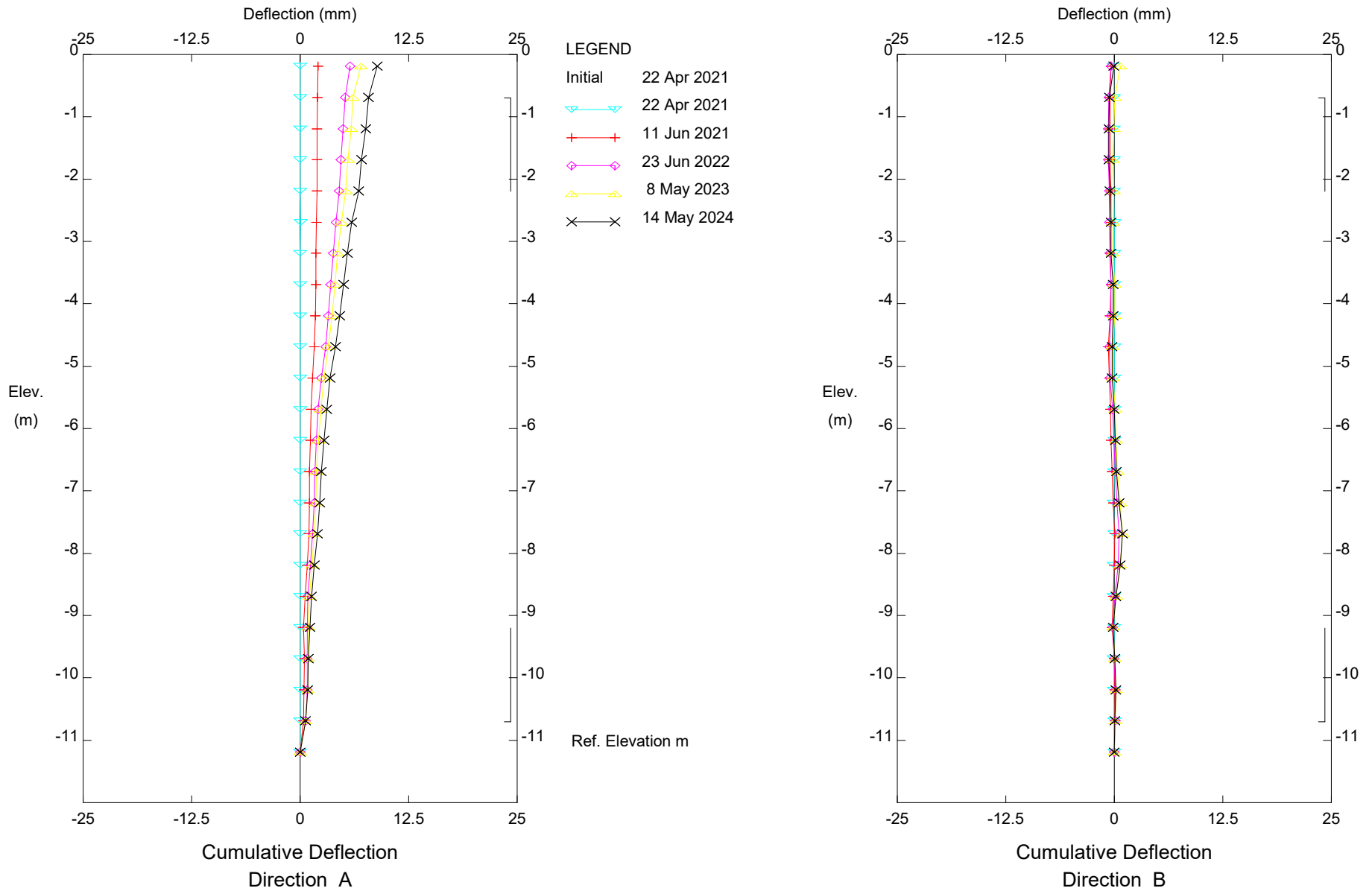
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FIG No.
1

APPENDIX I

Instrumentation Plots

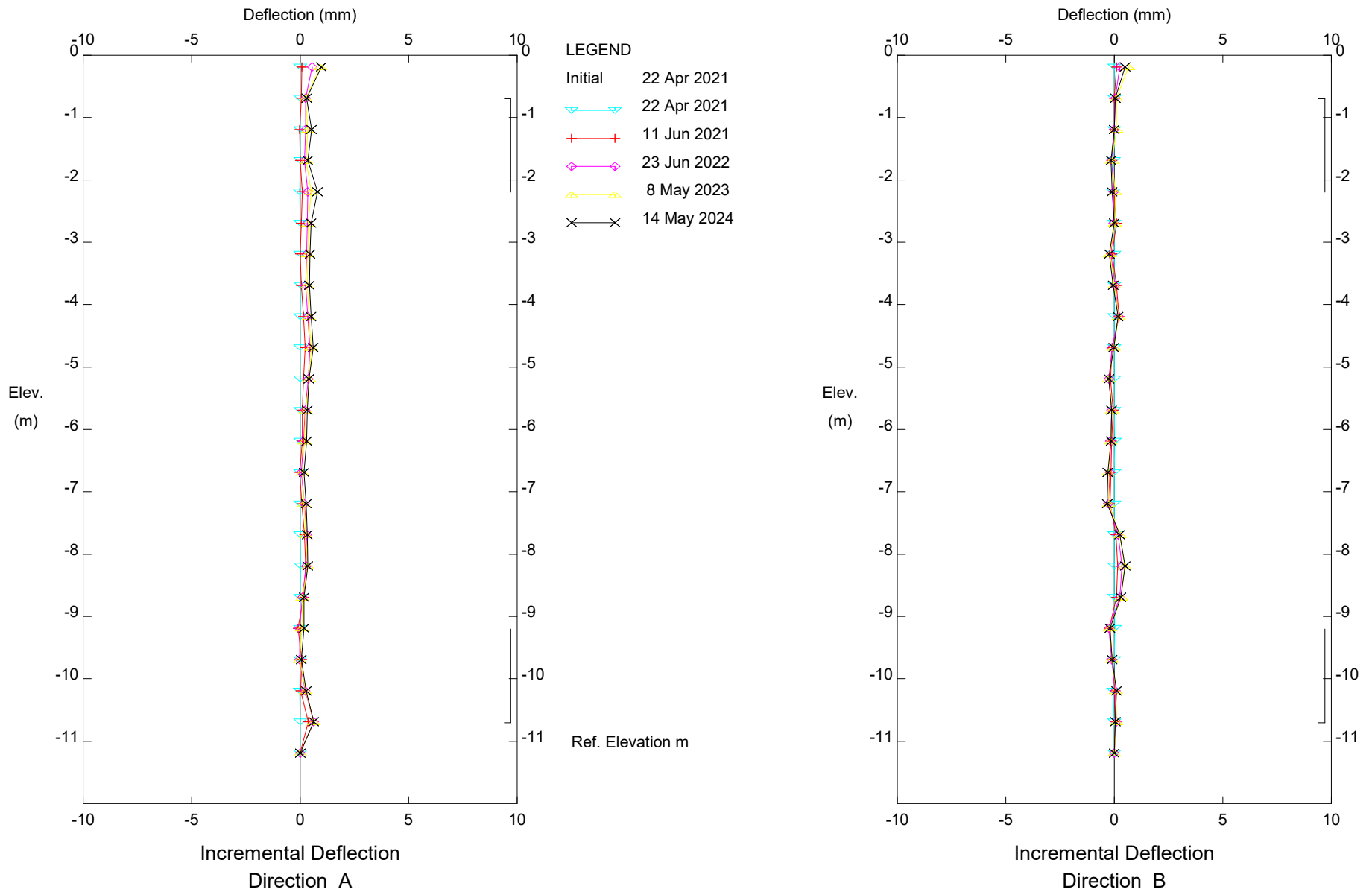
Klohn Crippen Berger - Calgary



C043; H619:06; Soil Nail Site, Inclinometer SI21-01

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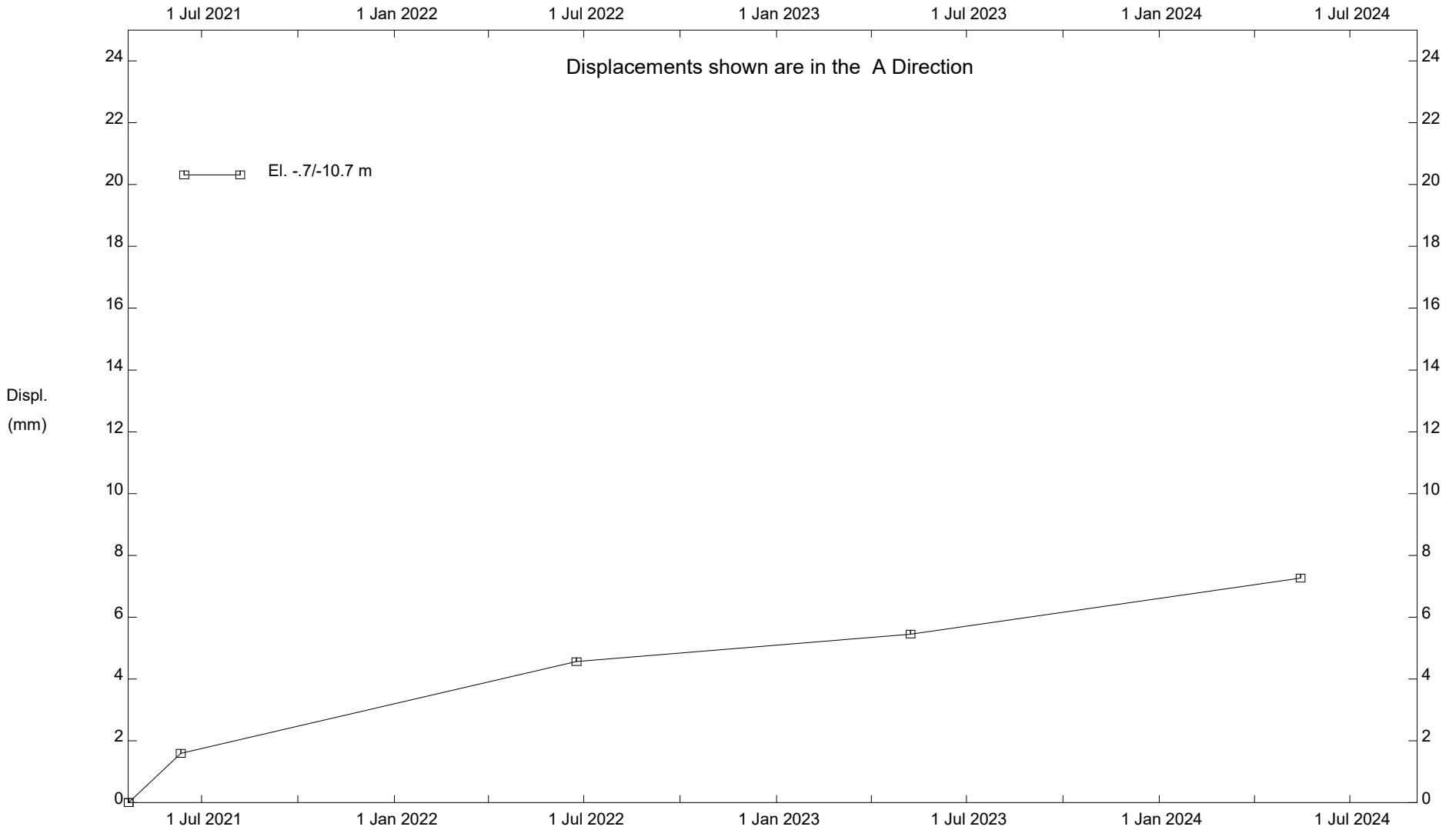
Klohn Crippen Berger - Calgary



C043; H619:06; Soil Nail Site, Inclinometer SI21-01

Alberta Transportation

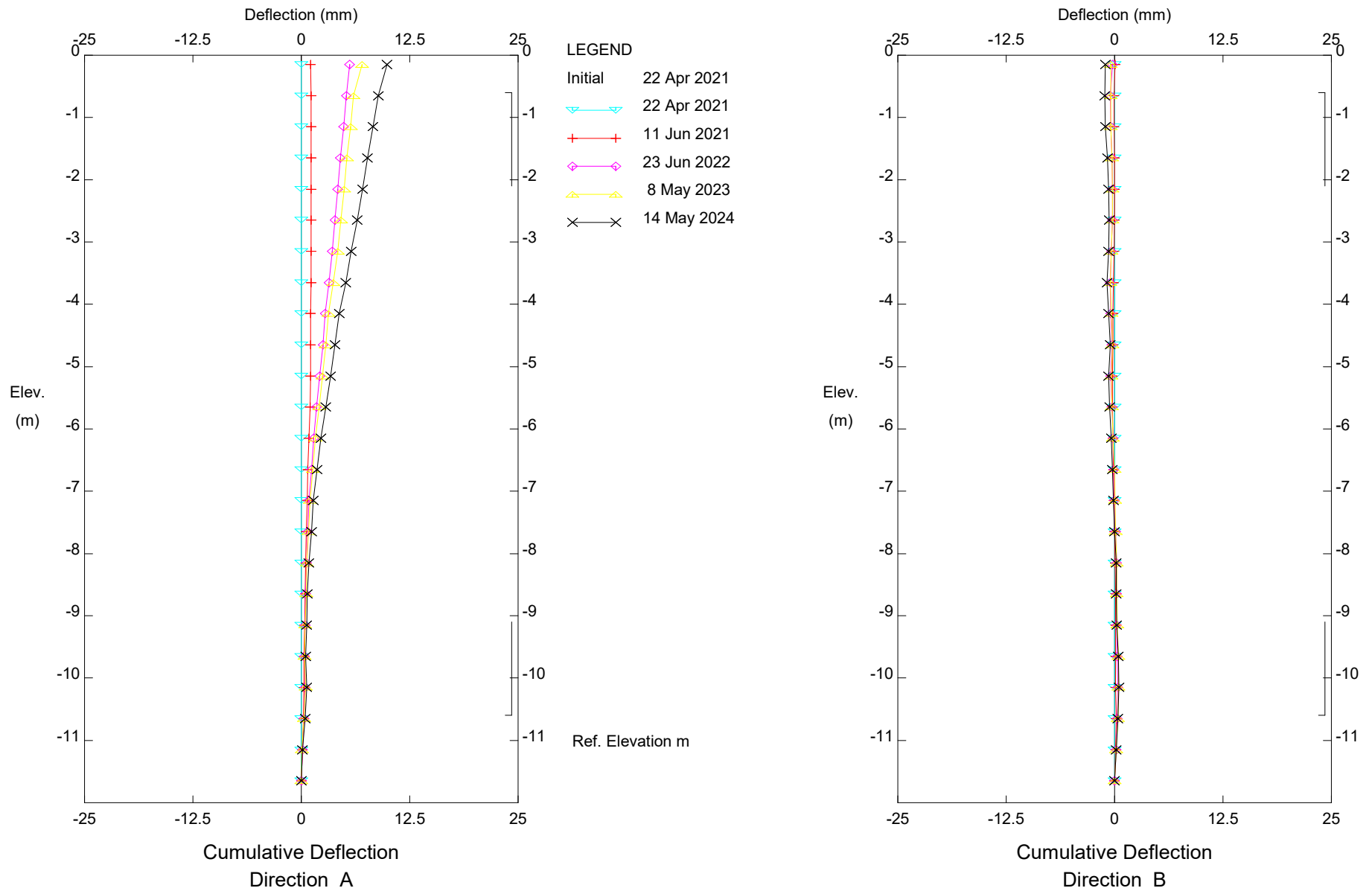
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C043; H619:06; Soil Nail Site, Inclinometer SI21-01

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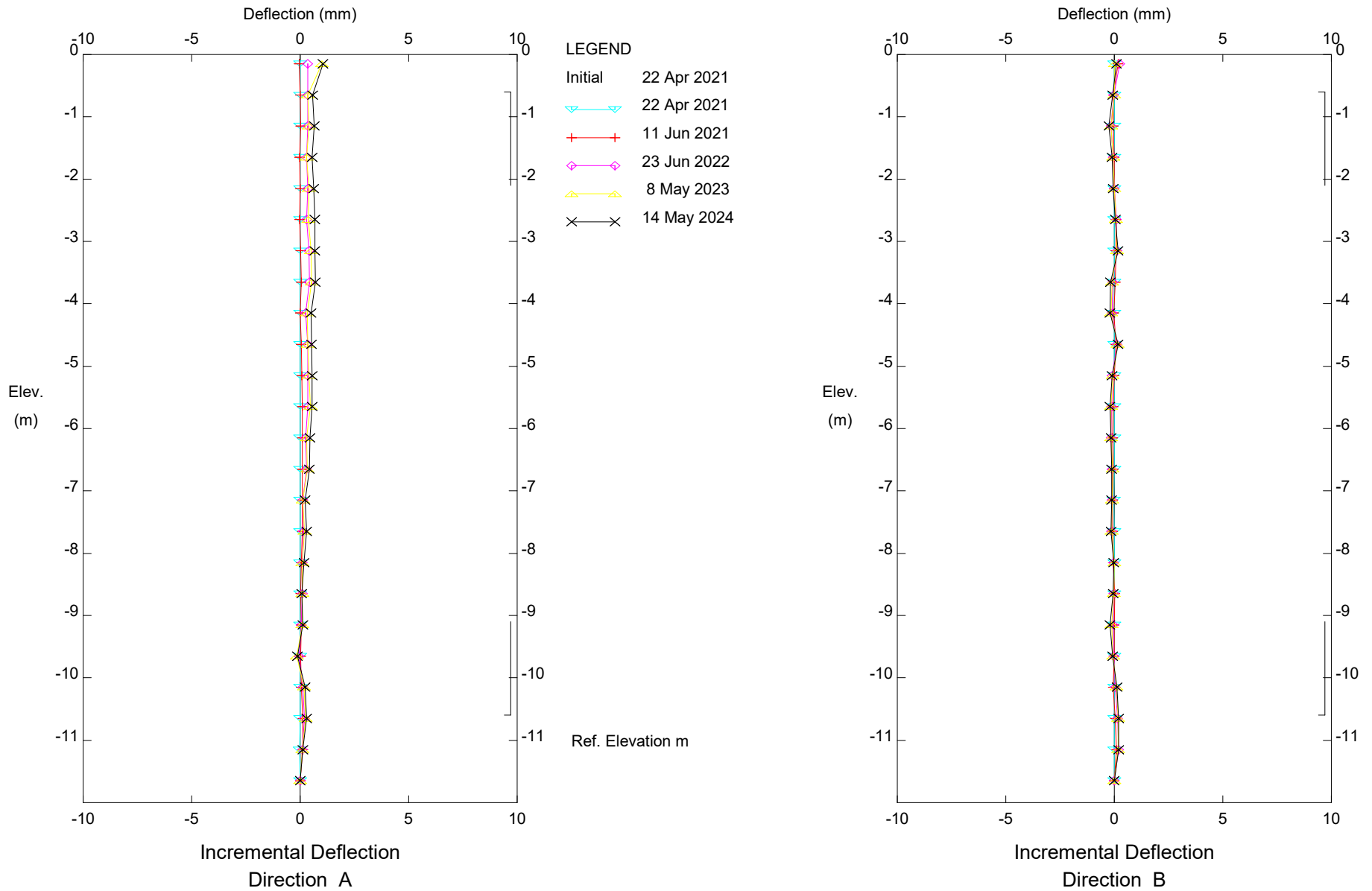
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C043; H619:06; Soil Nail Site, Inclinator SI21-02

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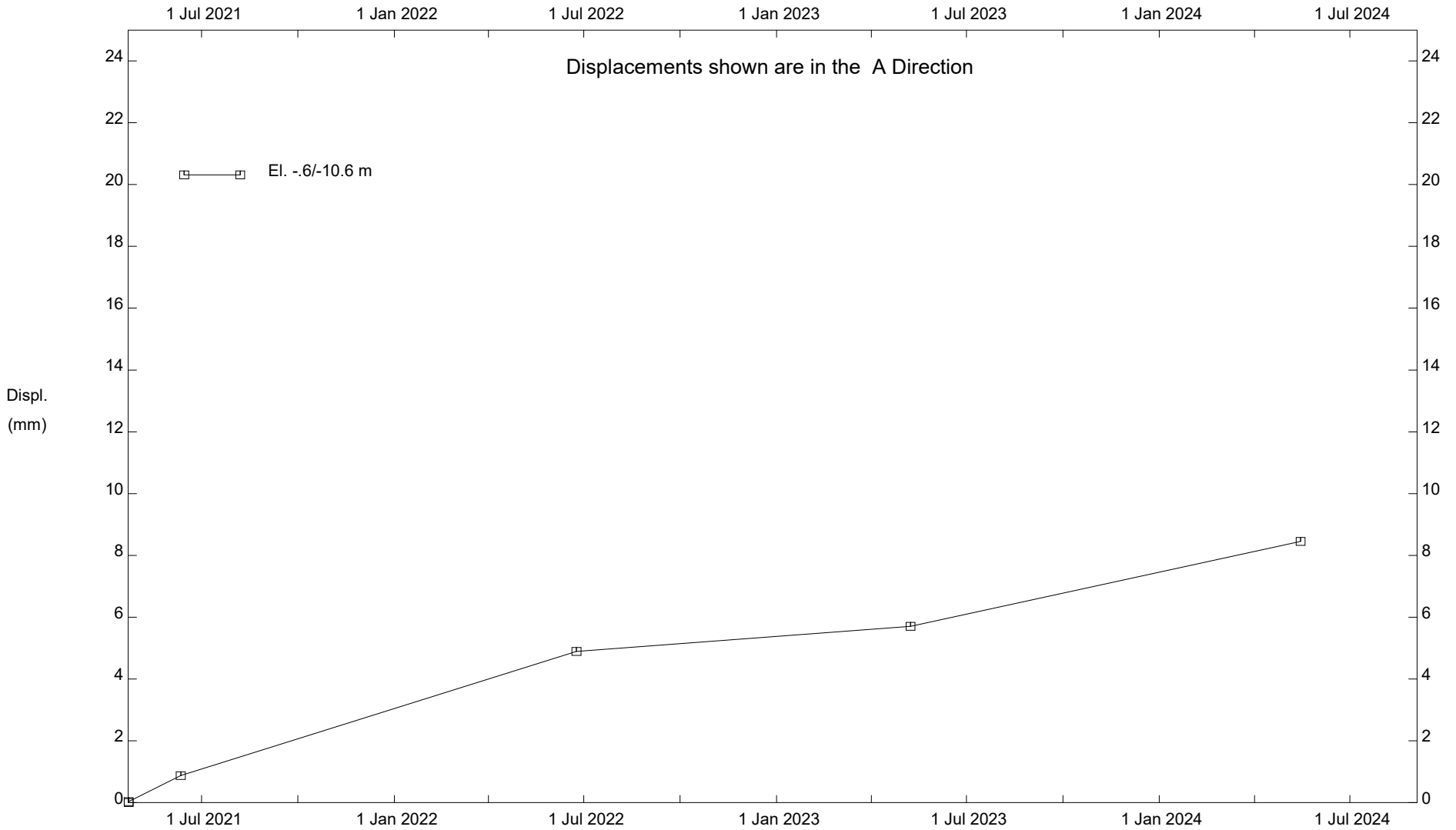
Klohn Crippen Berger - Calgary



C043; H619:06; Soil Nail Site, Inclinator SI21-02

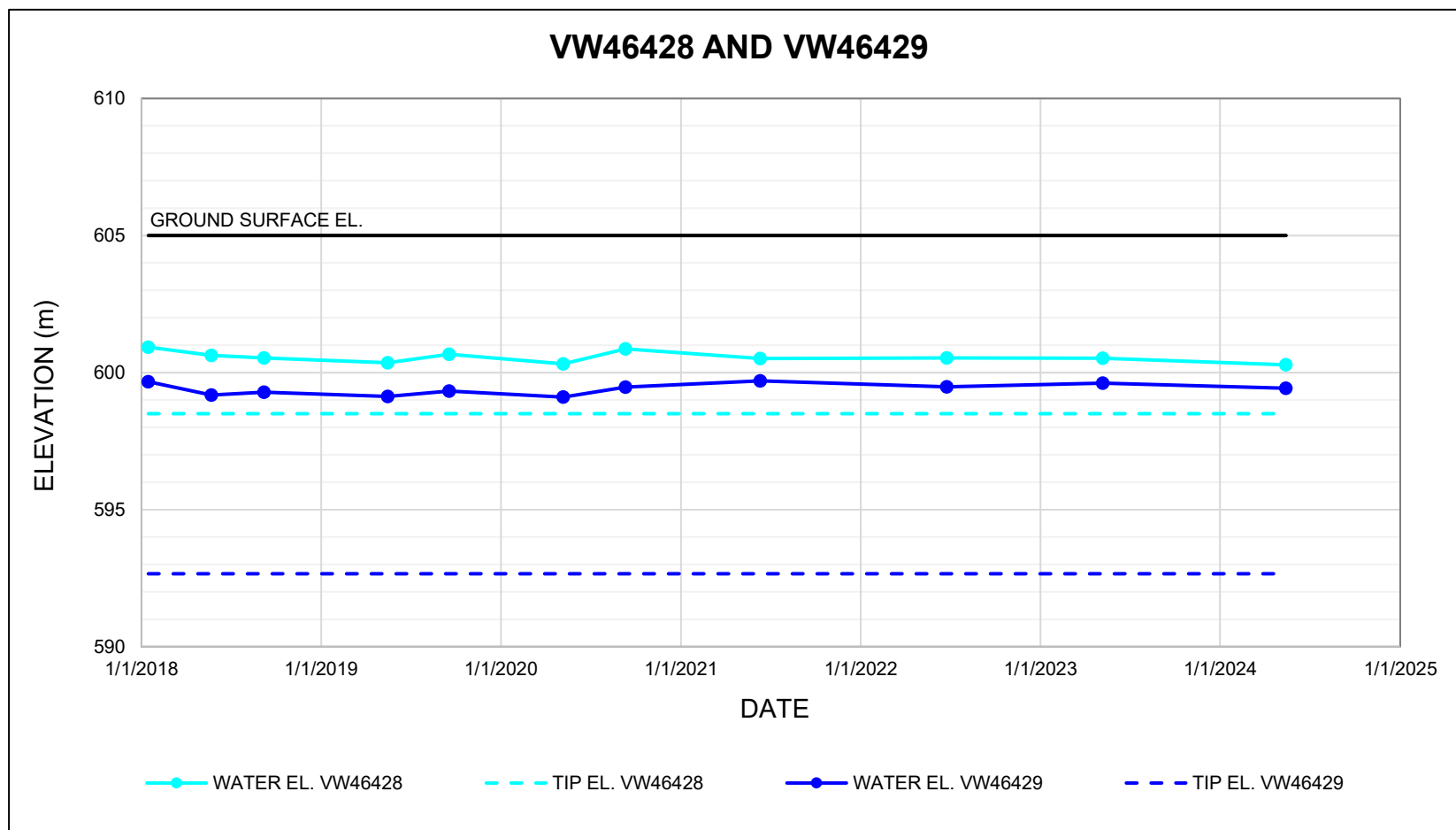
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C043; H619:06; Soil Nail Site, Inclinator SI21-02

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NOTES:
 1. GROUND SURFACE ELEVATION MEASURED WITH A HANDHELD GPS DURING INSTALLATION.

CLIENT		PROJECT	
 		CENTRAL REGION GEOHAZARD RISK MANAGEMENT PROGRAM	
		TITLE	
		Piezometer Data C043 - Soil Nail Site Hwy 619:06, km 12.206	
SCALE	PROJECT No.	A05116A02	FIG No. I-1