November 26, 2025

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 S003; H22:16 km 9.9 Cochrane
Section C – 2025 Fall Readings

1 GENERAL

Five slope inclinometers (SI) (SI18-01, SI23-01, SI23-02, SI23-03, and SI23-04), and three vibrating wire piezometers (VWPs) (VW18-01, VW18-02 and VW18-03) were read at the S003 site in Southern Region on October 8, 2025, by Mr. Shawn Keegan, 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 22:16 km 9.9, south of Cochrane, Alberta, approximately 1 km south of the Bow River bridge. The approximate site coordinates are 5672089 N, 676024 E (UTM Zone 11, NAD 83), and the legal land description for the site is SW 34-25-4-W5. A site plan is presented in Figure 1.

The geohazard at the S003 site consists of a landslide along the south slope of the Bow River valley. The landslide encroaches approximately 3 m into the northbound lane of Hwy 22:16. Previous remedial actions at this site included the construction of a ditch berm (date unknown) in the northeast (northbound lane) ditch to reduce surface water runoff from discharging onto the landslide. However, in late 2020, the ongoing movement of the slide area had caused the settlement of the ditch berm such that ditch flows were directed onto the slide area. In fall 2023, a pile wall consisting of 133 H-piles, spaced at 0.72 m, center to center, was constructed on the east side of the highway in the slide zone to stabilize the slope. The ditch across the slide area was also repaired to prevent water from flowing out of the ditch onto the slide mass.

Geotechnical site investigations, which included the installation of instruments, were conducted at the S003 site in 1991, 1994, 2007, and 2009 by the previous consultants. In March 2018, KCB conducted a geotechnical site investigation, during which instruments were installed to monitor movement and groundwater conditions. Drilling was completed by Mayfield Drilling and Environmental Service Ltd. The encountered stratigraphy during the 2018 investigation was as

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follows: medium-plastic clay, overlying medium-plastic clay till. As part of the 2023 construction, four (4) SIs were installed in the pile wall to monitor movement as the pile wall takes load from the slide mass.

1.1 Instrumentation

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.

Between 1991 and 2007, eleven (11) SIs and two (2) piezometers were installed at the site by the previous consultants to monitor movement and groundwater conditions, respectively. By May 2020, most of these instruments were inoperable (e.g., destroyed, sheared, or lost). The pneumatic piezometer (BH2007-02) was found to be inoperable after the pile wall construction was completed, which could have been caused by slope movement observed downslope of the pile wall during construction activities.

In fall 2023, four (4) SIs were installed along the newly constructed pile wall (SI23-01, SI23-02, SI2103, and SI21-04). The remaining operable instruments, including those installed by KCB in 2018 and 2023, are protected by either flush-mounted or above-ground casing protectors.

Table 1.1 Instrumentation Installation Details

Instrument ID[3]	Instrument Type	Date Installed[1]	UTM Coordinates[1] (m)		Ground Surface Elevation (m)	Stick Up (m)	Depth (mbgs[2])	Condition
			Northing	Easting				
SI18-01	SI	Mar. 2018	5672120	676028	1173.8	0.8	21.3	Operable
SI23-01	SI	Sept. 2023	5672156	675976	1171.0	1.3	16.4	Operable
SI23-02	SI	Sept. 2023	5672141	675990	1171.0	1.3	16.5	Operable
SI23-03	SI	Sept. 2023	5672108	676015	1171.0	1.1	16.5	Operable
SI23-04	SI	Sept. 2023	5672083	676035	1171.0	1.5	15.7	Operable
VW18-01	VWP	Mar. 2018	5672120	676028	1174.0	N/A	13.7	Operable
VW18-02	VWP	Mar. 2018	5672056	676047	1176.0	N/A	10.1	Operable
VW18-03	VWP	Mar. 2018	5672048	676027	1176.5	N/A	4.7	Operable

Notes:

[1] Instrument installation details taken from reports and data files prepared or provided by the previous consultant(s) or TEC. Coordinates reported by the previous consultants were confirmed by KCB with a handheld GPS with NAD83/UTM 11N Datum. The handheld GPS had a horizontal accuracy of +/- 5 m.

[2] Meters below ground surface (mbgs). Bottom casing depth for SIs and tip depth for piezometers.

[3] SI#3A, SI#4, SI#6, SI2007-1, and SI2009-1 have all sheared at depths between approximately 1.8 m and 4.0 m, respectively.

KCB replaced the SI reading equipment in October 2021 after the previous system became inoperative. Currently, KCB uses a metric RST Digital MEMS Inclinometer System to read the SIs. The VWPs were measured using an RST VWP readout box and a Water Level Meter.

2 INTERPRETATION

2.1 General

The SI plots presented in the report include cumulative displacement, incremental displacement, and displacement-time data (Appendix I). The displacement-time data is plotted in the A-direction (i.e., the direction of the A0-groove). Since October 2021, KCB has been using a new inclinometer probe and reel, which might lead to slight differences in data compared to earlier readings. However, during the review of the SI data for this report, all prior data corrections were removed to facilitate better interpretation of displacement trends.

For the operable piezometers, the recorded porewater pressures were converted to an equivalent water/piezometric elevation and plotted relative to ground surface elevation of each instrument's tip elevation.

Monthly precipitation data is also plotted with the piezometer data. The data was obtained from the Alberta Climate Information Service (ACIS) database, referencing the Calgary Springbank A Station.

The SI and piezometer data plots are included in Appendix I

2.2 Zones of Movement

Historical movements from SIs that are now inoperable were at depths between 1.0 m and 4.0 m below ground surface (approximately El. 1172.5 m to El. 1170.0).

Distributed movement continues to be recorded in SI18-01 from ground surface to an approximate depth of 2.3 m below ground surface (approximately El. 1173.6 m to El. 1171.3), and possible discrete movement between 2.3 m and 3.8 m (approximately El. 1171.3 m to El. 1169.8). The casing also appears to be settling or buckling between an approximate depth of 3.8 m and 8.8 m as discussed in Section 2.3. SI18-01 is located near the middle of the slide on the downslope side of the highway.

Distributed movement has started to be recorded in the SIs installed in the pile wall (SI23-01, SI23-02, and SI23-03) in the top 4 m to 6 m below the ground surface, indicating that the pile wall is taking load from the slide mass.

2.3 Interpretation of Monitoring Results

2.3.1 Slope Inclinometers

Settlement or buckling is observed in SI18-01, from approximately 3.8 m to 8.8 m below the ground surface, which could indicate that the instrument is poorly grouted, possibly with a grout void. The readings in this segment also do not stabilize, which further indicates a possible problem with the grout or casing damage. The movements of the slide mass and the interpretation of the SI data are complicated by the potential for settlement or buckling of the SI casing within the poorly grouted segment.

In SI18-01, about 104 mm of movement was observed between the spring 2023 readings and the November 2023 measurement after pile wall construction. The measurement was from 3.8 meters below ground surface to the surface. During construction, downslope survey pins recorded horizontal movement of up to 67 mm at the surface within the slide zone. This movement is believed to result from added weight on the slope during pile installation, excess pore pressures caused by the installation, and vibrations from piling. After the pile installation (2023), the cumulative movement in SI18-01 had a sharp increase between spring and fall of 2024 of approximately 17 mm, after there had been a slow, steady increase, which could result in shearing the casing. A resistance was noticed inside the SI casing when lowering the SI probe during the 2025 fall reading, between 3.5 m and 4.0 m below ground surface. SI18-01 was installed to support the design of an H-pile wall and drainage improvements to reduce slope movement impacts on Hwy 22:16.6.

The four SIs installed during the H-pile wall construction were initialized in November 2023, once construction was completed. The four SIs were installed in steel channels within the H-Pile flanges and backfilled with sand. Small amounts of distributed movement (up to approximately 4.0 mm) are being measured in the top 4 to 6 meters in SI23-01, SI23-02, and SI23-03, indicating that the pile wall has begun to take load from the slide mass. Additional readings will provide further interpretation of the pile wall movement as it continues to take load from the slide mass. Readings taken since the installation in SI23-04 have not been consistent due to poor data quality, and they have been re-read several times to attempt to obtain consistent readings. SI23-04 was re-initialized with the 2024 spring reading, and the data show an increase in displacement in the last four readings. However, SI23-04 is located outside the former slide mass, and no pavement cracking above the instrument has been noticed or reported; therefore, more readings are required to confirm whether the current trend is due to noise in the data.

2.3.2 Water Level and Precipitation

The initial readings for the VWPs (VW18-01 through VW18-03) were taken immediately following grouting operations. KCB believes that the initial water levels recorded in the VWPs were artificially high due to the grouting. Water levels recorded in these instruments decreased up to 12 m within a month of installation.

Excluding the first reading, water levels recorded in VW18-01 (located within the slide mass, downslope from the highway) have varied from 8.8 m to 13.4 m below ground surface, and water levels in VW18-02 (located within the slide mass, on the east shoulder of the highway) have varied from approximately 7.7 m to 10.1 m below ground surface. These water levels are below the depth of movement recorded in the SI (between the ground surface and 4.0 m below the ground surface). The data indicate that slide movements are likely in response to periods of increased precipitation, when surface water infiltrates into the top few meters, destabilizing the slope.

Water levels recorded in VW18-03 (located in the west highway ditch) have been within 0.4 m of the ground surface since 2021. The 2024 fall reading and 2025 spring reading recorded water levels at 0.2 m below the ground surface. However, the fall 2025 reading showed a sharp 3.7 m drop in water level despite having high records of precipitation in 2025; similar drops have been previously

measured in 2018, 2019, and 2020. Further readings would help confirm whether the high water level between 2024 and 2025 could have been associated with readings taken after a rainfall event and subsequent ground saturation.

Overall, the October 2025 readings for two of the three VWPs were consistent with historical trends observed in these instruments. More data is needed to assess long-term trends for the piezometers installed in 2018.

2.4 Summary

A summary of the SI and piezometer data is provided in Table 2.1 and Table 2.2, respectively.

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 TWP026-04-W5.

Table 2.1 Slope Inclinometer Reading Summary

Instrument ID	Date				Ground Surface Elevation (m)	Depth of Movement (mbgs[1])	Direction of Movement	Cumulative Movement (mm)			Rate of Movement (mm/year)		
	Initialized	Previous Maximum Cumulative Movement	Previous Reading	Most Recent Reading				Previous Maximum Cumulative	Incremental Since Previous Reading	Total	Previous Maximum	Most Recent Reading	Change from Previous Reading
SI18-01	Oct. 23, 2018[2]	May 8, 2024	May 20, 2025	October 8, 2025	1174	0.4 – 2.3	A-Direction	70.9	-2.1	68.8	57.3	-5.3	-5.0
						2.3 – 3.8	A-Direction	262.5	4.3	266.8	263.2	11.1	8.4
SI23-01	Nov. 28, 2023	May 8, 2024	May 20, 2025	October 8, 2025	1171	0 – 5.9	A-Direction	3.3	0.7	4.0	4.9	1.8	1.7
SI23-02	Nov. 28, 2023	September 16, 2024	May 20, 2025	October 8, 2025	1171	0 – 4.4	A-Direction	2.2	1.4	2.4	9.4	3.7	5.4
SI23-03	Nov. 28, 2023	September 16, 2024	May 20, 2025	October 8, 2025	1171	0.1 – 6.2	A-Direction	2.2	0.9	1.8	6.6	2.3	4.3
SI23-04	Nov. 28, 2023 (May 8, 2024)[3]	May 8, 2024	May 20, 2025	October 8, 2025	1171	1.2 – 15.2	A-Direction	91.83	50.5	87.8	297.2	130.5	211.4

Note:
[1] Meters below ground surface (mbgs).
[2] Initialized on October 23, 2018, due to an anomalous upslope deformation after installation.
[3] Re-initialized SI due to poor data quality.

Table 2.2 Vibrating Wire Piezometer Reading Summary

Instrument ID	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)
VW18-01	Mar. 5, 2018	May 20, 2025	October 8, 2025	1174.0	13.7	12.5	12.6	0.1
VW18-02	Mar. 5, 2018	May 20, 2025	October 8, 2025	1176.0	10.1	9.6	9.8	0.2
VW18-03	Mar. 5, 2018	Jul. 11, 2025	October 8, 2025	1176.6	4.7	0.2	3.9	3.7

Note:
[1] Meters below ground surface (mbgs).

3 RECOMMENDATIONS

3.1 Future Work

All instruments should be read twice per year (spring and fall).

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 and Maintenance

Voids are observed around the piles of the H-pile wall (Photo 3.1), particularly near the SI23-04 casing, causing the SI casing to be loose in the pile. These voids should be backfilled with a combination of sand and gravel.

Photo 3.1 Sinkholes between piles of the H-Pile wall near SI23-04 casing.

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 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.

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.

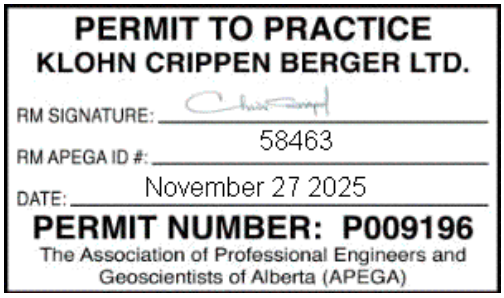
Use of or reliance upon this instrument of service by the Client is subject to the following conditions:

1. The report is to be read in full, with sections or parts of the report relied upon in the context of the whole report.
2. The observations, findings and conclusions in this report are based on observed factual data and conditions that existed at the time of the work and should not be relied upon to precisely represent conditions at any other time.
3. The report is based on information provided to KCB by the Client or by other parties on behalf of the client (Client-supplied information). KCB has not verified the correctness or accuracy of such information and makes no representations regarding its correctness or accuracy. KCB shall not be responsible to the Client for the consequences of any error or omission contained in Client-supplied information.
4. KCB should be consulted regarding the interpretation or application of the findings and recommendations in the report.
5. This report is electronically signed and sealed, and its electronic form is considered the original. A printed version of the original can be relied upon as a true copy when supplied by the author or when printed from its original electronic file.

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

Yours truly,

KLOHN CRIPPEN BERGER LTD.

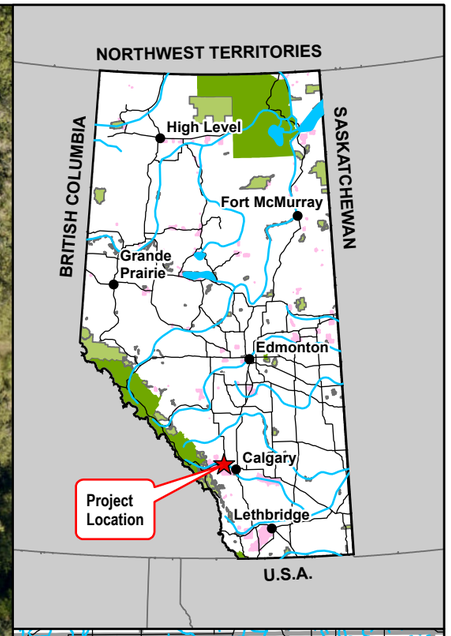


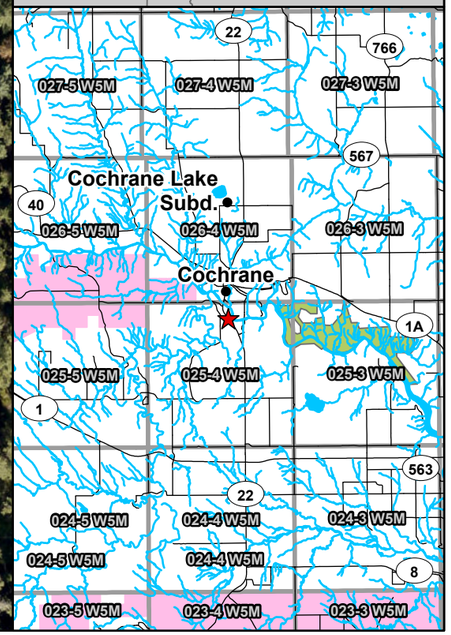
Jorge Rodriguez, Ph.D, M.Sc., P.Eng.
Geotechnical Engineer

JR:bb

ATTACHMENTS
Figure
Appendix I Instrumentation Plots

FIGURE





Legend

- Slope Inclinometer (SI)
- Vibrating Wire Piezometer (VW)
- Flow Direction
- Scarp
- Crack

0 45 Metres

NOTES:
1. HORIZONTAL DATUM: NAD83
2. GRID ZONE: UTM ZONE 11N
3. IMAGE SOURCE: TOWN OF COCHRANE, AB

CLIENT: Alberta

Klohn Crippen Berger

PROJECT: SOUTHERN REGION GEOHAZARD RISK MANAGEMENT PROGRAM

TITLE: Site Plan
S003 - Cochrane
Hwy 22:16, km 9.875

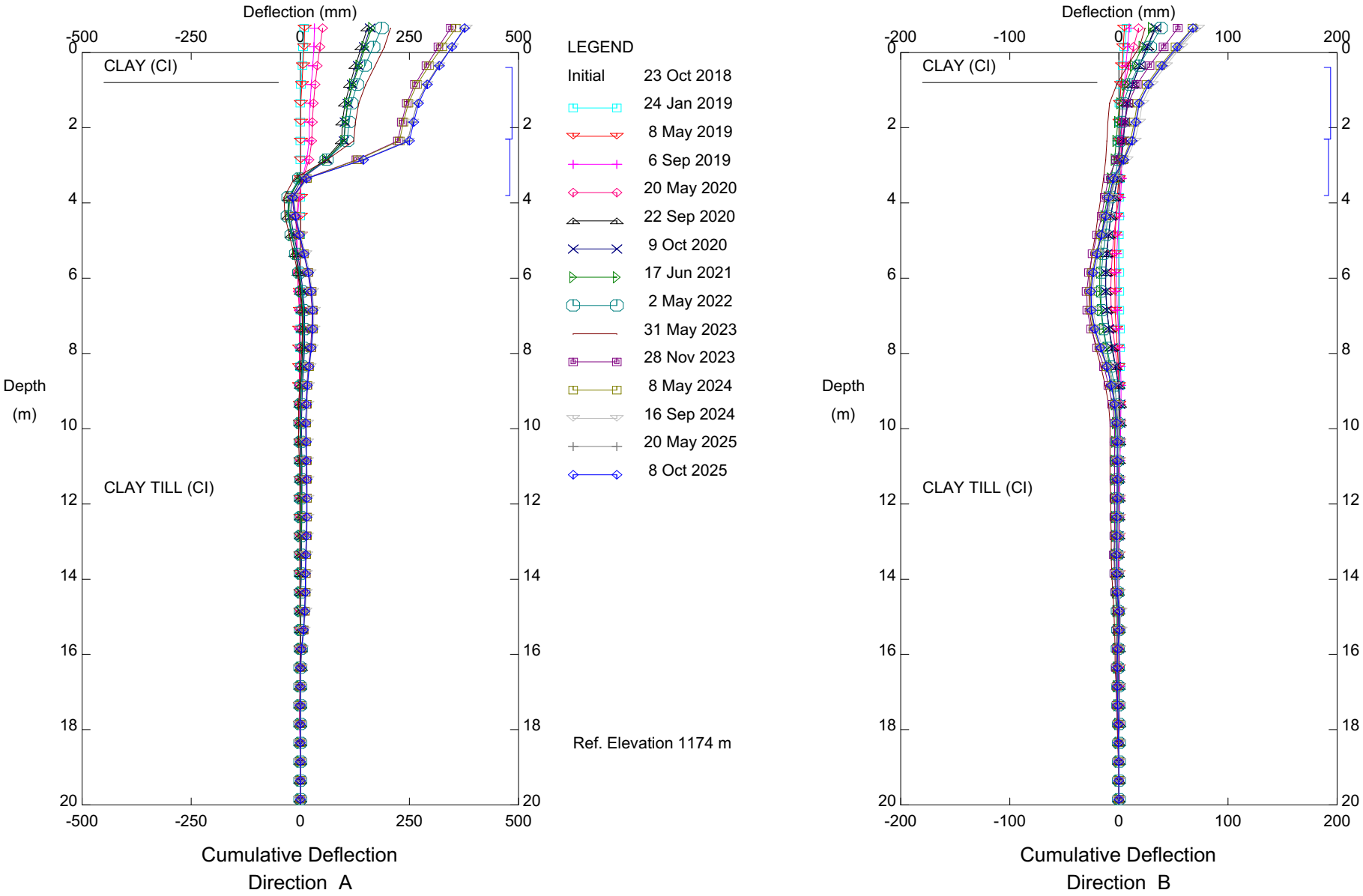
SCALE	PROJECT No.	FIG No.
1:1,000	A05116A03	1

File: \\int.klohn.com\ProjData\AICGY\Alberta\A05116A03 ABT Southern Region GRMP\400 Drawings\2024\Section C\Section_C_2024\Section_C_2024.aprx Date: Time: Creator: : EQuine

APPENDIX I

Instrumentation Plots

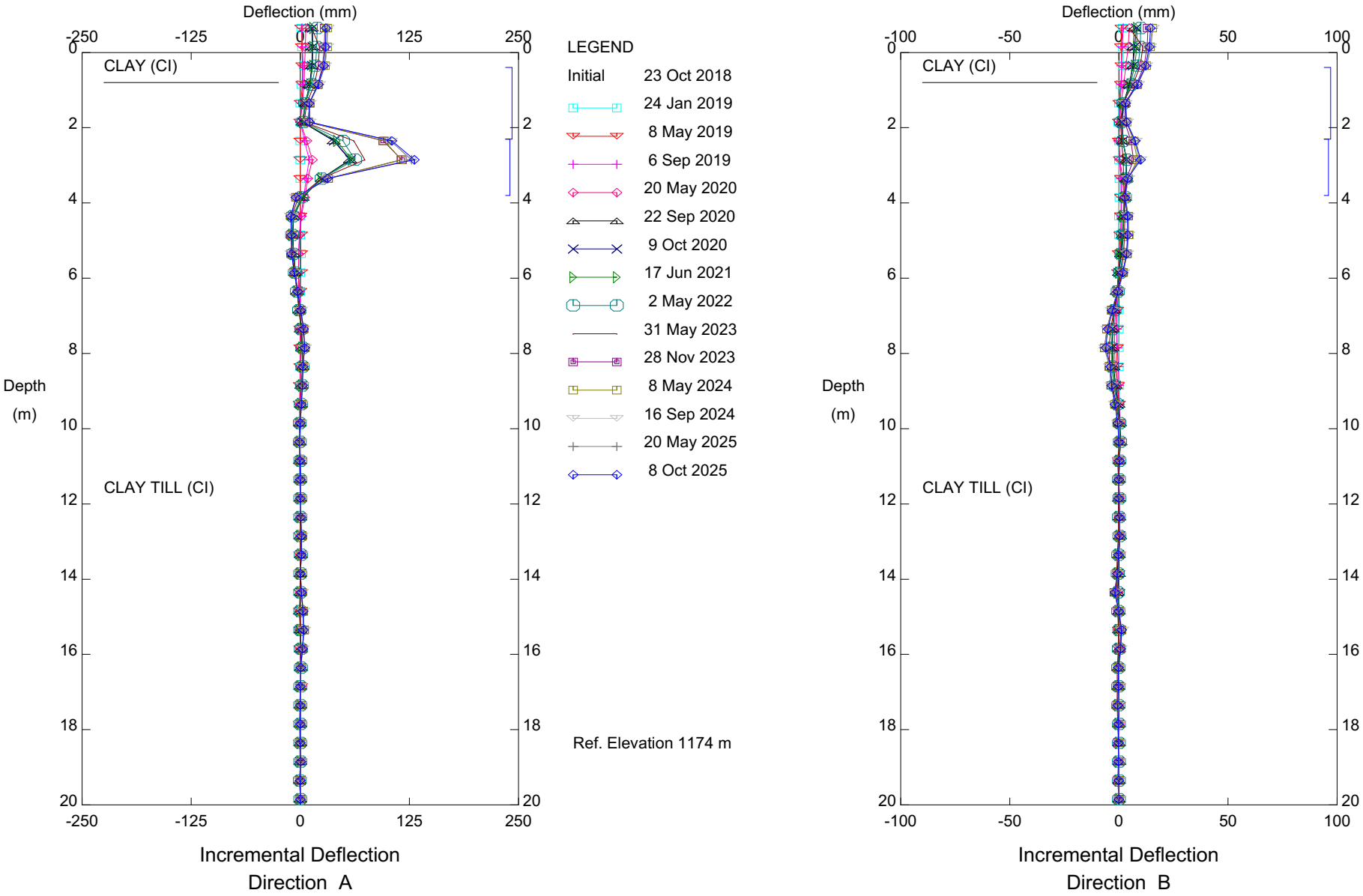
Klohn Crippen Berger - Calgary



S003; H22:16, Cochrane, Inclinometer SI18-01

Alberta Transportation

Klohn Crippen Berger - Calgary



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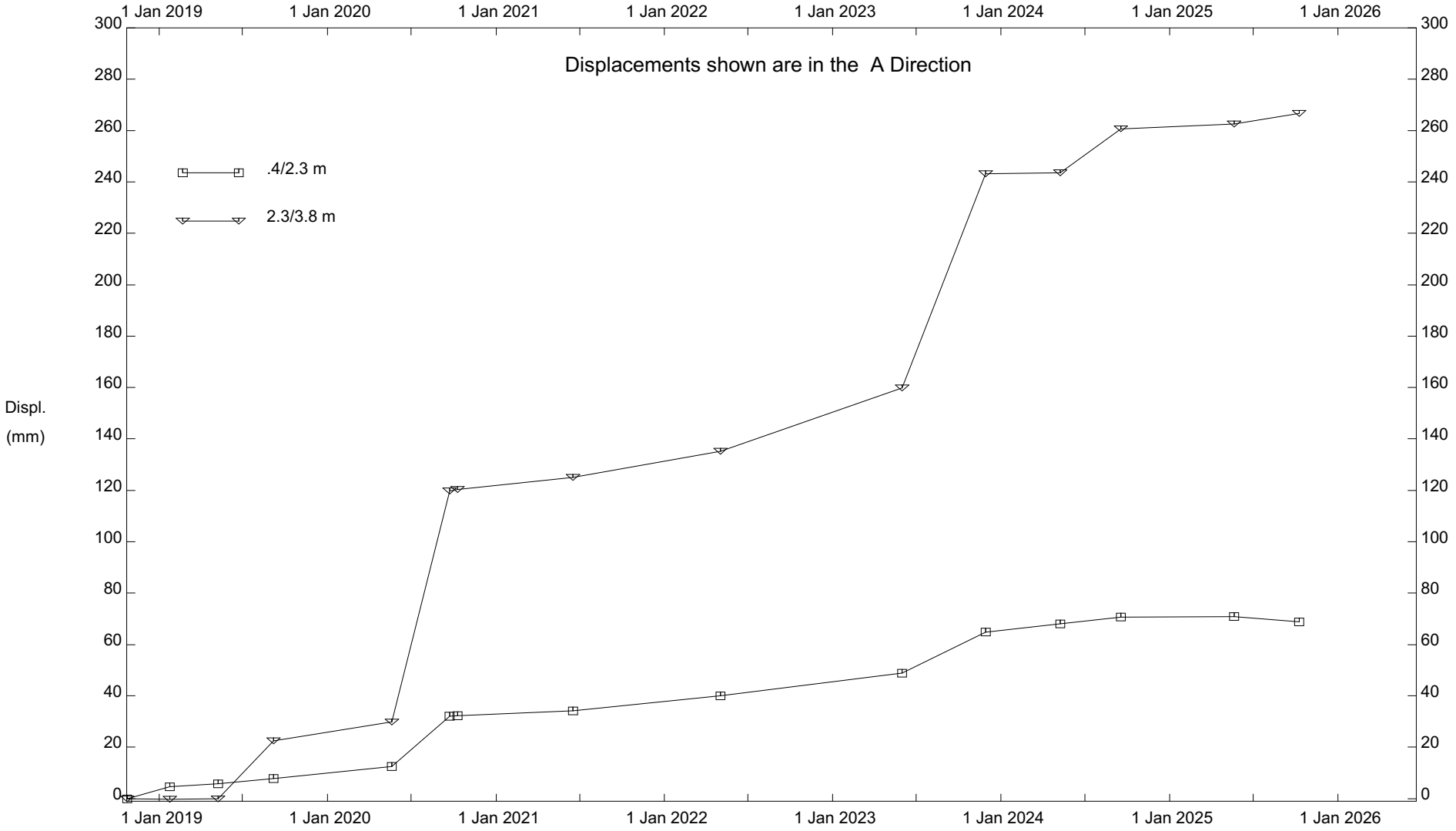
Alberta Transportation

Klohn Crippen Berger - Calgary



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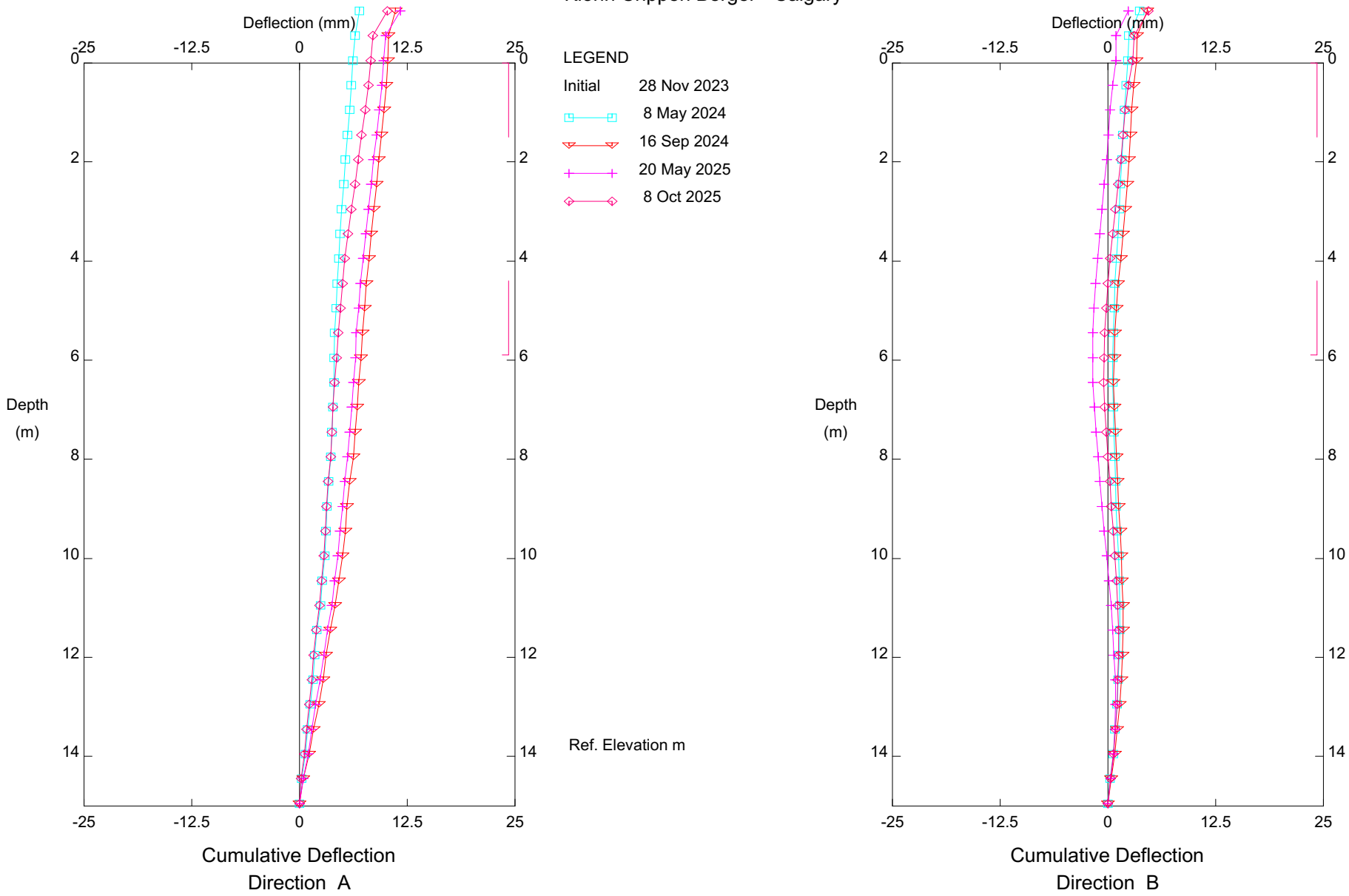
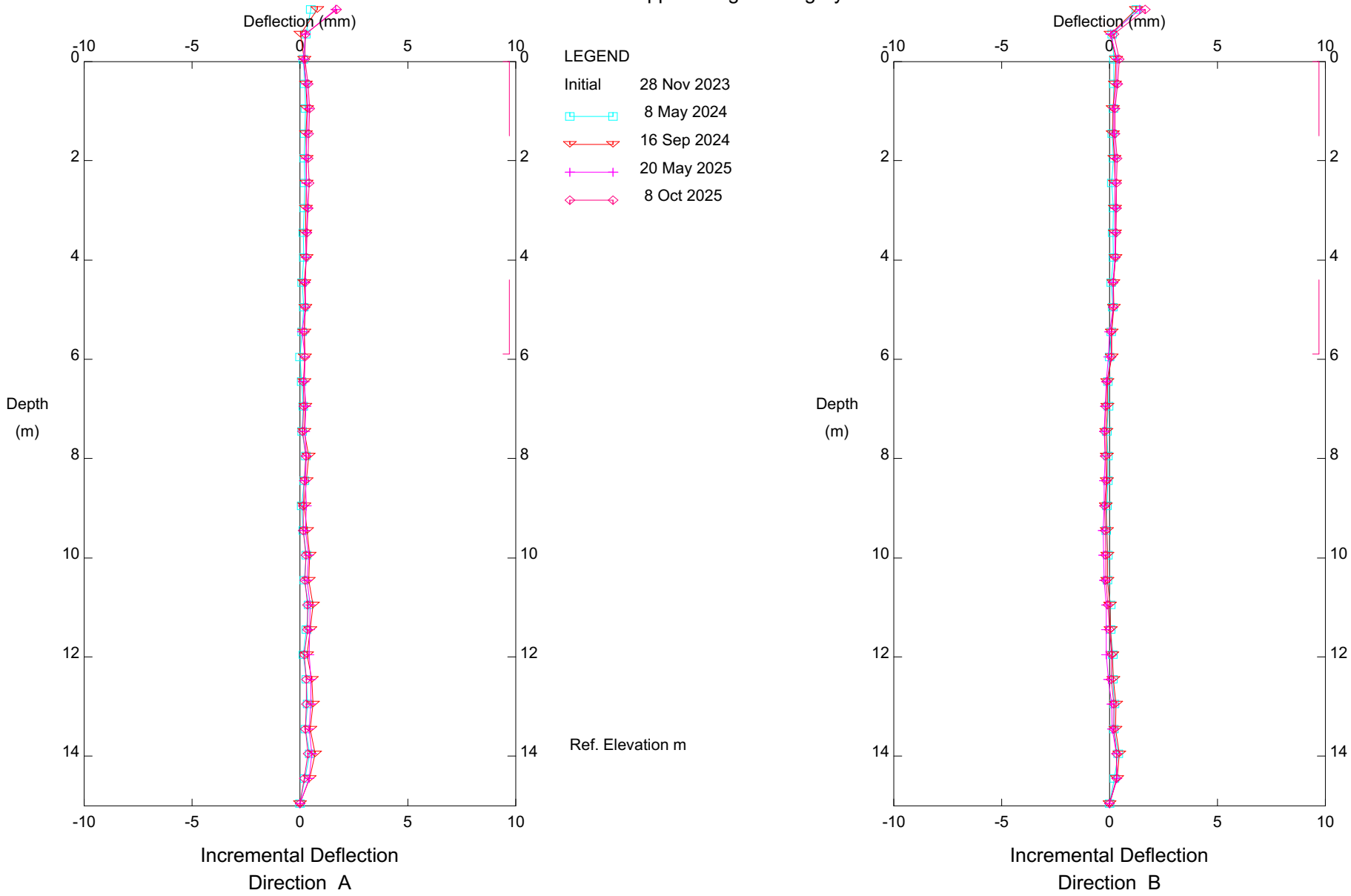
Alberta Transportation

Klohn Crippen Berger - Calgary



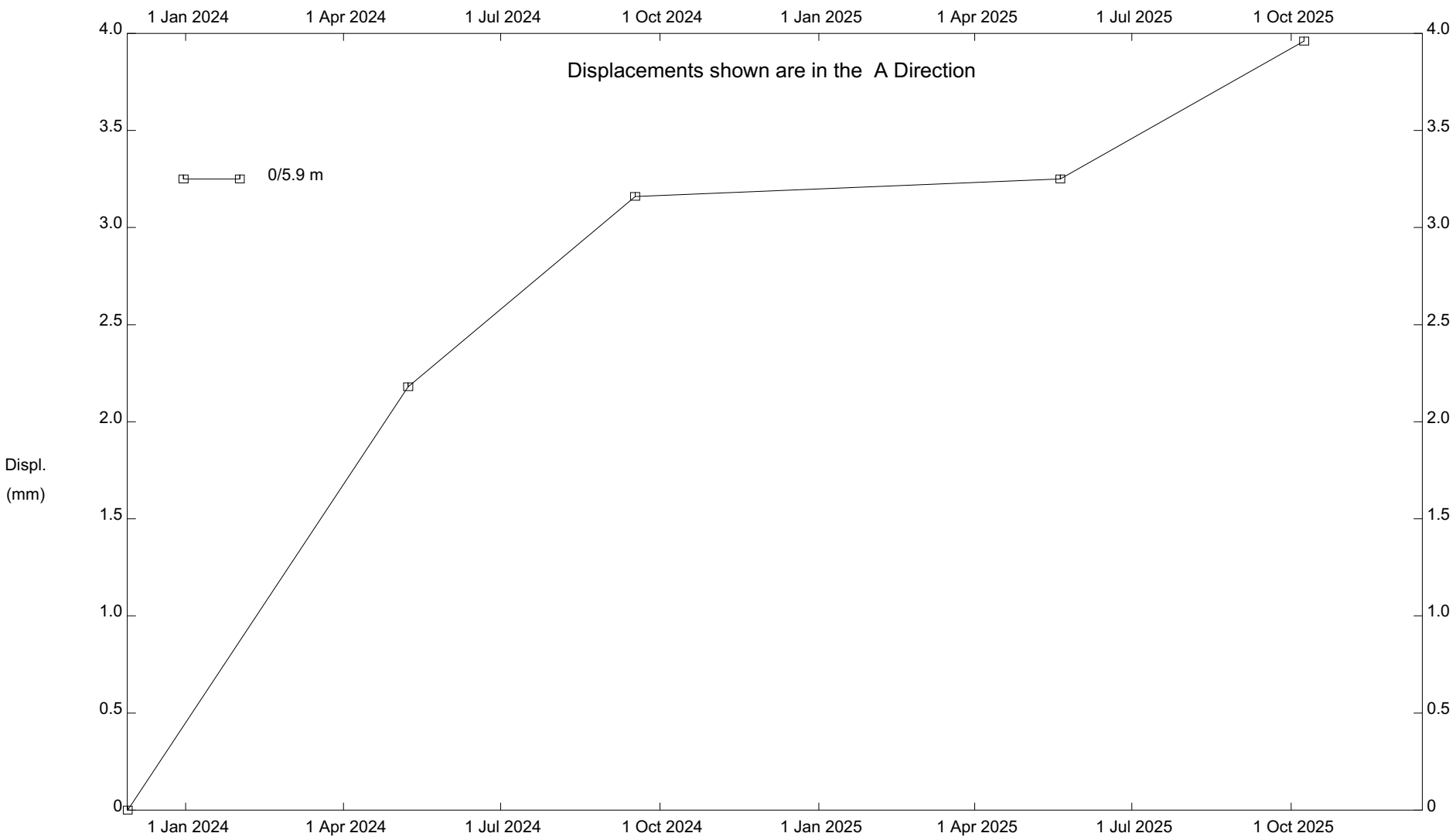
Cochrane, Inclinometer 23-01

Klohn Crippen Berger - Calgary



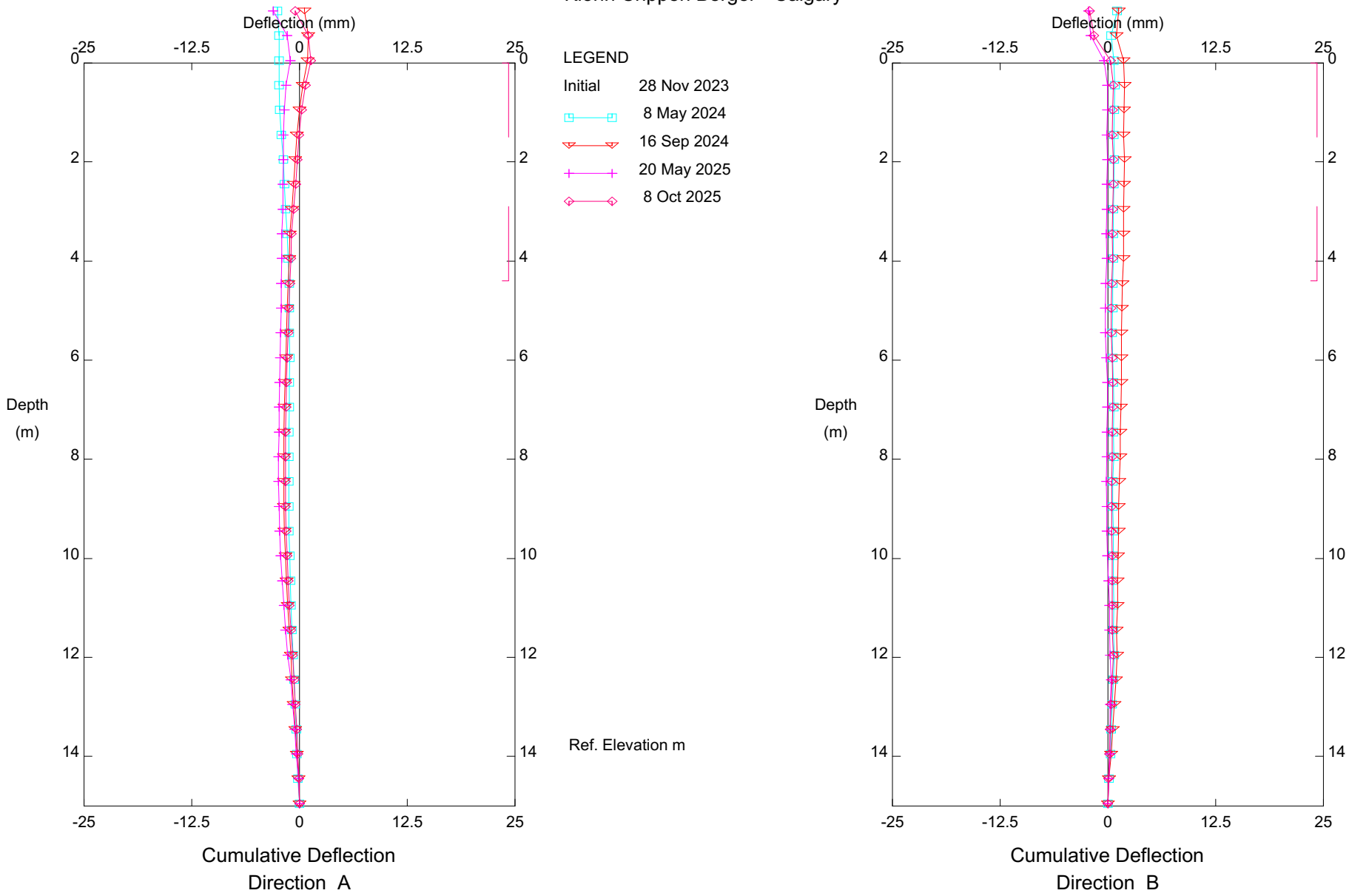
Cochrane, Inclinometer 23-01

Klohn Crippen Berger - Calgary



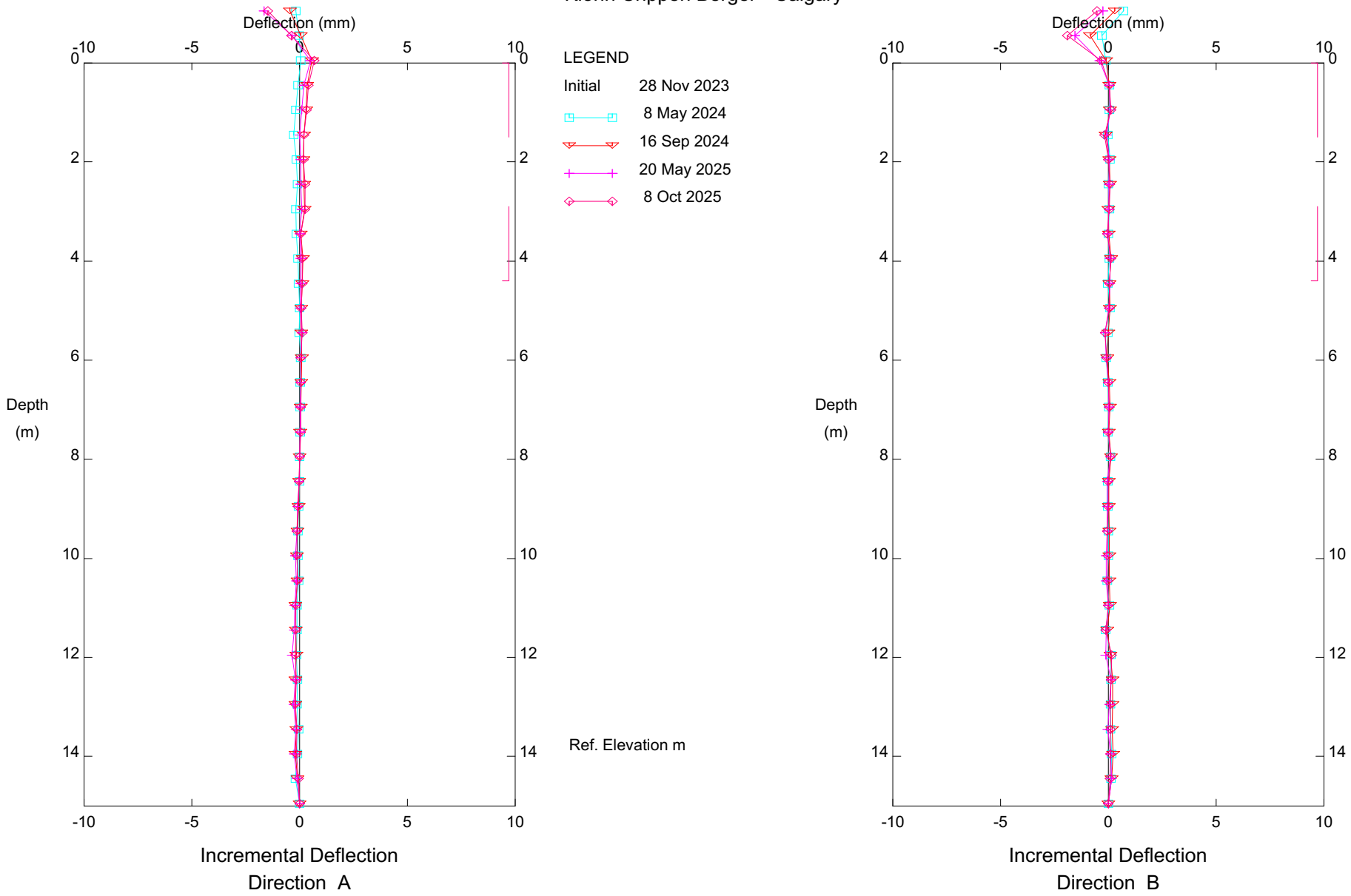
Cochrane, Inclinometer 23-01

Klohn Crippen Berger - Calgary



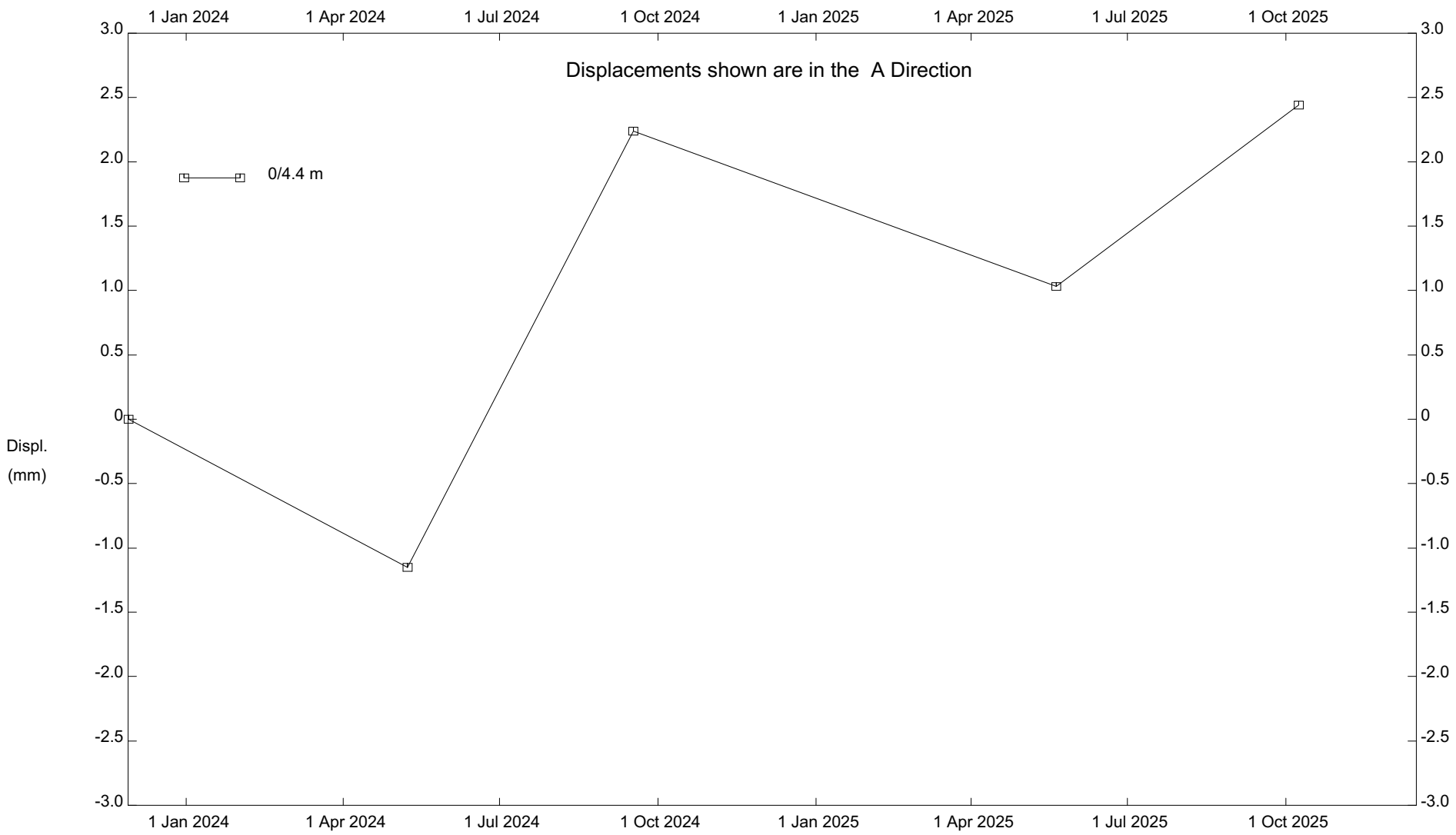
Cochrane, Inclinometer 23-02

Klohn Crippen Berger - Calgary



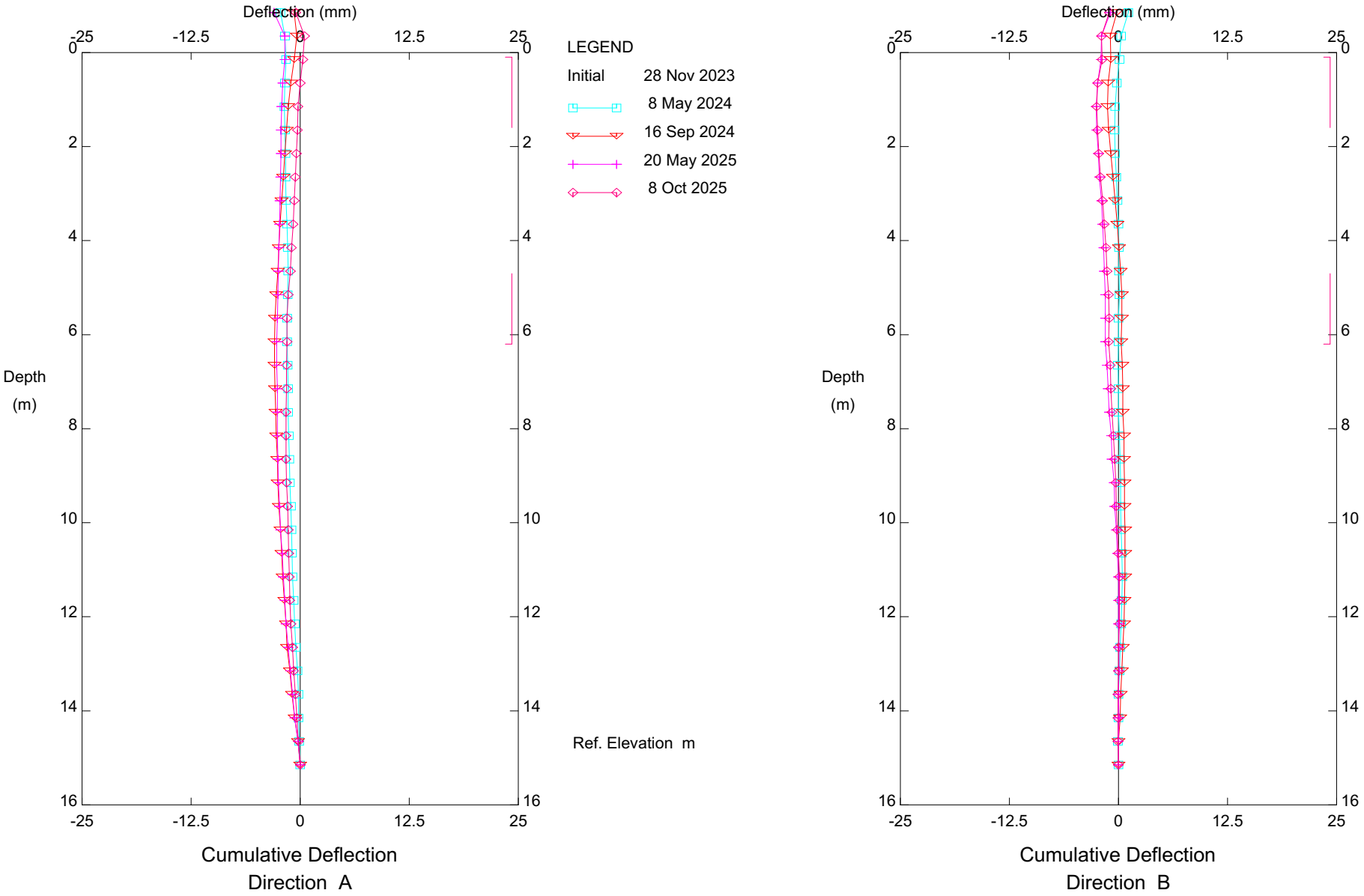
Cochrane, Inclinometer 23-02

Klohn Crippen Berger - Calgary



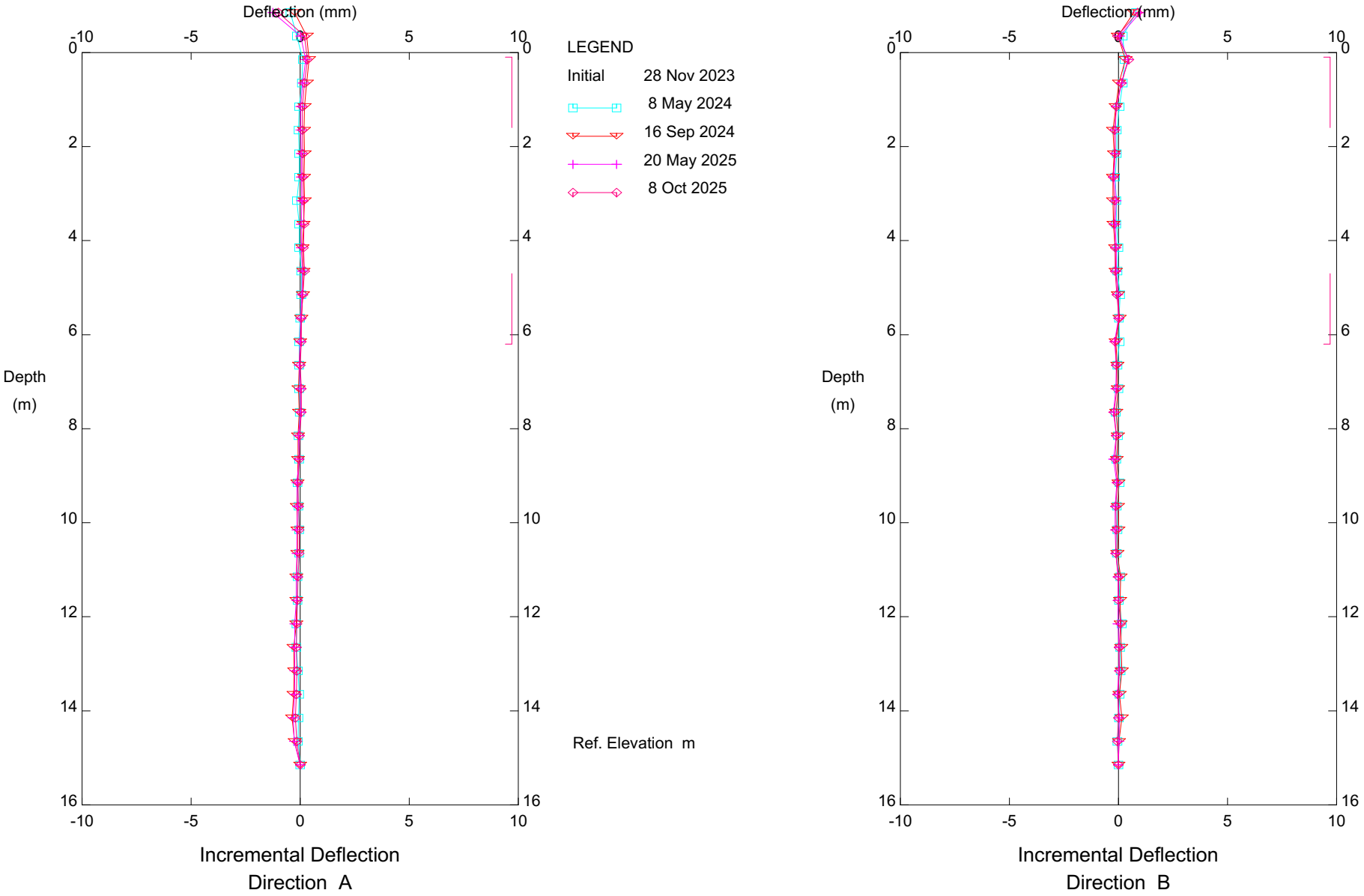
Cochrane, Inclinometer 23-02

Klohn Crippen Berger - Calgary



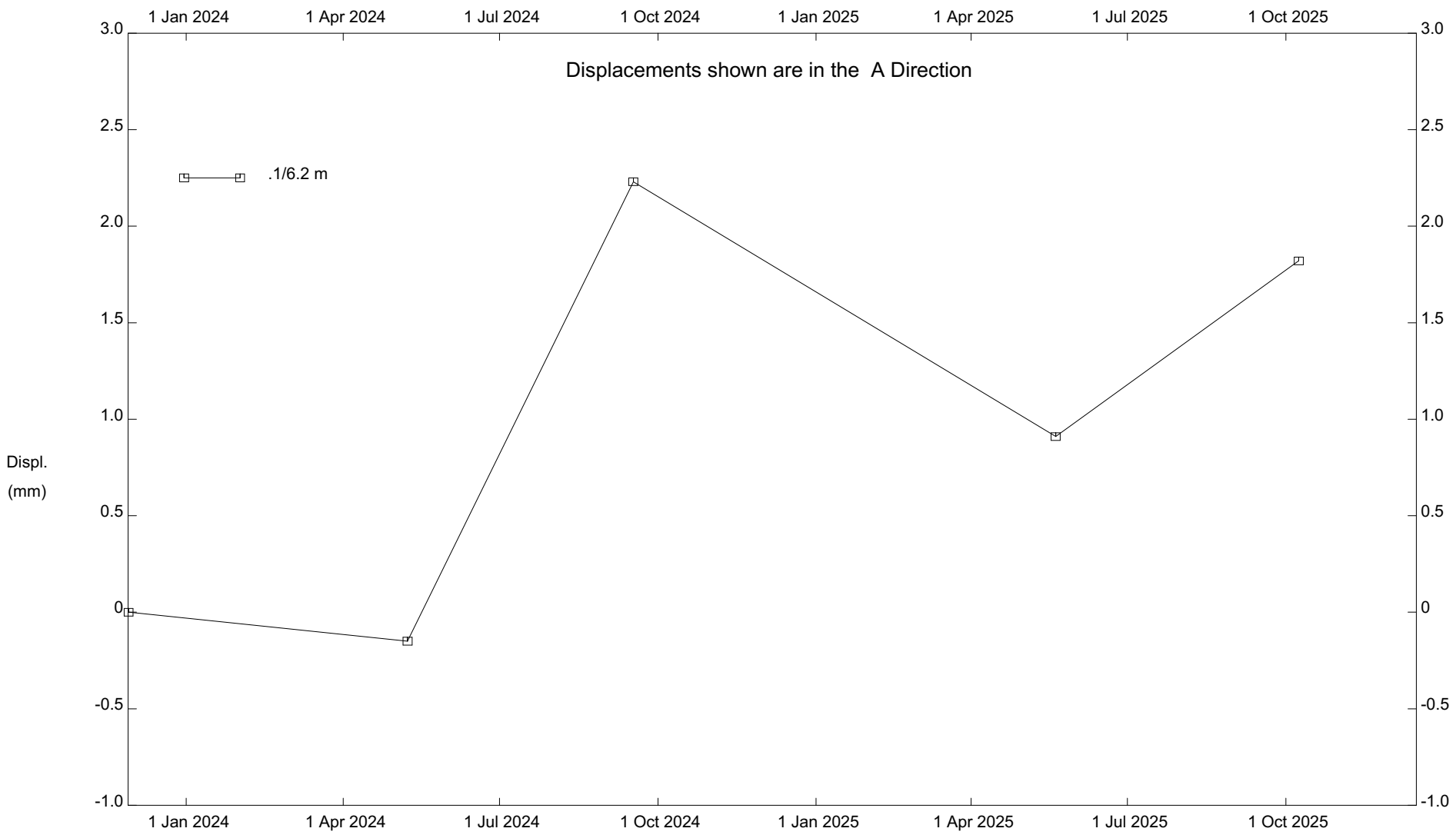
Cochrane, Inclinometer 23-03

Klohn Crippen Berger - Calgary



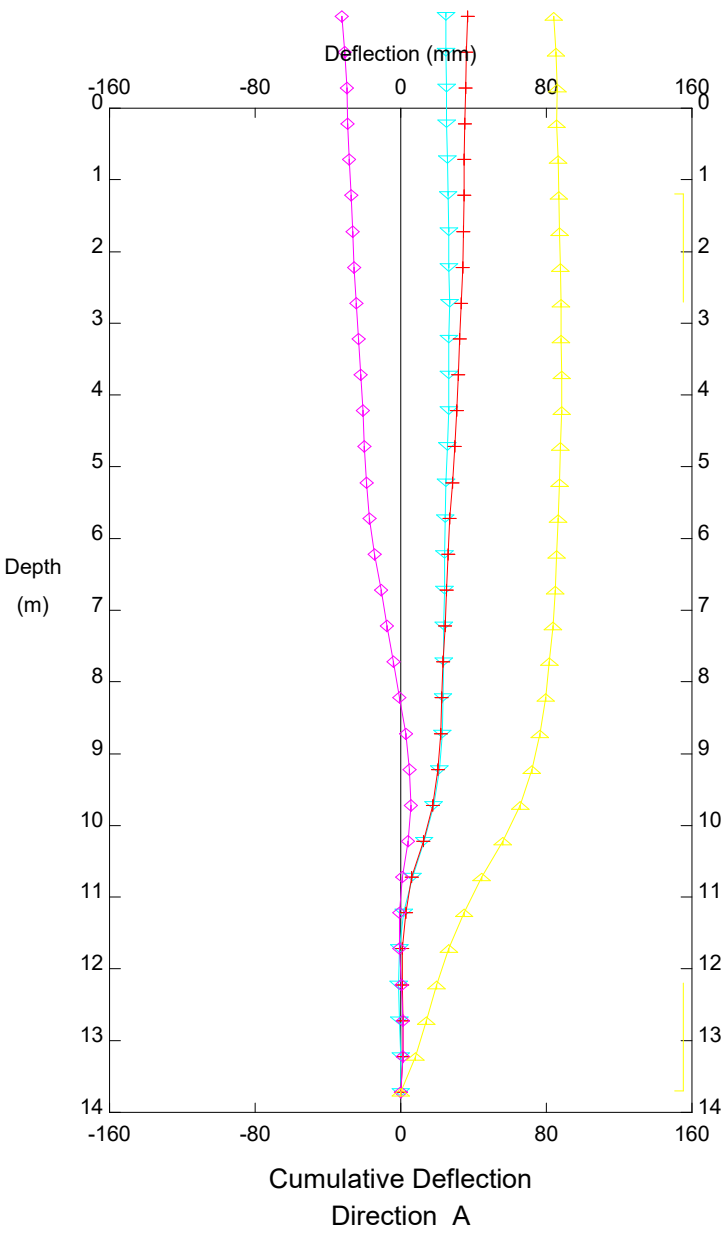
Cochrane, Inclinometer 23-03

Klohn Crippen Berger - Calgary



Cochrane, Inclinometer 23-03

Klohn Crippen Berger - Calgary



Cumulative Deflection
Direction A

LEGEND

Initial 8 May 2024

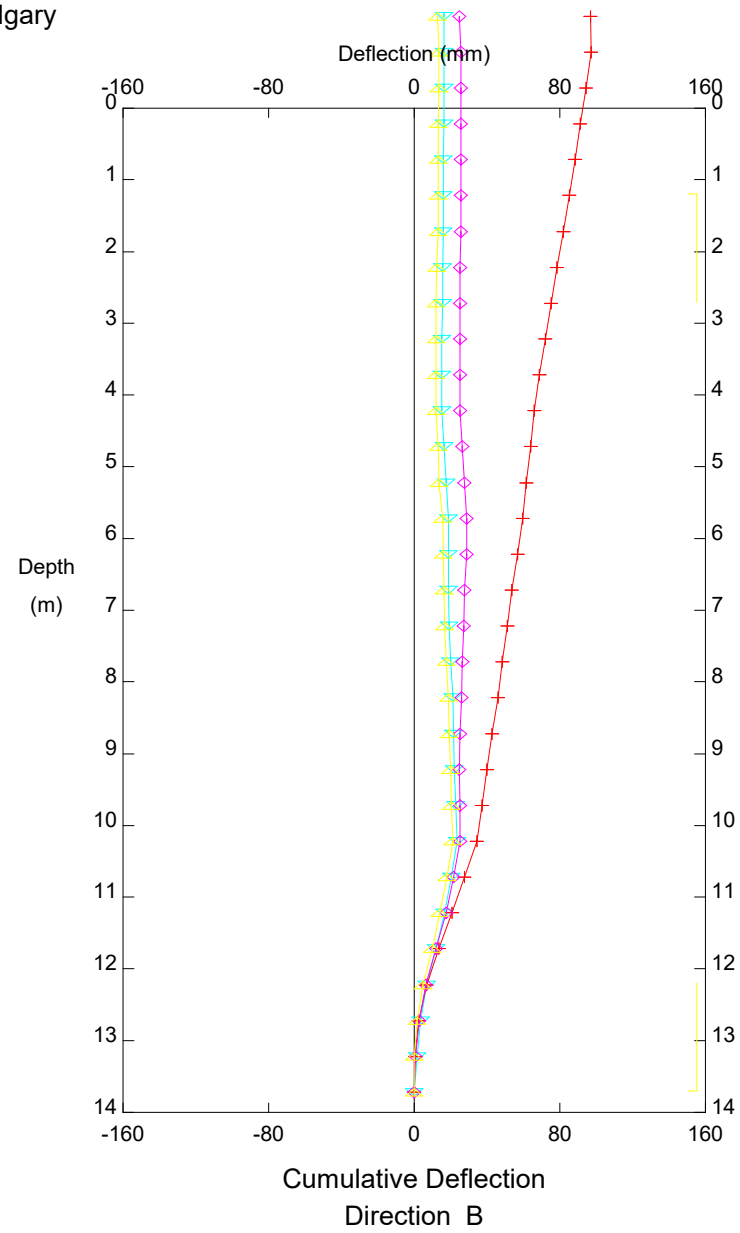
3 Jul 2024

16 Sep 2024

20 May 2025

8 Oct 2025

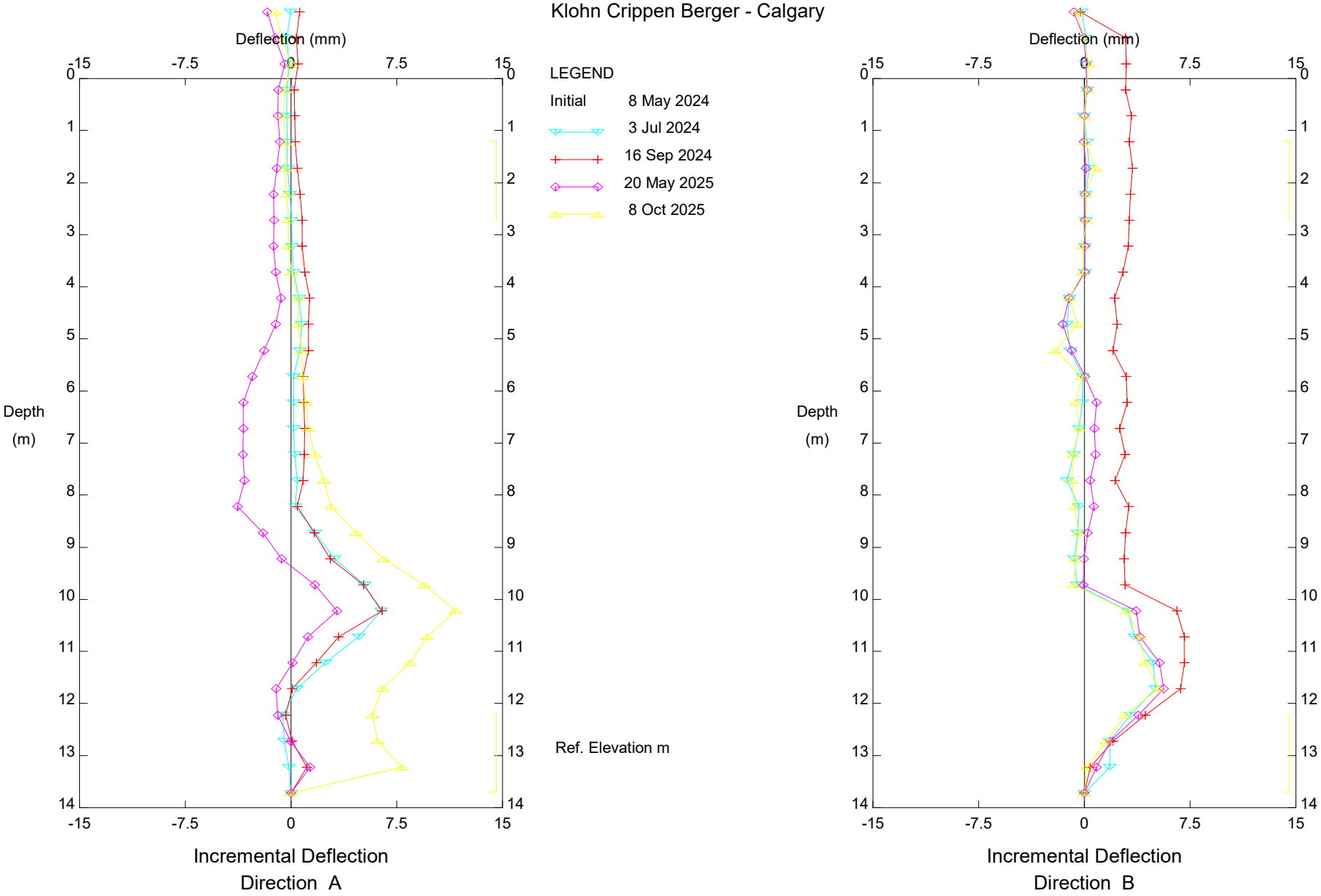
Ref. Elevation m



Cumulative Deflection
Direction B

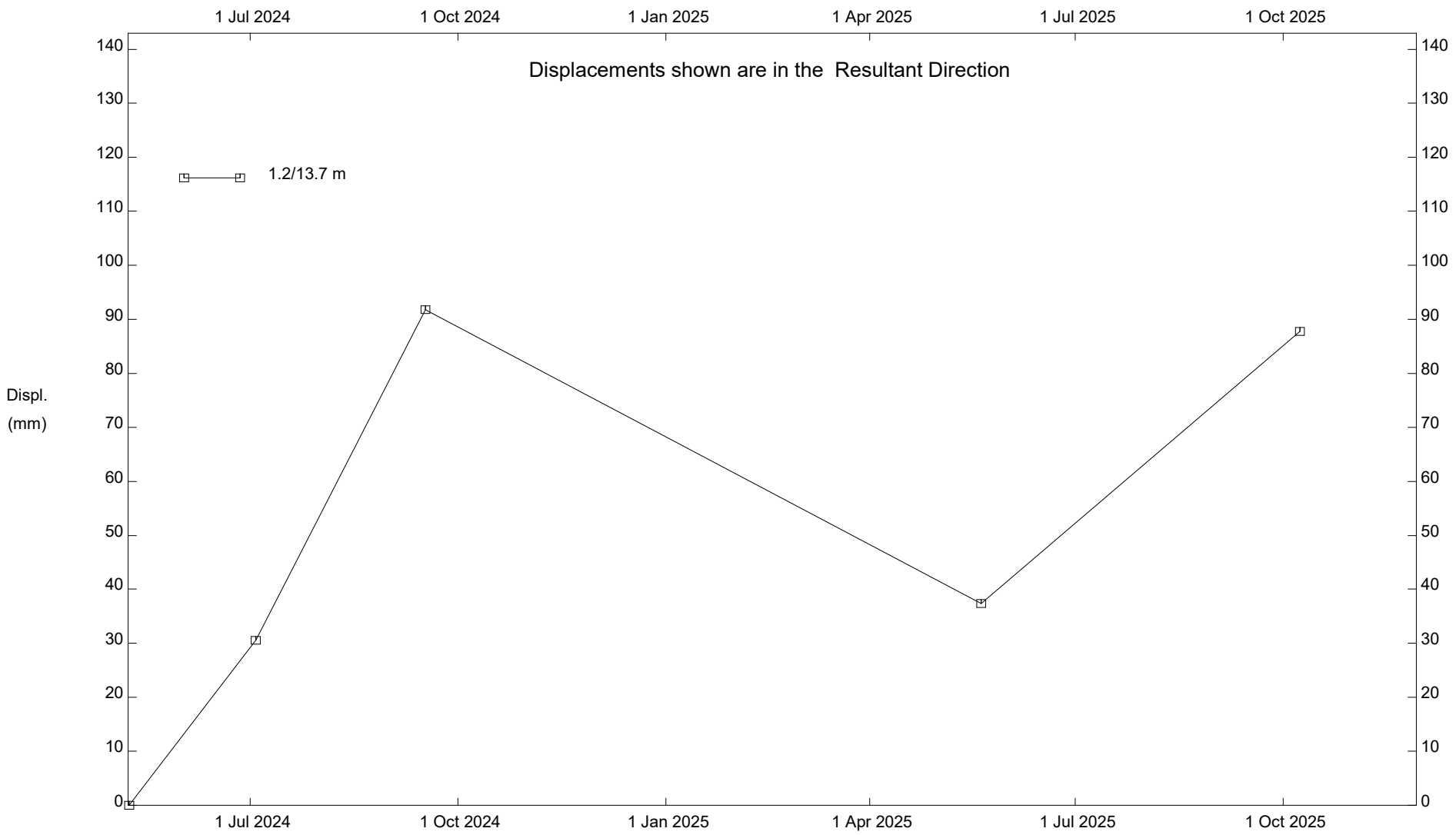
Cochrane, Inclinometer 23-04

Klohn Crippen Berger - Calgary

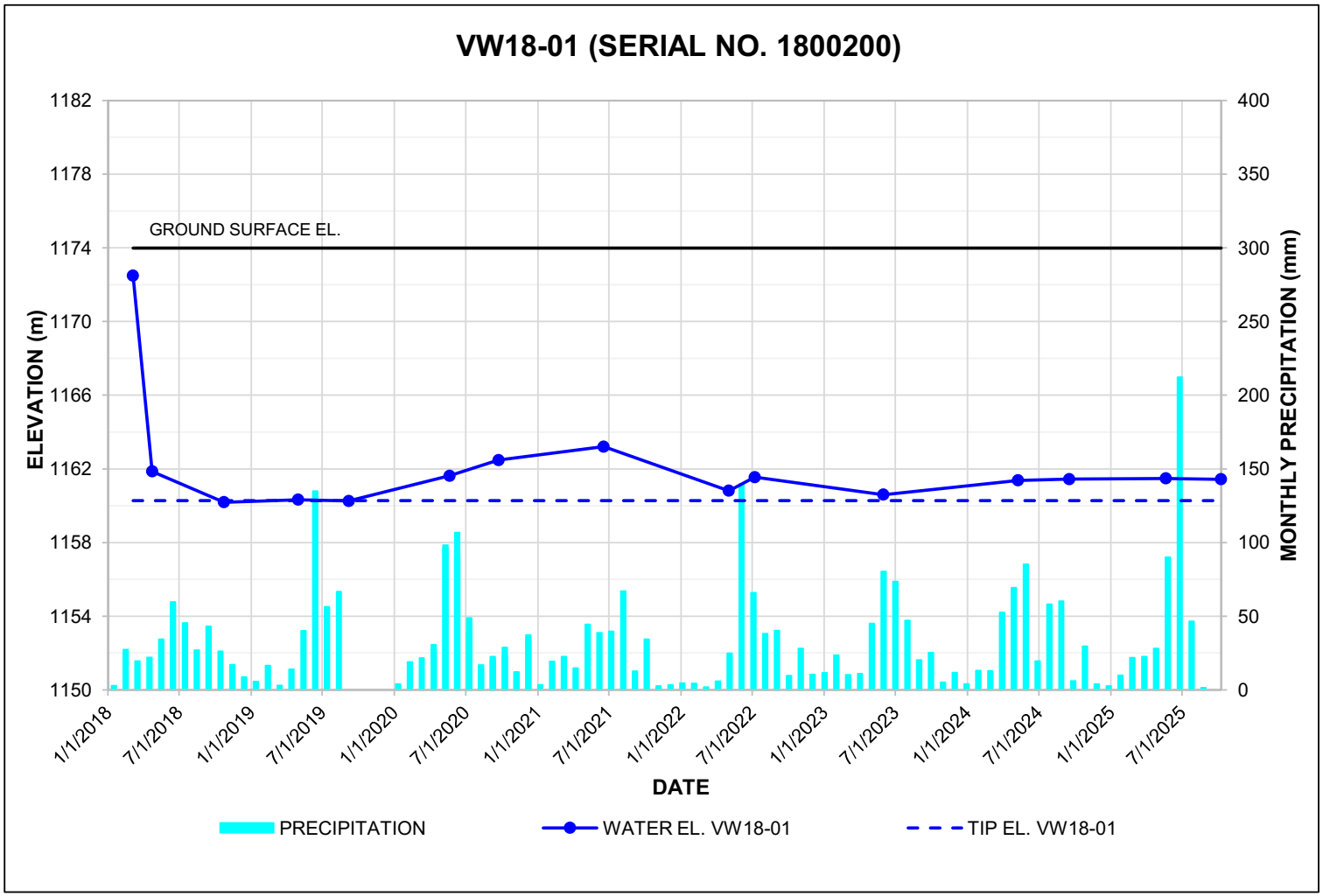


Cochrane, Inclinometer 23-04

Klohn Crippen Berger - Calgary



Cochrane, Inclinometer 23-04



NOTES:
1. MONTHLY PRECIPITATION DATA OBTAINED FROM THE ALBERTA CLIMATE INFORMATION SERVICE (ACIS) DATABASE, REFERENCING THE CALGARY SPRINKBANK A STATION.

CLIENT: Alberta

Klohn Crippen Berger

PROJECT: SOUTHERN REGION GEOHAZARD RISK MANAGEMENT PROGRAM

TITLE: Vibrating Wire Piezometer Data
S003 - Cochrane
Hwy 22:16, km 9.9

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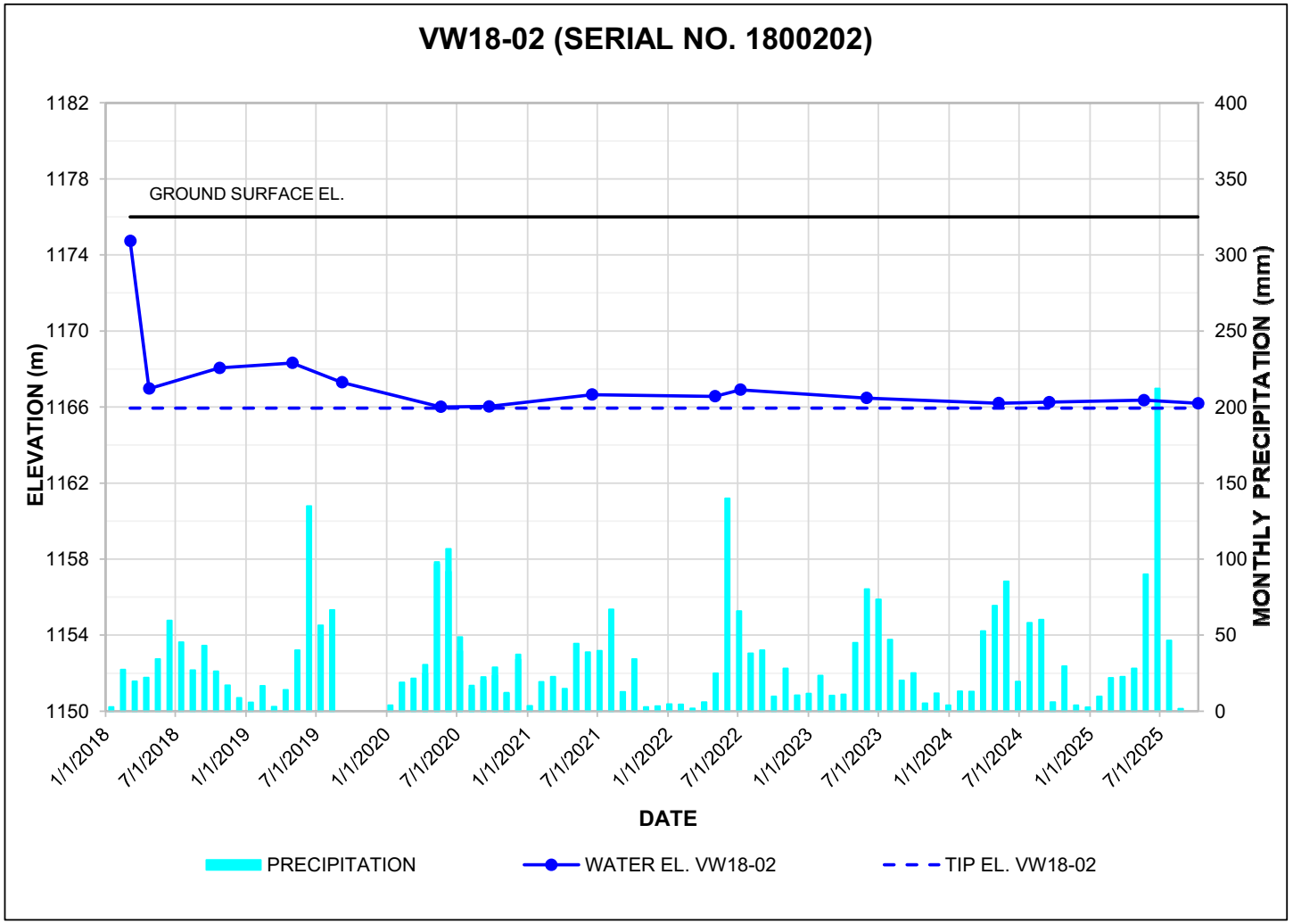
	A05116A03	



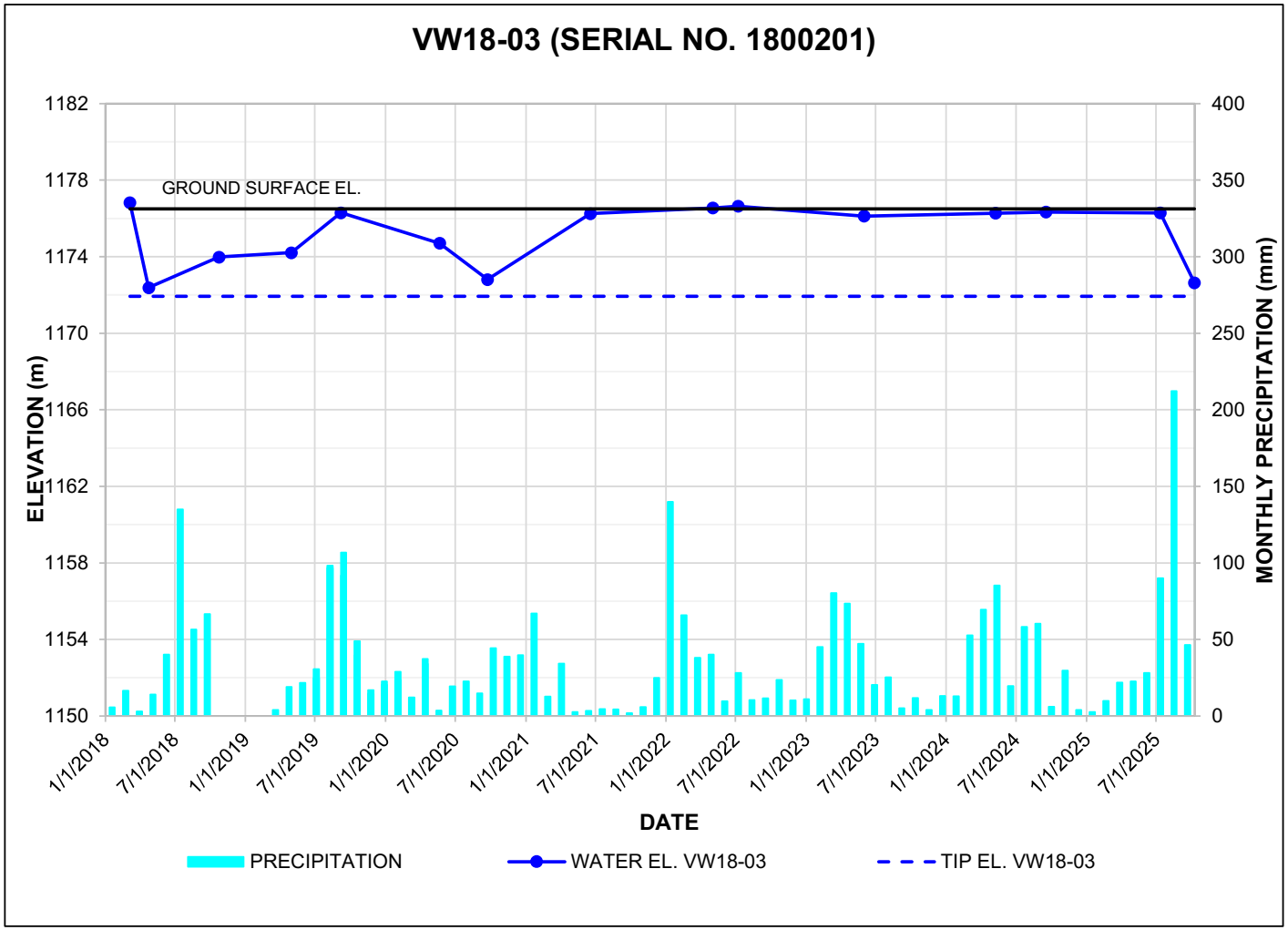
NOTES:
1. MONTHLY PRECIPITATION DATA OBTAINED FROM THE ALBERTA CLIMATE INFORMATION SERVICE (ACIS) DATABASE, REFERENCING THE CALGARY SPRINKBANK A STATION.

CLIENT
Alberta
Klohn Crippen Berger

PROJECT
SOUTHERN REGION GEOHAZARD RISK MANAGEMENT PROGRAM

TITLE
Vibrating Wire Piezometer Data
S003 - Cochrane
Hwy 22:16, km 9.9

SCALE	PROJECT No.	FIG No.
	A05116A03	



NOTES:
1. MONTHLY PRECIPITATION DATA OBTAINED FROM THE ALBERTA CLIMATE INFORMATION SERVICE (ACIS) DATABASE, REFERENCING THE CALGARY SPRINKBANK A STATION.

CLIENT: Alberta

Klohn Crippen Berger

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