July 10, 2024

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 S005; H36:02, km 37.1 Chin Coulee Slide
Section C – 2024 Spring Readings

1 GENERAL

Two slope inclinometers (SIs) (SI18-01 and SI18-02) and four vibrating wire piezometers (VWPs) (VW18-01A/B and VW18-02A/B) were read at the S005 site in Southern Region on May 16, 2024, 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 36:02 km 37.1, approximately 19 km south of Taber, Alberta, and approximately 500 m east of Chin Coulee Bridge. The approximate site coordinates are 5495444 N, 441404 E (UTM Zone 12, NAD 83) and the legal land description for the site is NW 36-07-17-W4. A site plan is presented in Figure 1.

The geohazard at the S005 site consists of a large, deep-seated translational landslide located on the north slope of the Chin Coulee Reservoir that is retrogressing north towards Hwy 36:02. Previous remedial actions at the site include:

- In 2008, soil nails and a geosynthetic-reinforced-soil (GRS) masonry wall were constructed upslope of the previous highway alignment; and
- In 2016, the highway was realigned further north to avoid being impacted by the landslide.

Geotechnical site investigations, which included installing instruments, were conducted at the S005 site in 1981, 1998, 2002, and 2015 by the previous consultants. In January 2018, KCB completed a geotechnical site investigation during which instruments were installed to monitor for deep-seated movement retrogressing back towards the realigned highway and groundwater conditions, respectively. The encountered stratigraphy during the 2018 investigation was as follows: embankment fill, overlying clay till, overlying a thin layer of sand, and overlying bedrock (shale).

Klohn Crippen Berger Ltd.
500 - 2618 Hopewell Place NE ▪ Calgary AB T1Y 7J7 ▪ Canada
t 403.274.3424 ▪ f 403.274.5349 ▪ www.klohn.com

1.1 Instrumentation

Instrumentation installation details are tabulated in **Error! Reference source not found.**. 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 1981 and 2015, eight SIs and four piezometers were installed at the site by previous consultants to monitor movement and groundwater conditions, respectively. All of these instruments are now inoperable (e.g., destroyed, sheared, or lost).

In 2018, KCB installed two SIs (SI18-01 and SI18-02) and four VWPs (VW18-01A/B and VW18-02A/B) to monitor the depth of movement and groundwater conditions, respectively. The instruments were installed in boreholes located at the crest of the slide. KCB and Alberta Transportation (AT) believe that the SIs could first intercept a retrogressing backscarp at a relatively shallow depth, providing advance warning of risks to the realigned highway. Two VWPs were installed in each borehole, one in the clay till and one in the bedrock (shale) near the base of the borehole.

The instruments are protected by above-ground casing protectors.

In addition to the SIs and VWPs, geocube global-positioning system (GPS) instruments were installed at the site in the spring of 2018 as part of the KCB-AT-University of Alberta (UofA) research project. The geocube monitoring results and interpretation were submitted in a separate annual report. The geocubes were removed from site in 2023.

KCB changed the SI reading equipment in July 2022 after the previous equipment became inoperable. Currently, KCB is reading the SIs with a metric RST Digital MEMS Inclinometer System.

The VWPs were read using an RST VWP readout box.

Table 1.1 Instrument Installation Details

Instrument ID	Instrument Type	Date Installed	UTM Coordinates[1] (m)		Ground Surface Elevation (m)	Stick Up (m)	Depth (mbgs[2])	Condition
			Northing	Easting				
SI18-01	SI	Jan. 18, 2018	5495460	414773	884.0	0.9	68.5	Operable
SI18-02	SI	Jan. 20, 2018	5495454	414726	881.0	0.9	69.5	Operable
VW18-01B	VWP	Jan. 18, 2018	5495460	414773	884.0	N/A	32.8	Operable
VW18-01A	VWP	Jan. 18, 2018	5495460	414773	884.0	N/A	67.7	Operable
VW18-02B	VWP	Jan. 20, 2018	5495454	414726	881.0	N/A	33.4	Operable
VW18-02A	VWP	Jan. 20, 2018	5495454	414726	881.0	N/A	68.2	Operable

Notes:
[1] Coordinates were obtained by KCB with a handheld GPS during installation. The handheld GPS has an accuracy of ±5 m.
[2] Meters below ground surface (mbgs). Bottom casing depth for SIs and tip depth for piezometers.

2 INTERPRETATION

2.1 General

For the operable SIs, the cumulative displacement, incrementation displacement, and displacement-time data was plotted in the A-direction (i.e., in the direction of the A0-grooves) and, where applicable, the X-direction (i.e., the direction of maximum movement obtained at a skew angle from the A0-grooves). SI18-01 has a skew angle of 325° measured clockwise from the direction of the A0-grooves.

For the 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.

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 TWP007-17-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.

2.2 Zones of Movement

Distributed movement has been recorded in SI18-01 from an approximate depth of 5 m to 60 m below ground surface (approximately El. 879 m to El. 824 m). The casing also appears to be settling or buckling between an approximate depth of 13.5 m and 16 m below ground surface (approximately El. 868.1 m and El. 871.1 m), as discussed below.

Distributed movement has been recorded in SI18-02 from an approximate depth of 1 m to 50 m below ground surface (approximately El. 880 m to El. 831 m).

Both SI18-01 and SI18-02 are located at the crest of the slide.

2.3 Interpretation of Monitoring Results

The settlement or buckling observed in SI18-01 (from approximately 13.5 m and 16 m below ground surface) could be an indication that the instrument is poorly grouted with a possible grout void. The movements of the slide mass and interpretation of the SI data is complicated by the potential for settlement or buckling of the SI casing in the poorly grouted casing segment. The instrument was previously re-initialized to the October 2018 reading to remove possible noise associated with this zone. Overall, data quality has improved since the instrument was re-initialized, but settlement or buckling of the casing is still occurring at this depth. The rate of settlement or buckling has slowed since the first few months following installation and has been generally negligible since the instrument was re-initialized. If the settlement or buckling begins to impact the interpretation of the SI data again, the instrument may need to be re-initialized.

The near-surface movement recorded in the upper 5 m of SI18-01 and SI18-02 may be related to settlement of the highway-realignment fill or early signs of slope retrogression. The near-surface movements appear to be in the southeastern direction. Small tension cracks have been identified parallel to the crest where the SIs are located, which may correspond with the near-surface movement recorded in the SIs.

Since installation, the overall rate of movement recorded in SI18-01 and SI18-02 has been slow (less than 5 mm/year), with total movement of 8 mm and 6 mm, respectively, since installation.

The initial readings for the VWPs (VW18-01A/B and VW18-02A/B) were taken immediately following grouting operations, and KCB believes that the initial water levels recorded in the VWPs were artificially high due to grouting. Water levels recorded in these instruments decreased up to 13 m within a month of installation.

Overall, water levels recorded in VW18-01A, VW18-02A, and VW18-02B have decreased approximately 7.3 m, 5.7 m, and 5.2 m, respectively, since the spring of 2018. Whereas water levels recorded in VW18-01B have remained relatively steady (±0.1 m). The relatively steady decrease in water level recorded in VW18-01A, VW18-02A, and VW18-02B can most likely be attributed to excess porewater pressure dissipation following realignment of the highway (and the resulting fill placement) completed in 2016. A water level increase of 1.8 m was recorded in VW18-02B between spring 2023 and spring 2024. Further readings will be needed to confirm if this increase is the start of a new trend. It does not appear the water levels recorded in the VWPs at the S005 site fluctuate seasonally or in response to prolonged or heavy rainfall or freshet infiltration. However, the current annual reading frequency of the instruments may not capture short-term fluctuations (i.e., increases and decreases) in water levels that occur between readings.

Table 2.1 Slope Inclinometer Reading Summary

Instrument ID	Date				Ground Surface Elevation (m)	Depth of Movement (mbgs[1])	Direction of Movement, Skew Angle[3]	Movement (mm)		Rate of Movement (mm/year)		
	Initialized (Re-Initialized)[2]	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
SI18-01	Jan. 24. 2018 (Oct. 21, 2018)	Jun. 16, 2021	June 15, 2023	May 16, 2024	884.0	2.0 – 5.0	X-Direction, 325°	8.3	1.5	3.3	4.3	5.5
						13.5 – 16.0		1.2	-0.1	1.2	-0.4	-0.7
SI18-02	Jan. 24, 2018	Jun. 16, 2021	June 15, 2023	May 16, 2024	881.0	1.5 – 5.0	A-Direction	6.2	-0.9	3.5	-1.0	2.0

Notes:
[1] Meters below ground surface (mbgs).
[2] SI18-01 was re-initialized in October 2018 after the SI casing "settled" between January and April 2018.
[3] Skew angle of X-direction measured clockwise from the A-direction.

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)
VW18-01A	Jan. 18, 2018	June 15, 2023	May 16, 2024	884.0	67.7	35.3	38.6	-3.3
VW18-01B	Jan. 18, 2018	June 15, 2023	May 16, 2024	884.0	32.8	18.3	18.7	-0.4
VW18-02A	Jan. 20, 2018	June 15, 2023	May 16, 2024	881.0	68.2	34.7	35.7	-1.0
VW18-02B	Jan. 20, 2018	June 15, 2023	May 16, 2024	881.0	33.4	26.5	24.7	1.8

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

3 RECOMMENDATIONS

3.1 Future Work

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

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 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.

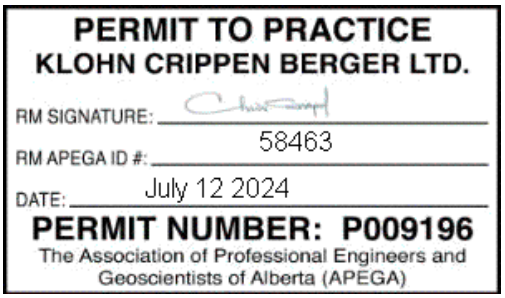
Use of or reliance upon this instrument of service by the Client is subject to the following conditions:

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.

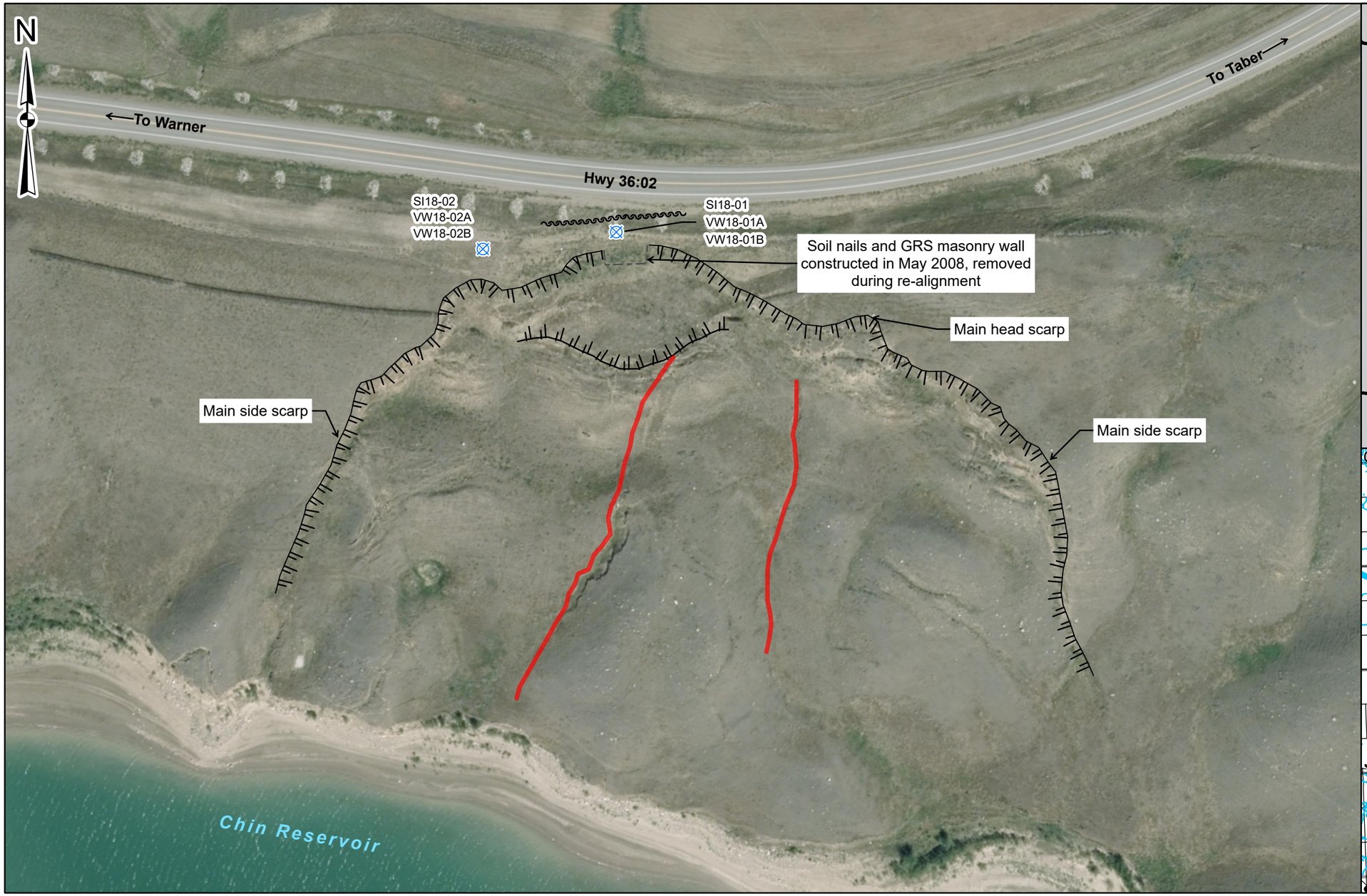


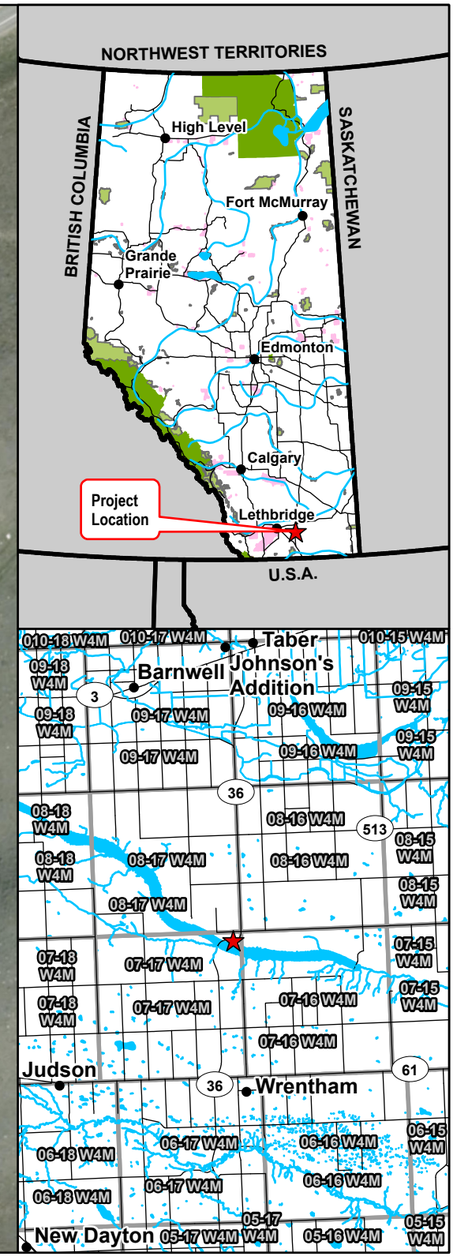
Peter Roy, P.Eng.
Civil Engineer

PR:kb

Attachments
Figure
Appendix I Instrumentation Plots

FIGURE





Legend

- Slope Inclinometer (SI)
- Vibrating Wire Piezometer (VW)
- Wall
- Scarp
- Backscarp
- Erosion
- Crack

0 50 Metres

NOTES:
1. HORIZONTAL DATUM: NAD83
2. GRID ZONE: UTM ZONE 12N
3. IMAGE SOURCE: TOWN OF PINCHER CREEK, WARNER, MAXAR

CLIENT: Alberta

Klohn Crippen Berger

PROJECT: SOUTHERN REGION GEOHAZARD RISK MANAGEMENT PROGRAM

TITLE: Site Plan
S005 - Chin Coulee (South of Taber)
Hwy 36:02, km 37.1

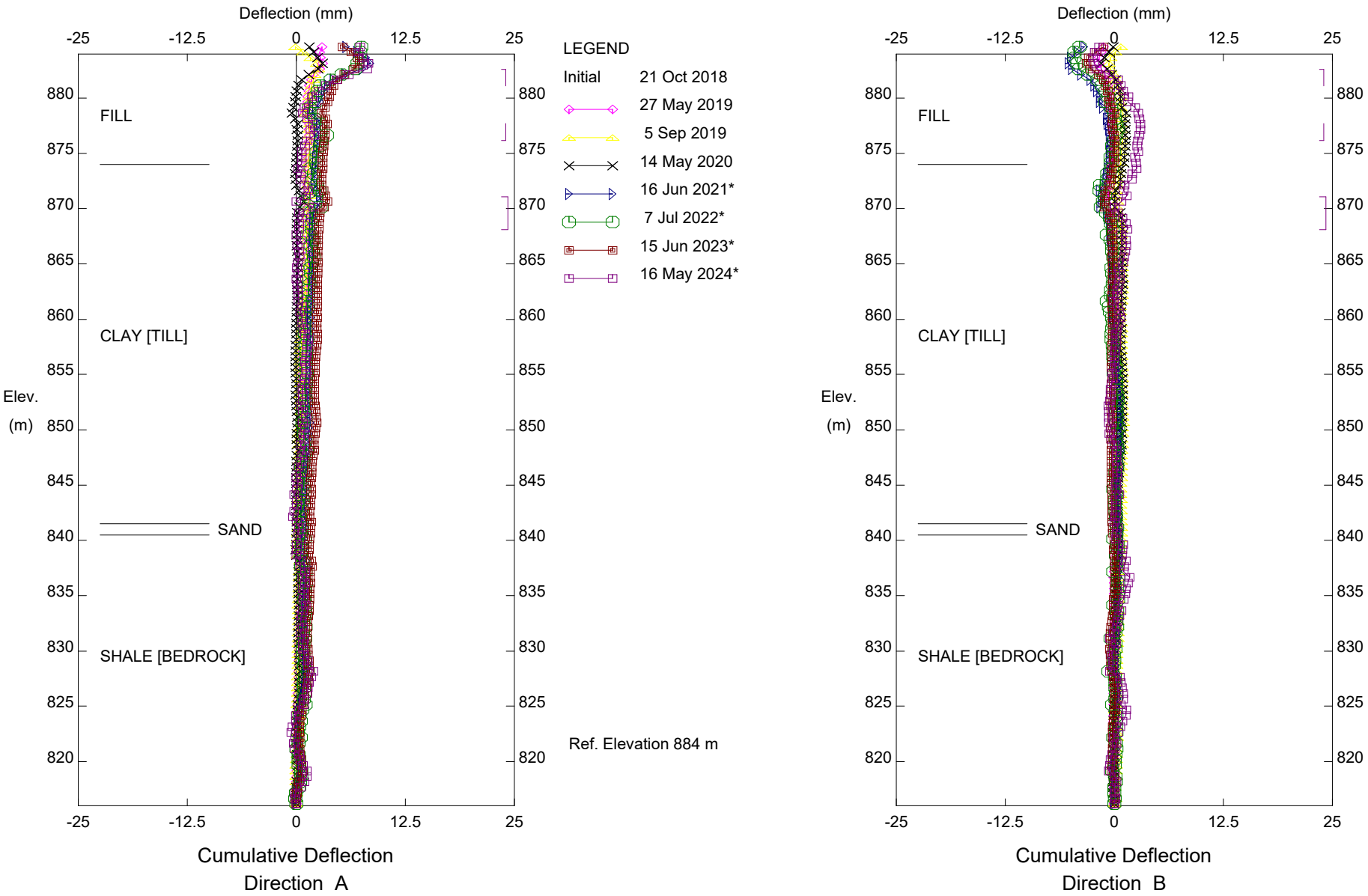
SCALE	PROJECT No.	FIG No.
1:1,500	A05116A03	1

File: Z:\AC\GY\Alberta\A05116A03 ABT Southern Region GRMP\400 Drawings\2022\Section C\Section C - Spring 2022\Section C - Spring 2022.aprx Date: Time: Creator: : aharrison

APPENDIX I

Instrumentation Plots

Klohn Crippen Berger Ltd. - Calgary, AB



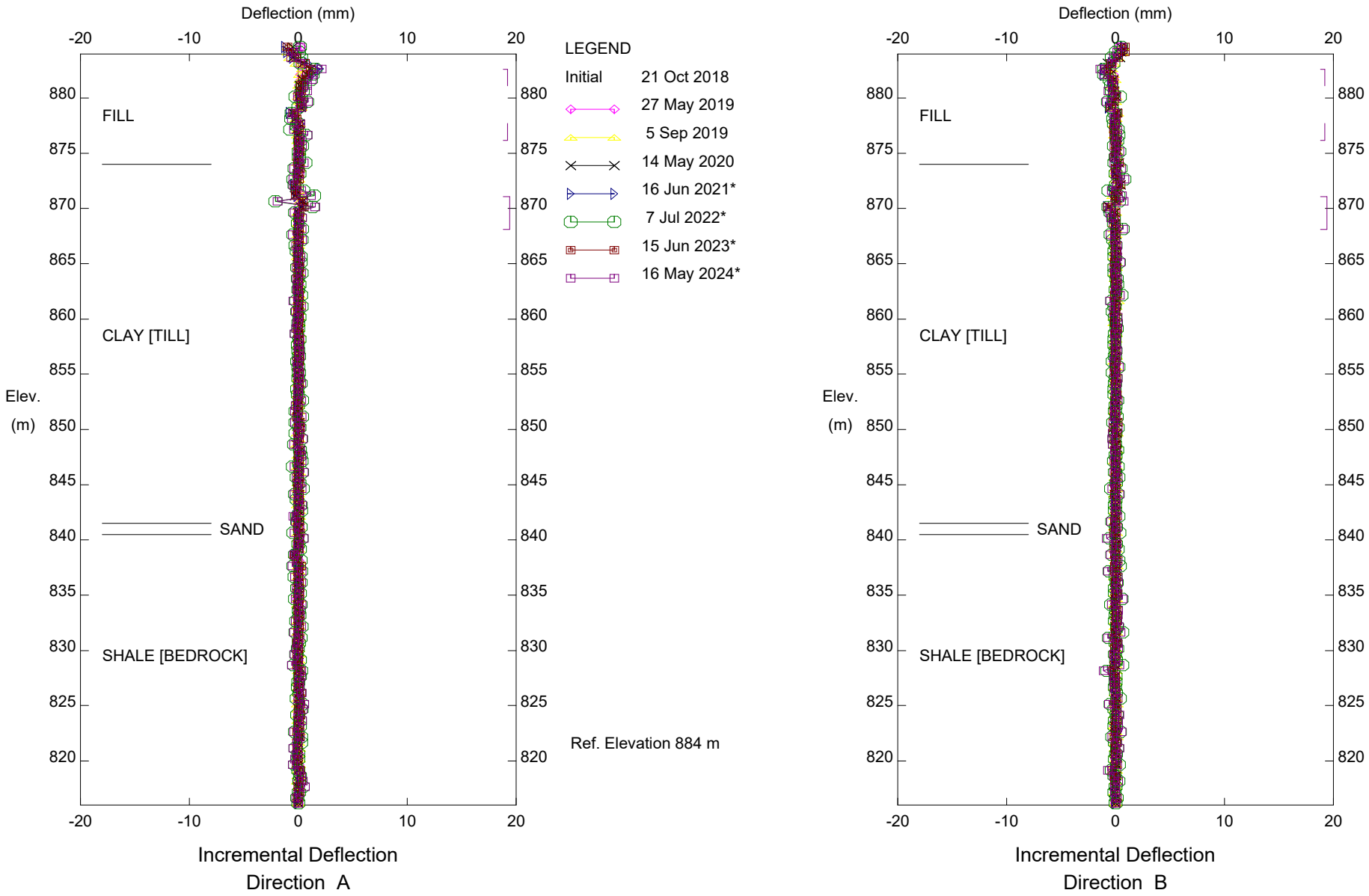
S005; H36:03, Chin Coulee, Inclinometer SI18-01

Alberta Transportation

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

Z:\A\CGY\ALBERTA\A05116A03 ABT SOUTHERN REGION GRMP\300 DESIGN\2024\SECTION C\04 INSTRUMENTATION\S005 - CHIN COULEE\3. SI\ABT S005 SI18-01 (RE-INITIALIZED OCT 2018).G

Klohn Crippen Berger Ltd. - Calgary, AB



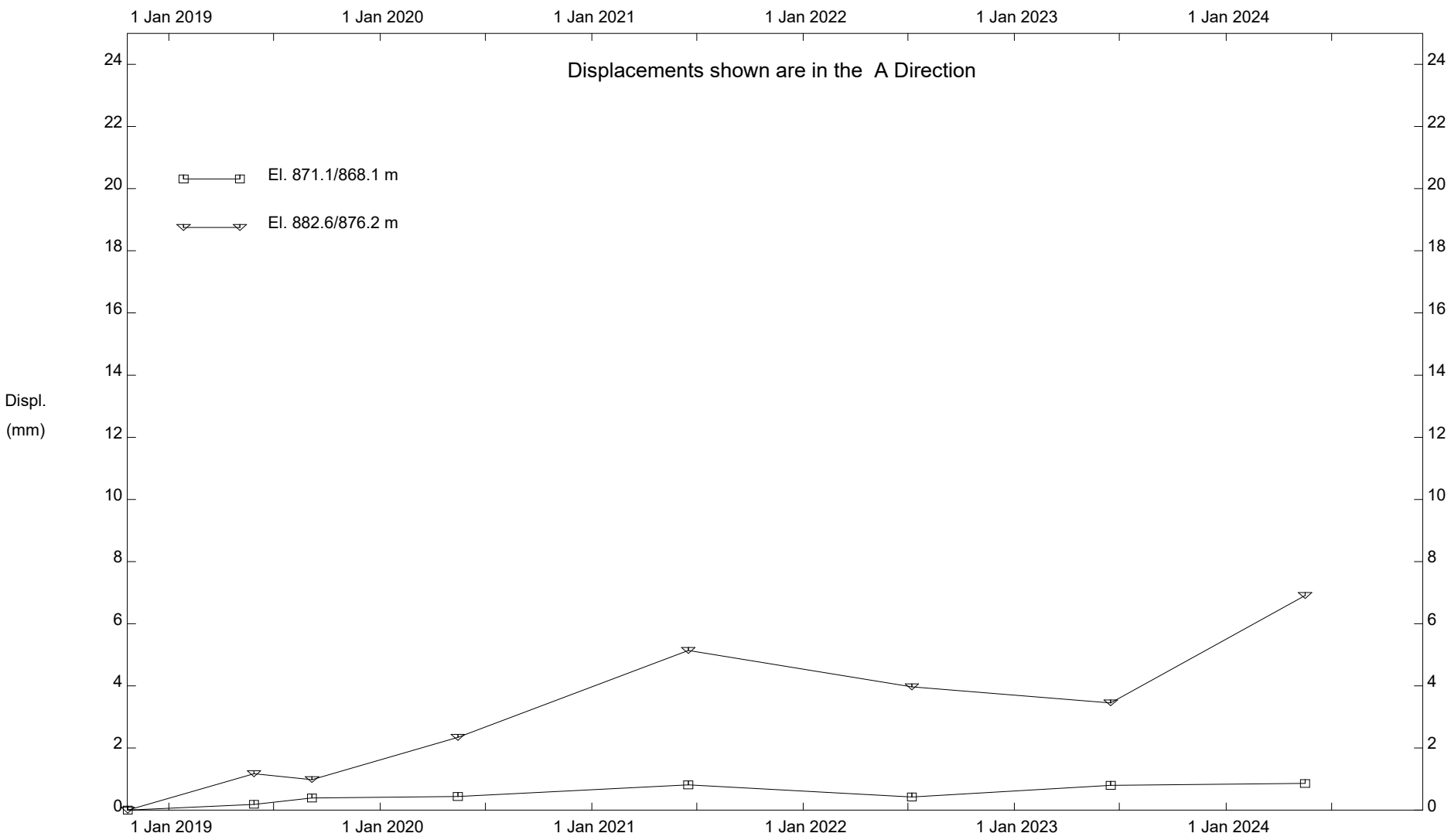
S005; H36:03, Chin Coulee, Inclinometer SI18-01

Alberta Transportation

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

Z:\A\CGY\ALBERTA\A05116A03 ABT SOUTHERN REGION GRMP\300 DESIGN\2024\SECTION C\04 INSTRUMENTATION\S005 - CHIN COULEE\3. SI\ABT S005 SI18-01 (RE-INITIALIZED OCT 2018).G

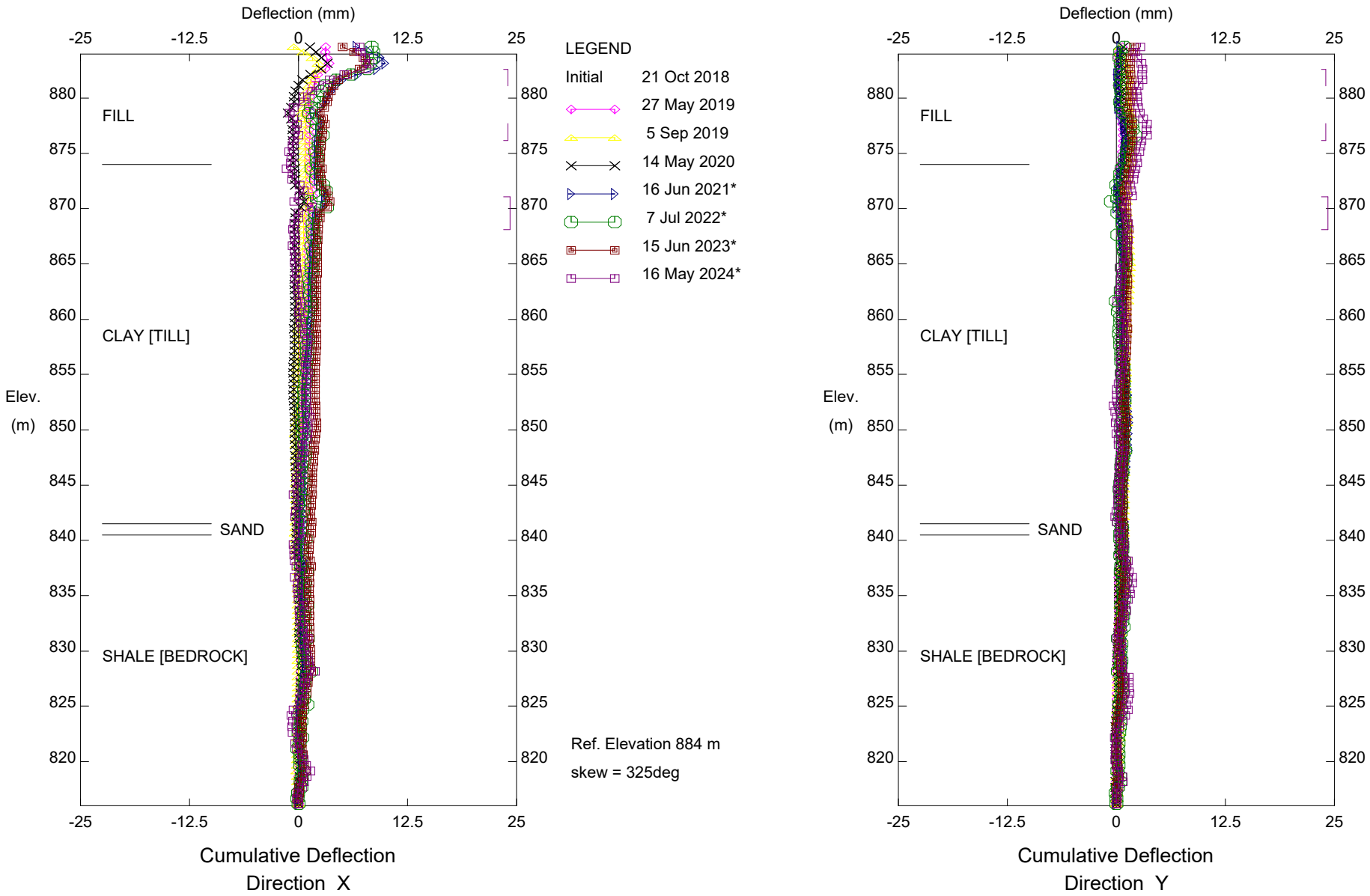
Klohn Crippen Berger Ltd. - Calgary, AB



S005; H36:03, Chin Coulee, Inclinometer SI18-01

Alberta Transportation

Klohn Crippen Berger Ltd. - Calgary, AB



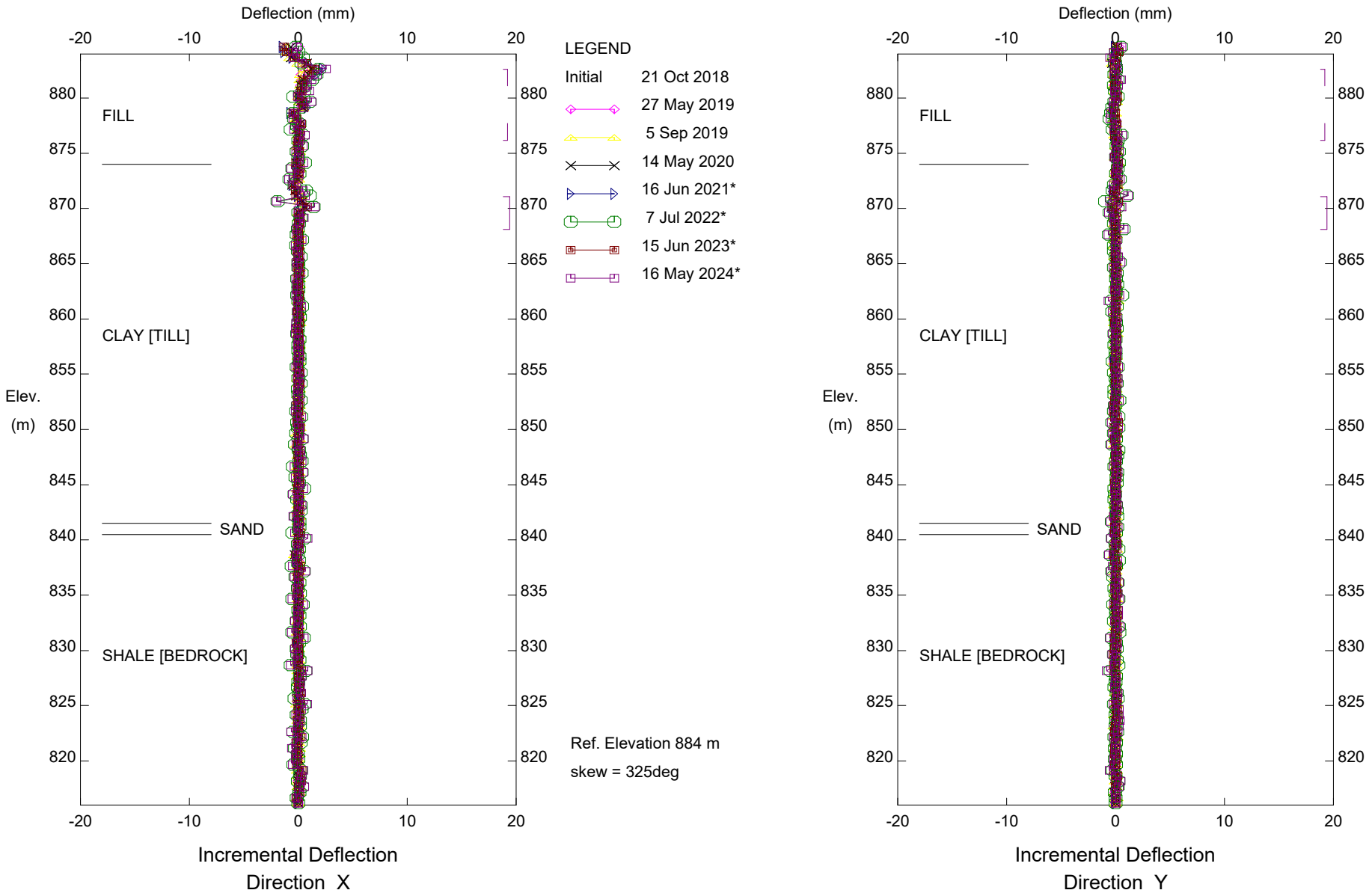
S005; H36:03, Chin Coulee, Inclinometer SI18-01

Alberta Transportation

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

Z:\A\CGY\ALBERTA\A05116A03 ABT SOUTHERN REGION GRMP\300 DESIGN\2024\SECTION C\04 INSTRUMENTATION\S005 - CHIN COULEE\3. SI\ABT S005 SI18-01 (RE-INITIALIZED OCT 2018).GT

Klohn Crippen Berger Ltd. - Calgary, AB



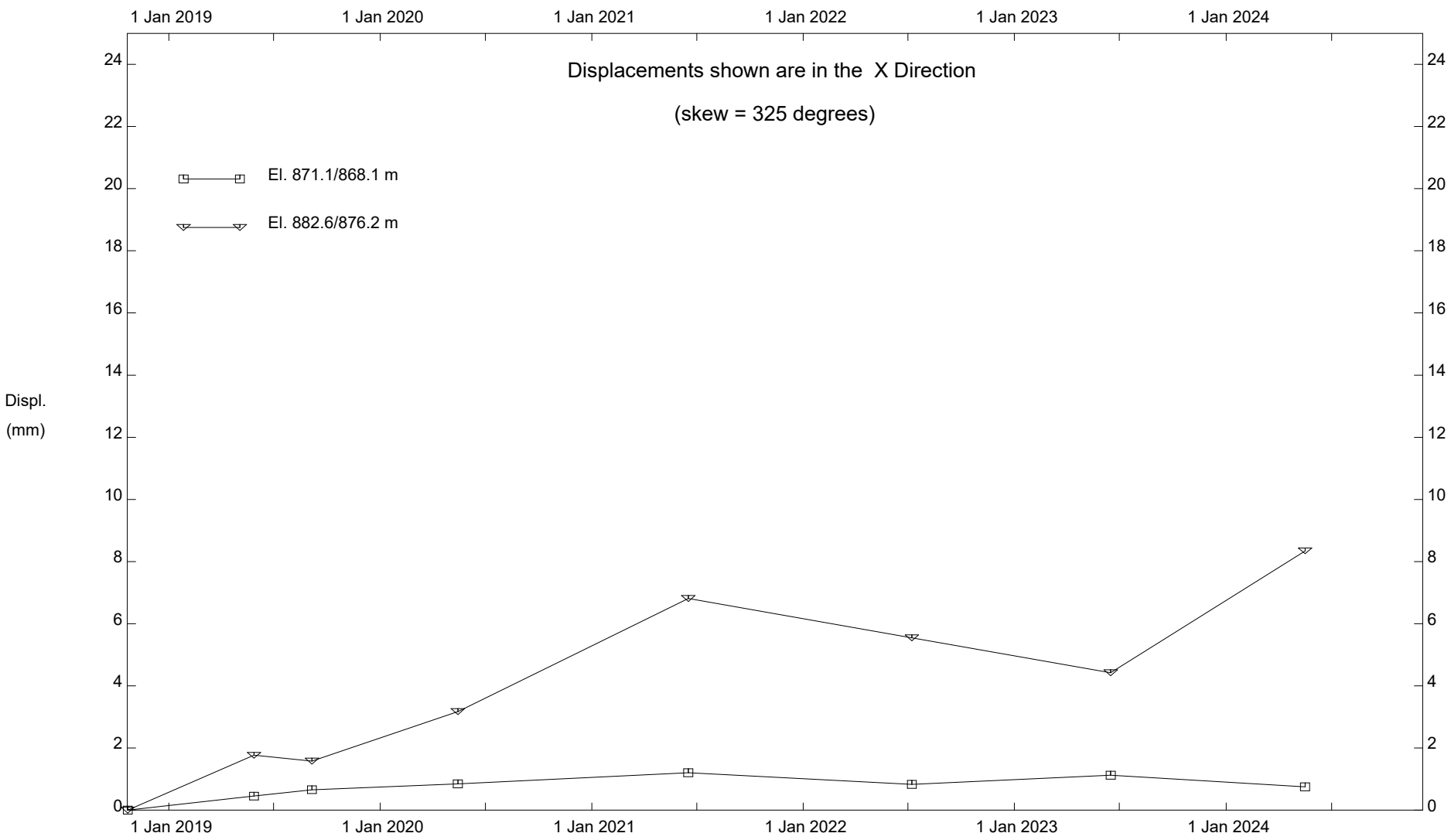
S005; H36:03, Chin Coulee, Inclinometer SI18-01

Alberta Transportation

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

Z:\A\CGY\ALBERTA\A05116A03 ABT SOUTHERN REGION GRMP\300 DESIGN\2024\SECTION C\04 INSTRUMENTATION\S005 - CHIN COULEE\3. SI\ABT S005 SI18-01 (RE-INITIALIZED OCT 2018).GT

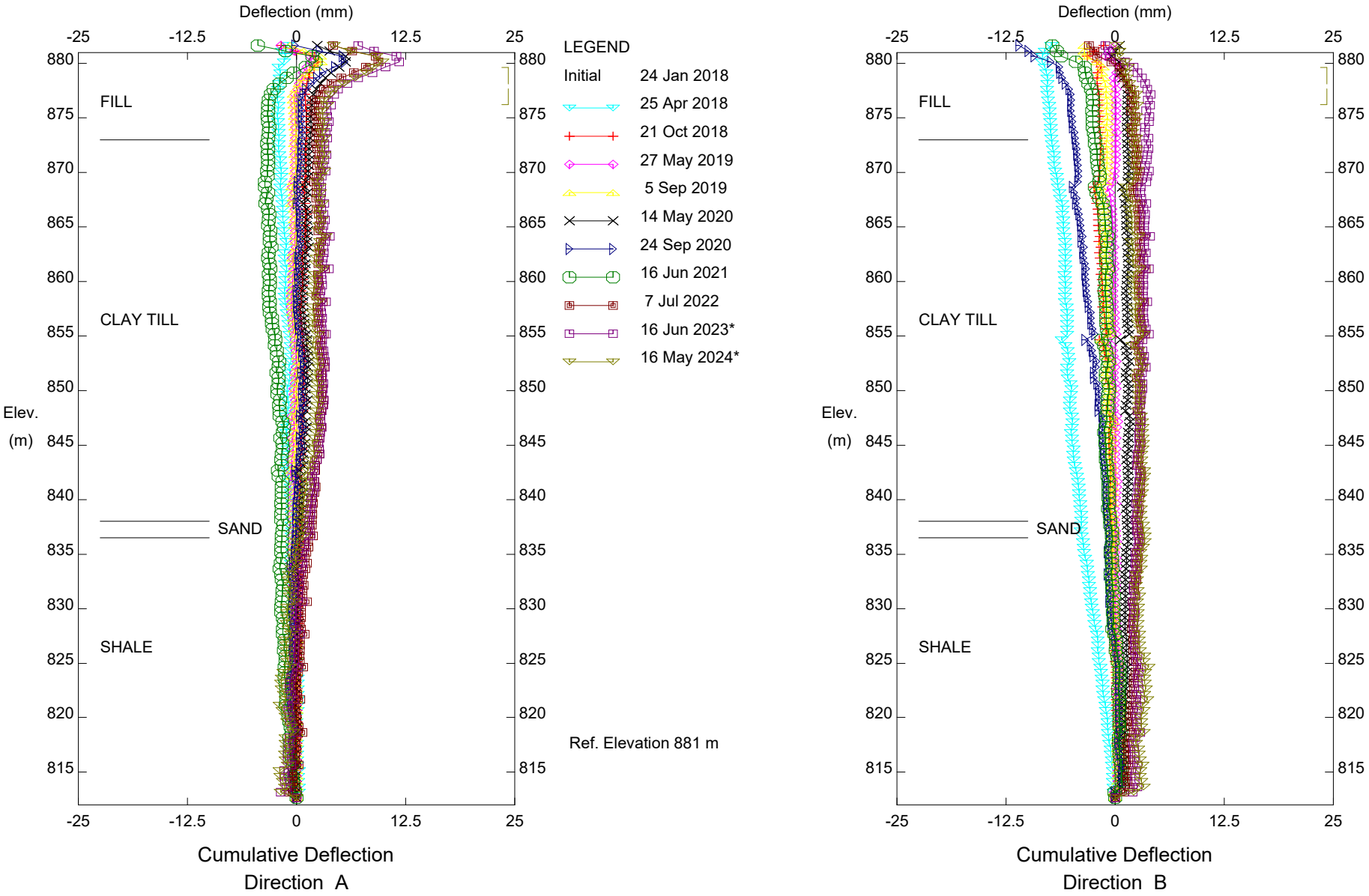
Klohn Crippen Berger Ltd. - Calgary, AB



S005; H36:03, Chin Coulee, Inclinometer SI18-01

Alberta Transportation

Klohn Crippen Berger Ltd. - Calgary, AB



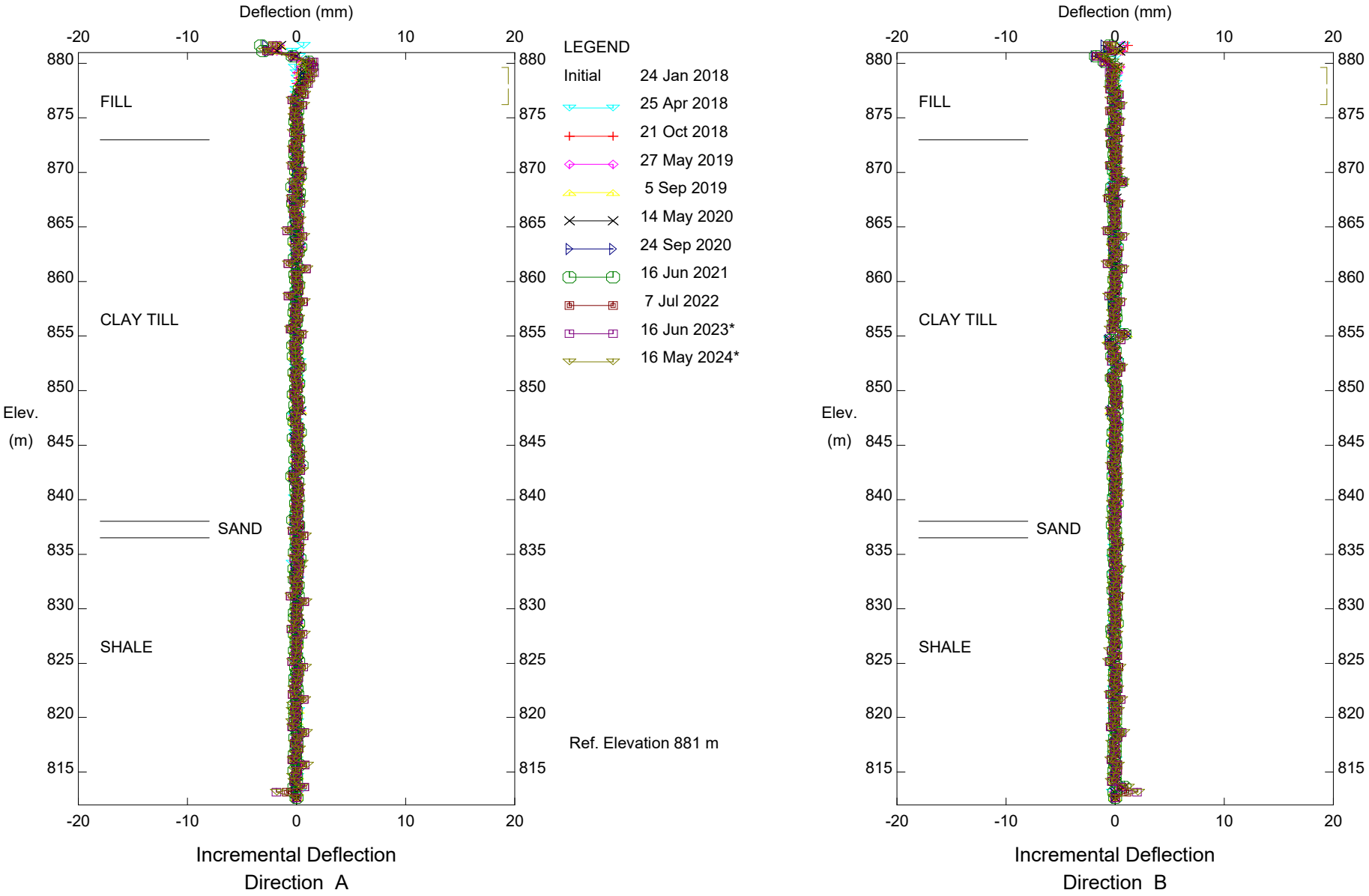
S005; H36:02, Chin Coulee, Inclinometer SI18-02

Alberta Transportation

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

Z:\A\CGY\ALBERTA\A05116A03 ABT SOUTHERN REGION GRMP\300 DESIGN\2024\SECTION C\04 INSTRUMENTATION\S005 - CHIN COULEE\3. SI\ABT S005 SI18-02.GTL

Klohn Crippen Berger Ltd. - Calgary, AB



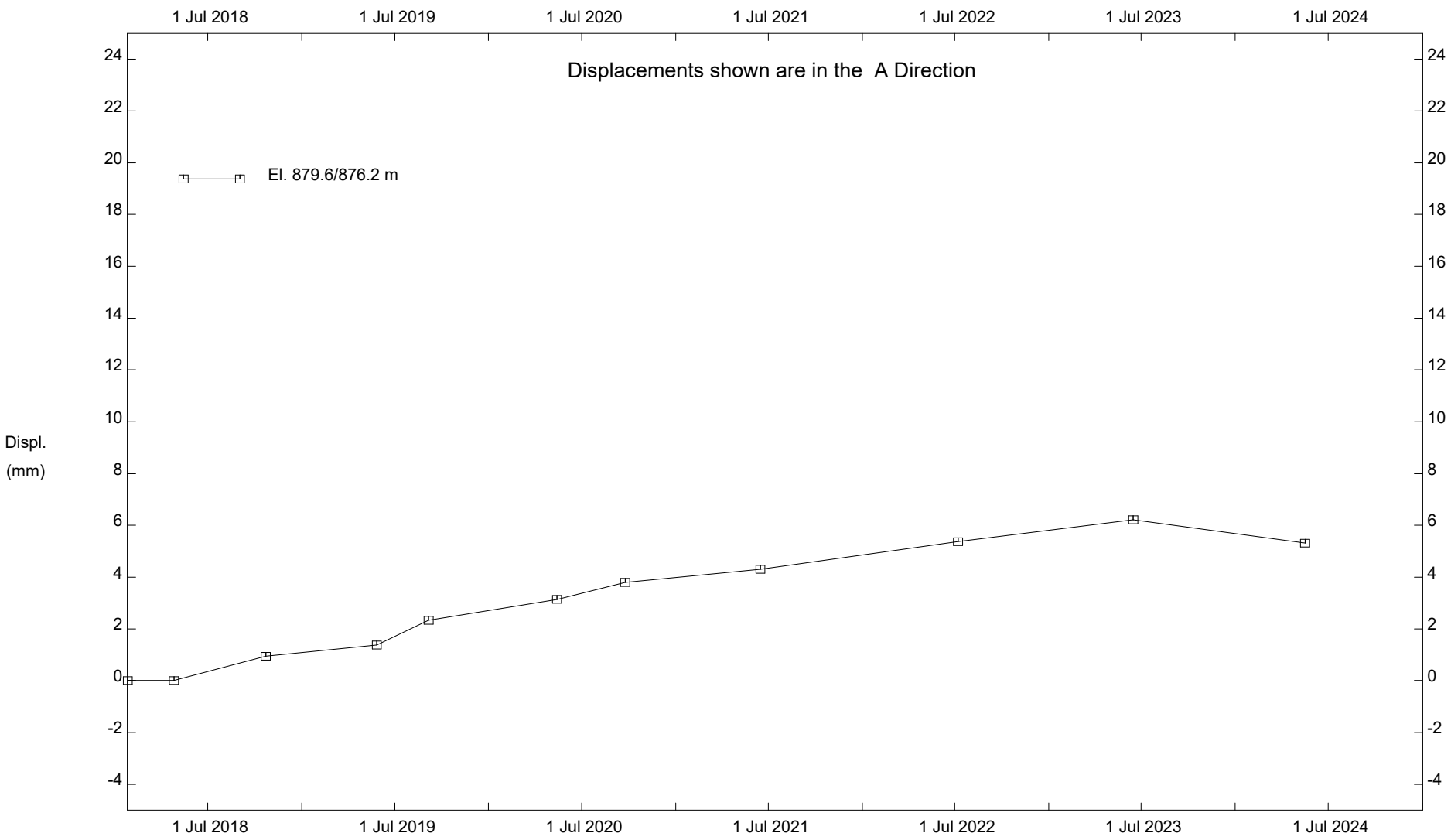
S005; H36:02, Chin Coulee, Inclinometer SI18-02

Alberta Transportation

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

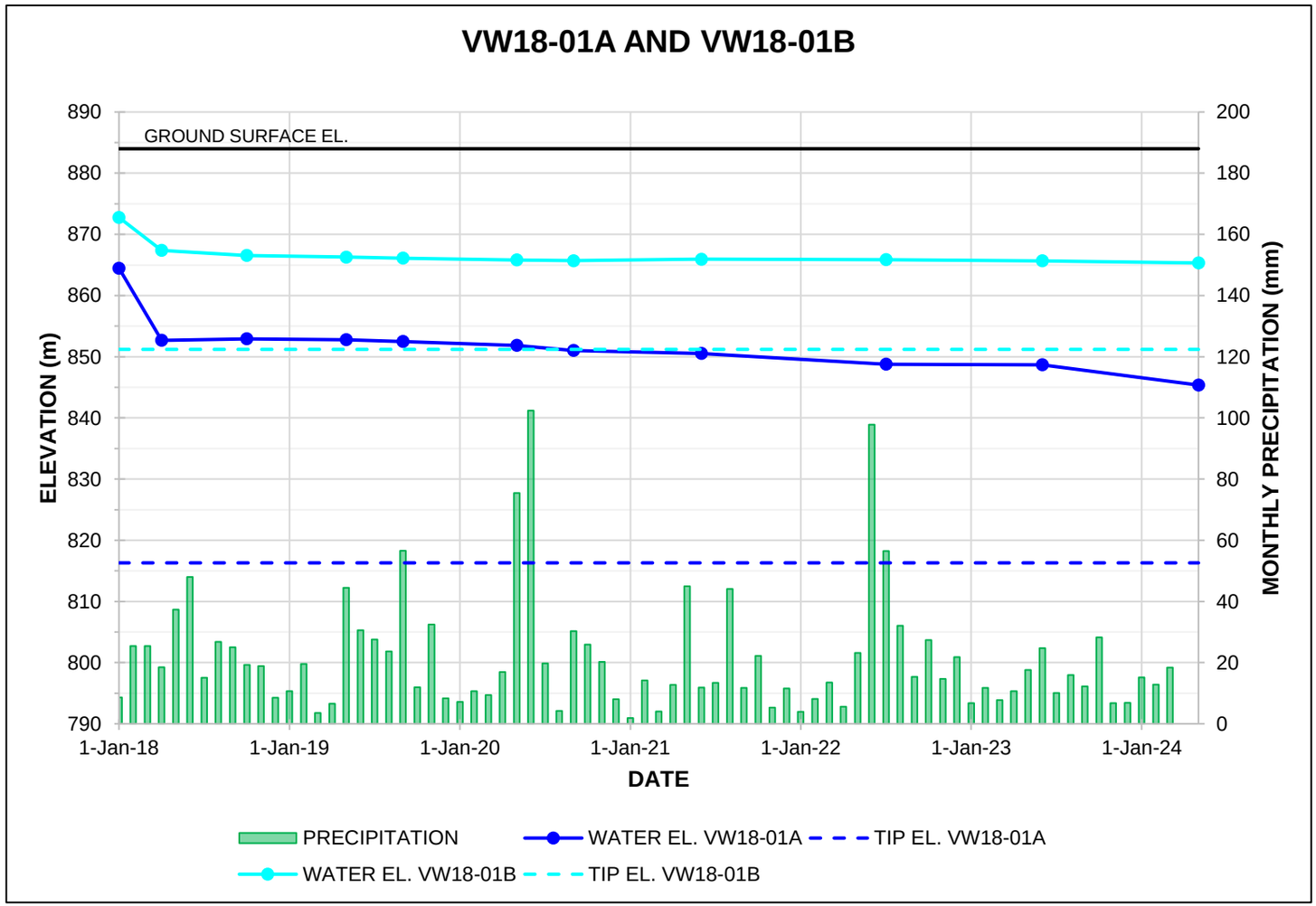
Z:\A\CGY\ALBERTA\A05116A03 ABT SOUTHERN REGION GRMP\300 DESIGN\2024\SECTION C\04 INSTRUMENTATION\S005 - CHIN COULEE\3. SI\ABT S005 SI18-02.GTL

Klohn Crippen Berger Ltd. - Calgary, AB



S005; H36:02, Chin Coulee, Inclinometer SI18-02

Alberta Transportation



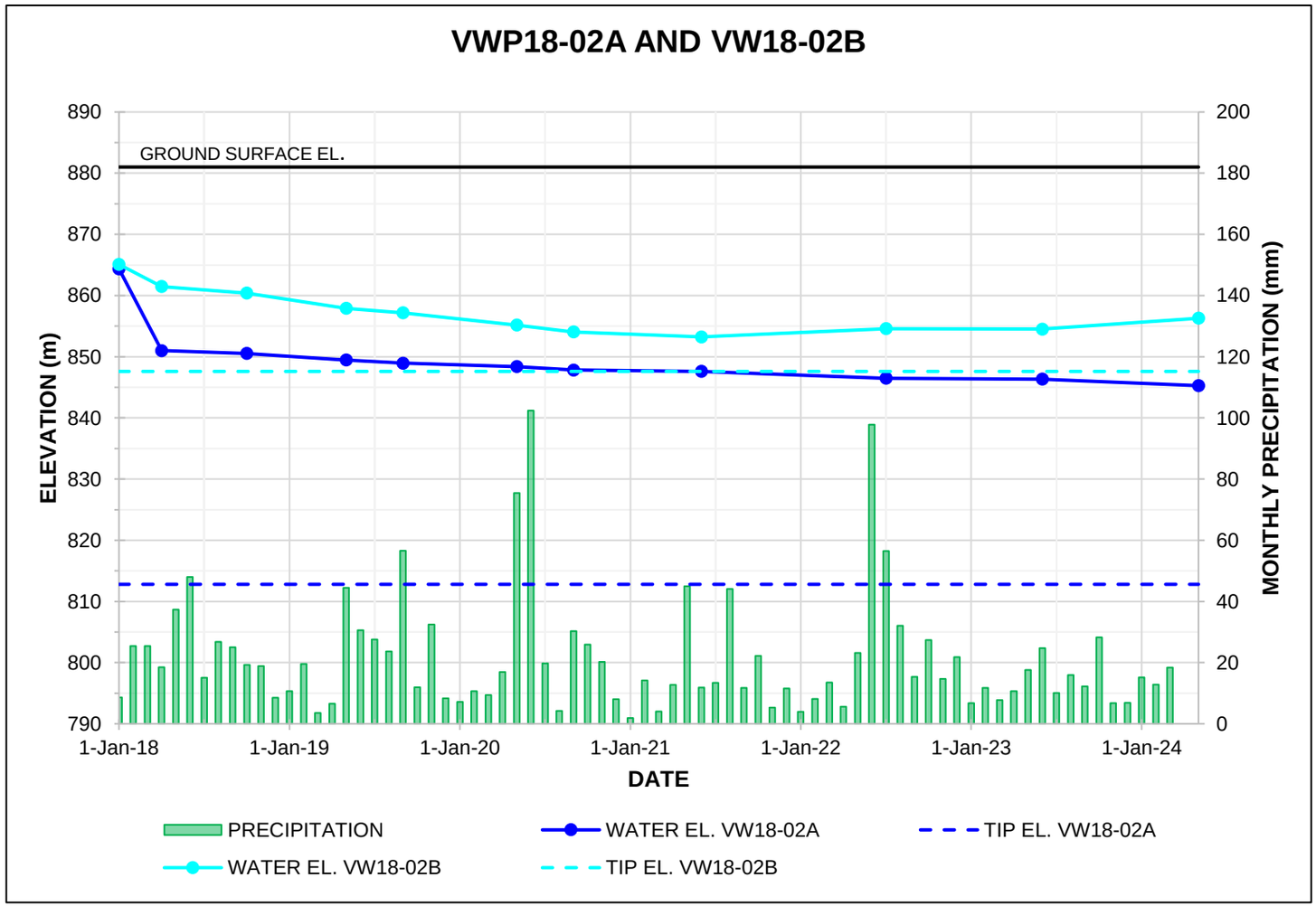
NOTES:
1. MONTHLY PRECIPITATION DATA OBTAINED FROM THE ALBERTA CLIMATE INFORMATION SERVICE (ACIS) DATABASE, REFERENCING LEGAL SUBDIVISION T007R17W4.

CLIENT
Alberta
Klohn Crippen Berger

PROJECT
SOUTHERN REGION GEOHAZARD RISK MANAGEMENT PROGRAM

TITLE
Vibrating Wire Piezometer Data
S005 - Chin Coulee
Hwy 36:02, km 37.1

SCALE	PROJECT No.	FIG No.
	A05116A03	



NOTES:
1. MONTHLY PRECIPITATION DATA OBTAINED FROM THE ALBERTA CLIMATE INFORMATION SERVICE (ACIS) DATABASE, REFERENCING LEGAL SUBDIVISION T007R17W4.

CLIENT
Alberta
Klohn Crippen Berger

PROJECT
SOUTHERN REGION GEOHAZARD RISK MANAGEMENT PROGRAM

TITLE
Vibrating Wire Piezometer Data
S005 - Chin Coulee
Hwy 36:02, km 37.1

SCALE	PROJECT No.	FIG No.
	A05116A03	