November 30, 2022

Alberta Transportation
Main Floor, Provincial Building
9621 – 96th Avenue
Peace River, Alberta
T8S 1T4

Ed Szmata
Construction Technologist

Dear Mr. Szmata:

CON0022166 Peace Region (Grande Prairie District – South) GRMP Instrumentation Monitoring Site GP008; H40:36, km 16.365 Road Surface Slumping (2.5 km North of McIntyre Mine) Section C – 2022 Fall Readings

1 GENERAL

Three slope inclinometers (SIs) (SI-1 through SI-3) and two pneumatic piezometers (PNs) (PN-2A/B) were read at the GP008 site in the Peace Region (Grande Prairie District – South, GP South Region) on September 26, 2022 by Messrs. Gabriel Bonot, E.I.T. and Guerin White, E.I.T. of Klohn Crippen Berger Ltd. (KCB). These instruments were read as part of the GP South Region Geohazard Risk Management Program (GRMP). The site is located on Hwy 40:36, km 16.365, north of the former McIntyre Mine. The approximate site coordinates are 5986982 N, 362802 E (UTM Zone 11, NAD 83). A site plan is presented in Figure 1.

The geohazard at the GP008 site consists of three landslides in a possible mine-waste fill/dump below Hwy 40:36:

- the west/south slide, which cuts diagonally across the highway;
- the middle slide, which is confined to the northbound lane and shoulder; and
- the east/north slide, which encompasses both lanes.

In 2022, the rockfall component of the GP008 site was made into a separate site (GP053) and the ATCO slide to the northeast was added to the GP008 site. Instruments are only installed at the west/south slide.

Previous remedial actions completed at the GP008 site include regular surface patching and paving, including a recent patch completed in 2021 at the west slide area.

In 2004, a geotechnical site investigation, which included installing instruments, was conducted at the GP008 site by a previous consultant. The encountered stratigraphy was as follows: embankment fill, overlying peat, overlying bedrock (shale).

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1.1 Instrumentation

KCB has been reading the instruments at this site since the spring of 2021. 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 2004, three SIs (SI-1, SI-2, and SI-3) and three PNs (PN-1, PN-2A, and PN-2B) were installed at the west/south slide by a previous consultant to monitor movement and groundwater conditions, respectively. SI-1, SI-2, and SI-3 are installed in the upper one-third of the slope, near the midslope, and at toe of the slope, respectively. PN-1 is now inoperable.

The instruments are protected by above-ground casing protectors.

The operable SIs were read using the same metric RST Digital MEMS Inclinometer System that has been used to read the SIs since KCB took over the readings in June 2021.

The operable PNs were read using an RST C109 pneumatic piezometer readout.

Table 1.1 Instrumentation Installation Details

Instrument ID	Instrument Type	Date Installed[1]	UTM Coordinates[1] (m)		Ground Surface Elevation[1] (m)	Stick Up[1] (m)	Depth[1] (mbgs[2])	Condition
			Northing	Easting				
SI-1	SI	Sep. 2004	5986974	362849	939.4	0.7	12.3	Operable
SI-2	SI	Sep. 2004	5986946	362850	928.7	0.7	11.3	Operable
SI-3	SI	Sep. 2004	5986915	362864	918.5	0.7	12.3	Operable
~~PN-1~~	~~PN~~	~~Sep. 2004~~	~~5986974~~	~~362849~~	~~939.4~~	~~N/A~~	~~7.6~~	~~Inoperable~~
PN-2A	PN	Sep. 2004	5986946	362850	928.0	N/A	5.2	Operable
PN-2B	PN	Sep. 2004	5986946	362850	928.0	N/A	9.1	Operable

Notes:
[1] Installation details taken from reports and data files prepared or provided by the previous consultant(s) or AT. Instrument coordinates and stick ups (where applicable) were confirmed by KCB using a handheld GPS (accuracy of ± 5 m) and tape measure, respectively.
[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, incremental displacement, and displacement-time data was plotted in the A-direction (i.e., the direction of the A0-groove) and the X-direction (i.e., the direction of maximum movement obtained at a skew angle from the A0-grooves). SI-1, SI-2, and SI-3 have skew angles of 14°, 350°, and 85°, respectively, measured clockwise from the direction of the A0-grooves.

For the operable PNs, the recorded porewater pressures were converted to an equivalent water/piezometric elevation and plotted relative to ground surface elevation and each instruments tip elevation.

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.

In 2021, KCB reviewed the instrumentation data provided by the previous consultant and removed corrections applied to the historical SI data based on our experience. The instrumentation data obtained by KCB is consistent with the data obtained by the previous consultant, except for the PNs due to an increase recorded in 2021, as discussed in Section 2.3. No re-initialization of the SIs is recommended. The SI data plots presented herein include data for readings taken with both the previous consultants' and KCB's SI reading equipment.

Table 2.1 Slope Inclinometer Reading Summary

Instrument ID	Date				Ground Surface Elevation (m)	Depth of Movement (mbgs[1])	Direction of Movement, Skew Angle[2]	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
SI-1	Sep. 27, 2004	Jun. 28, 2021	Jun. 23, 2022	Sep. 26, 2022	939.4	0.0 – 1.1	X-Direction, 14°	13.6	-0.2	4.4	-0.7	-1.4
		Jun. 28, 2021				3.6 – 7.1	X-Direction, 14°	19.8	0.4	2.2	1.6	0.8
SI-2	Sep. 27, 2004	Jun. 28, 2021	Jun. 23, 2022	Sep. 26, 2022	928.7	0.0 – 2.1	X-Direction, 350°	28.5	-0.2	10.0	-0.6	-0.7
		Jun. 28, 2021				2.1 – 4.1	X-Direction, 350°	4.6	-0.2	1.8	0.1	-0.1
SI-3	Sep. 27, 2004	Jun. 28, 2021	Jun. 23, 2022	Sep. 26, 2022	918.5	1.1 – 2.1	X-Direction, 85°	6.2	0.2	2.5	0.9	1.0

Notes:
[1] Meters below ground surface (mbgs).
[2] Skew angle of X-direction measured clockwise from the A-direction. Azimuth of SI A0-grooves measured by KCB with a magnetic compass during spring 2022 readings.

Table 2.2 Pneumatic 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)
PN-2A	29181	Sep. 2004	Jun. 23, 2022	Sep. 26, 2022	928.0	5.2	5.2	5.2	0.0
PN-2B	29182	Sep. 2004	Jun. 23, 2022	Sep. 26, 2022	928.0	9.1	9.0	9.1	-0.1

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

2.2 Zones of Movement

Distributed movement is being recorded in

- SI-1 from ground surface to an approximate depth of 1.1 m below ground surface, and from approximately 3.6 m to 7.1 m below ground surface;
- SI-2 from ground surface to an approximate depth of 2.1 m below ground surface, and from approximately 2.1 m to 4.1 m below ground surface; and
- SI-3 from an approximate depth of 1.2 m to 2.1 m below ground surface with most the movement being recorded since May 2015.

The movement being recorded in all three SIs is occurring within the fill.

2.3 Interpretation of Monitoring Results

Since the instruments were installed in 2007, the rate of movement being recorded in SI-1, SI-2, and SI-3 in the fill has been slow (less than 2 mm/year), except for increased movement (up to approximately 6 mm/year) recorded in the X-direction of SI-2 in early 2006 and 2021. In 2021, the increased rate of movement recorded in SI-2 was likely a result of the SI reading equipment being changed when KCB took over the instrument readings. Since 2021, the movement rates are once again slow (less than 2 mm/year).

AT has noted that cracking usually reflects through pavement patches at the site very quickly. It is noted that the existing SIs are installed at the west slide area only and movements recorded in them may not be reflective of movements occurring at the middle or east/north slide areas where no instruments are installed.

Although a peat layer was identified in the SI data plots, the distributed shearing movements recorded in SI-1 appear to be in the lower portion of the fill, above the peat layer. The peat layer is the most likely cause of the movement and the SI data points may be shifted upwards due to soil logging or SI stick up issues. Alternatively, there could be a loose zone of fine-grained segregated material near the base of the fill that is straining under embankment load. Observations of the fill surface during the 2021 Section B Inspection indicated that the fill material is likely mine waste that could have been end-dumped in thick lifts (with minimal compaction) before or as part of highway construction. Movements recorded in SI-2 and SI-3 are well above the peat layer, indicating that straining of the embankment along a segregated fine-grained layer in the mine-waste fill is more likely.

SI-1 and SI-2 (located near the top of the slope and mid-slope, respectively) are recording movement to the southeast. However, SI-3 (located near the toe of the slope) is recording movement more towards the southwest. This could indicate that the movement pattern for the highway embankment is complicated and difficult to assess, given that the highway embankment was constructed in thick lifts with minimal compaction.

Since the instruments were installed in 2004, water levels recorded in PN-2A and PN-2B have been near tip elevation (i.e., the instruments have been dry), except during the spring and fall 2021 readings when water levels increased to 0.2 m and 0.4 m above tip elevation, respectively. The spring and fall 2022 readings indicate the instruments are dry again.

3 RECOMMENDATIONS

3.1 Future Work

All operable instruments should continue to be read twice per year (spring and fall). Spring readings should be completed after late-May or early-June, due to the risk of water inside the instruments casing being frozen earlier in the year.

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

3.2 Instrument Repairs and Maintenance

No instrument repairs or maintenance is required.

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 (Client) for the specific application to GP South Geohazard Risk Management Program (Contract No. CON0022166), 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:

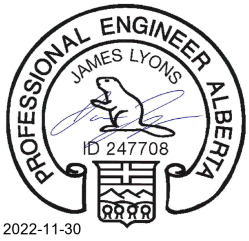
1. The report is to be read in full, with sections or parts of the report relied upon in the context of the whole report.
2. The observations, findings and conclusions in this report are based on observed factual data and conditions that existed at the time of the work and should not be relied upon to 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.



2022-11-30

James Lyons, P.Eng.
Civil Engineer

Chris Gräpel, M.Eng., P.Eng.
Senior Civil Engineer, Associate

JL:bb

PERMIT TO PRACTICE
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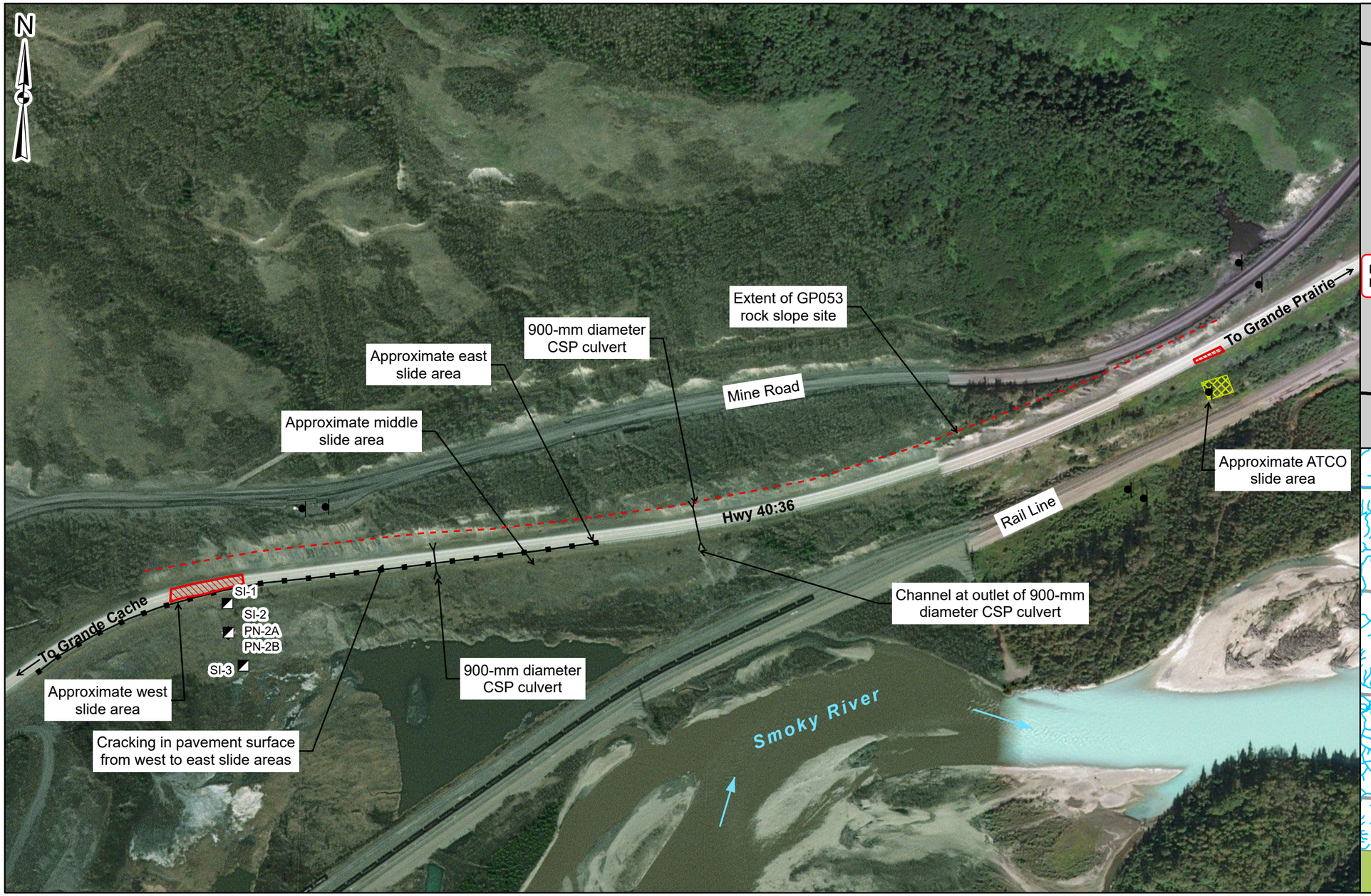
RM APEGA ID #: 187607
DATE: 30 Nov. 2022
PERMIT NUMBER: P009196
The Association of Professional Engineers and Geoscientists of Alberta (APEGA)

ATTACHMENTS
Figure
Appendix I Instrumentation Plots

FIGURE



Legend

- Powerpole
- Approximate Pneumatic Piezometer Location
- Approximate Slope Inclinometer Location
- Flow Direction
- Rockfall Corridor
- Guardrail
- Culvert
- ATCO Excavation
- Pavement Patch

0 150 Metres

NOTES:
1. HORIZONTAL DATUM: NAD83
2. GRID ZONE: UTM ZONE 11N
3. IMAGE SOURCE: 2022 MICROSOFT CORPORATION, 2022 MAXAR CNES, DISTRIBUTION AIRBUS DS

CLIENT: Alberta

Klohn Crippen Berger

PROJECT: PEACE REGION (GRANDE PRAIRIE DISTRICT-SOUTH) GEOHAZARD RISK MANAGEMENT PROGRAM

TITLE: Site Plan
GP008 - Road Surface Slumping
(2.5 km North of McIntyre Mine)
Hwy 40:36, km 16.365 and 17.139

SCALE	PROJECT No.	FIG No.
1:4,000	A05116A01	1

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APPENDIX I

Instrumentation Plots

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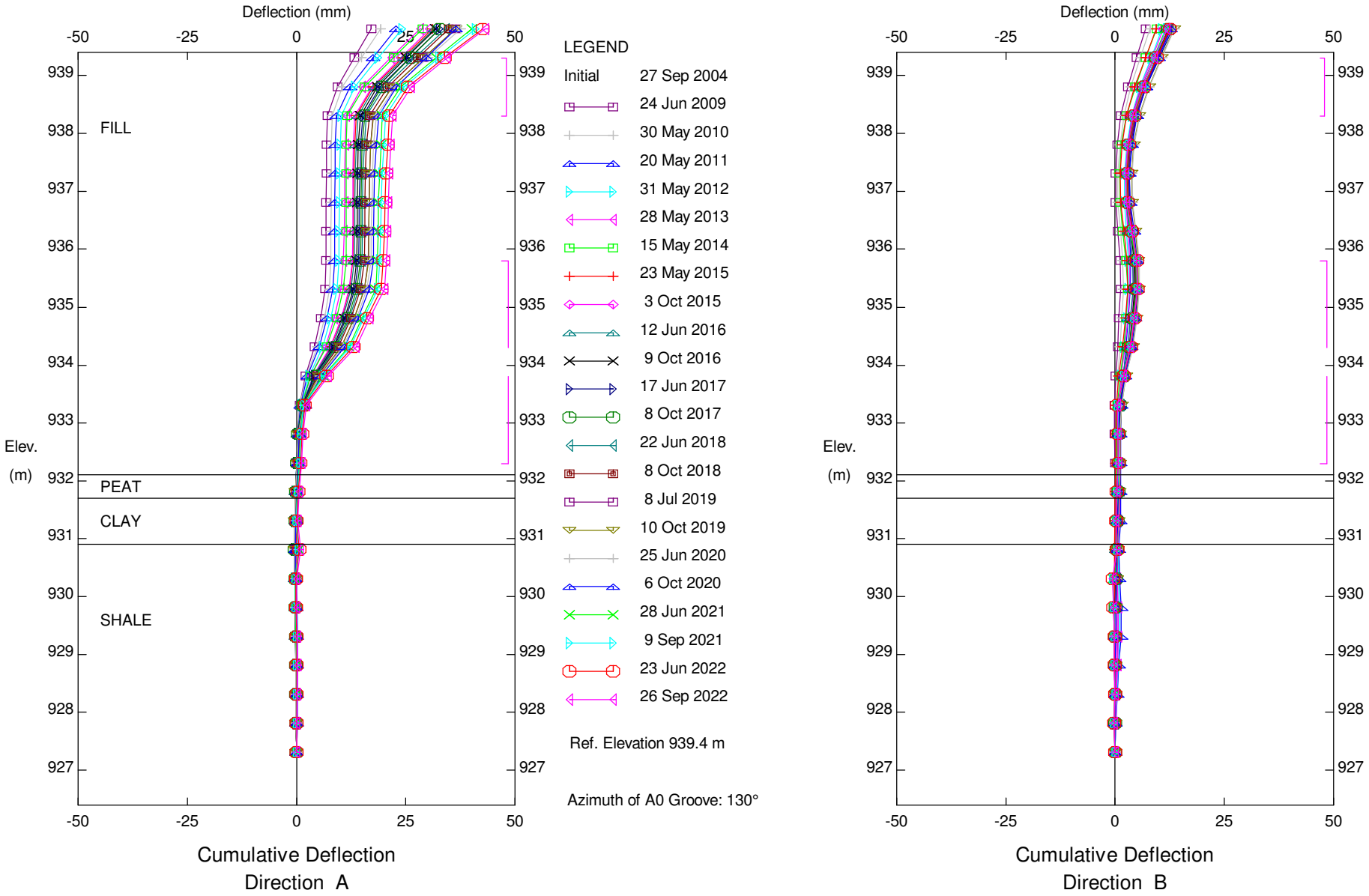

GP008; H40:36, Road Surface Slumping, Inclinometer SI-1

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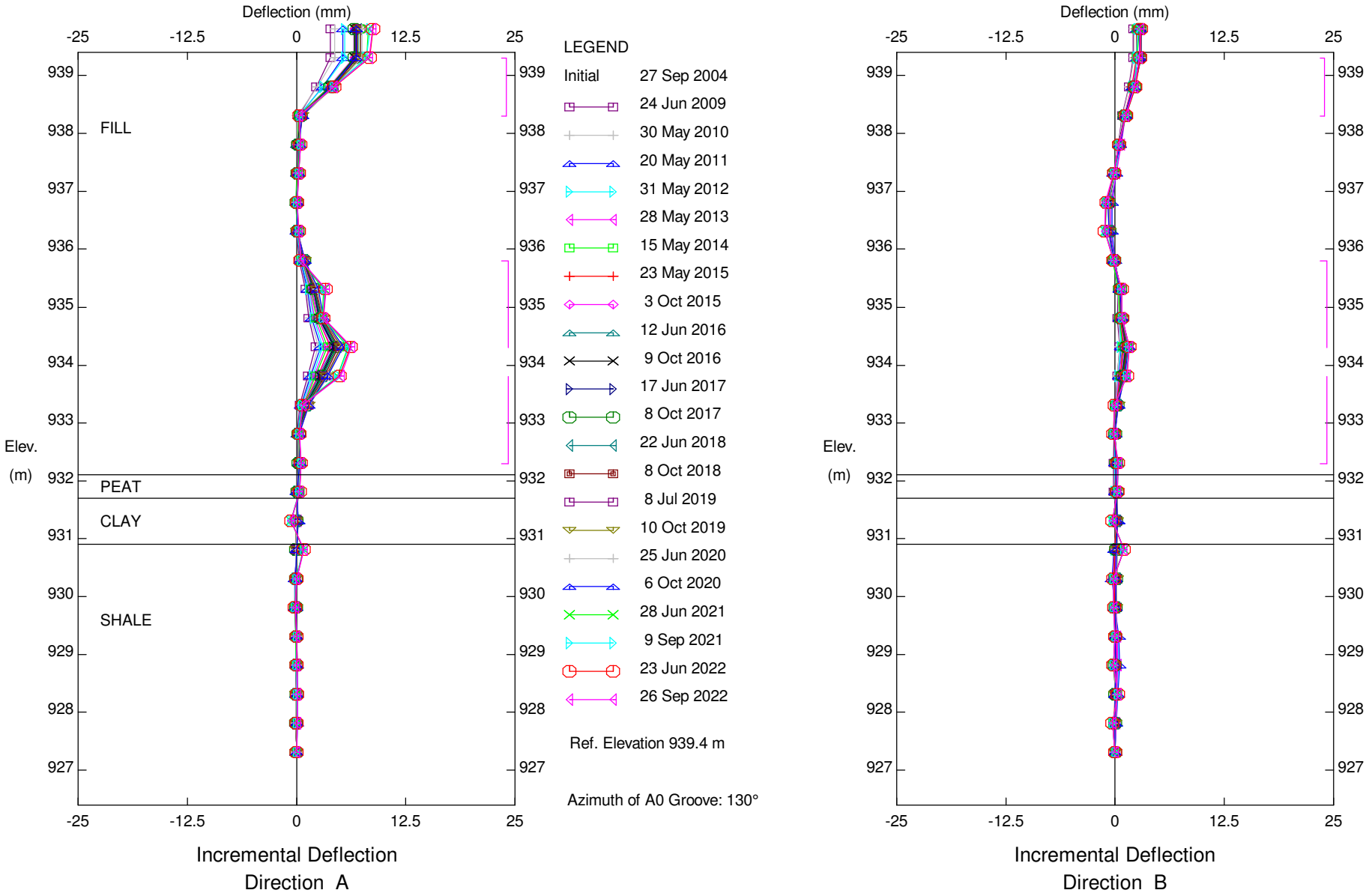

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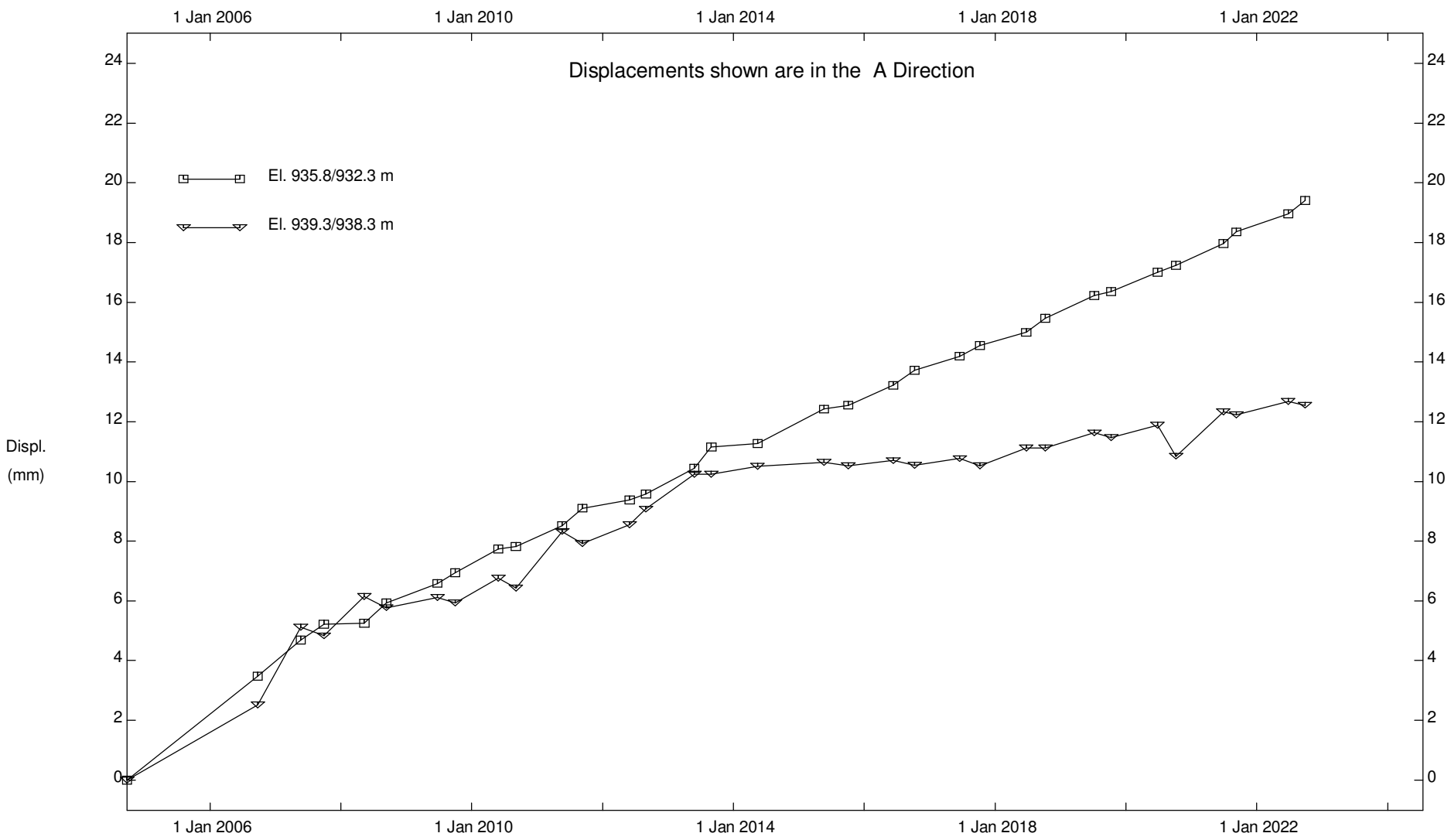
Alberta Transportation

Klohn Crippen Berger - Calgary



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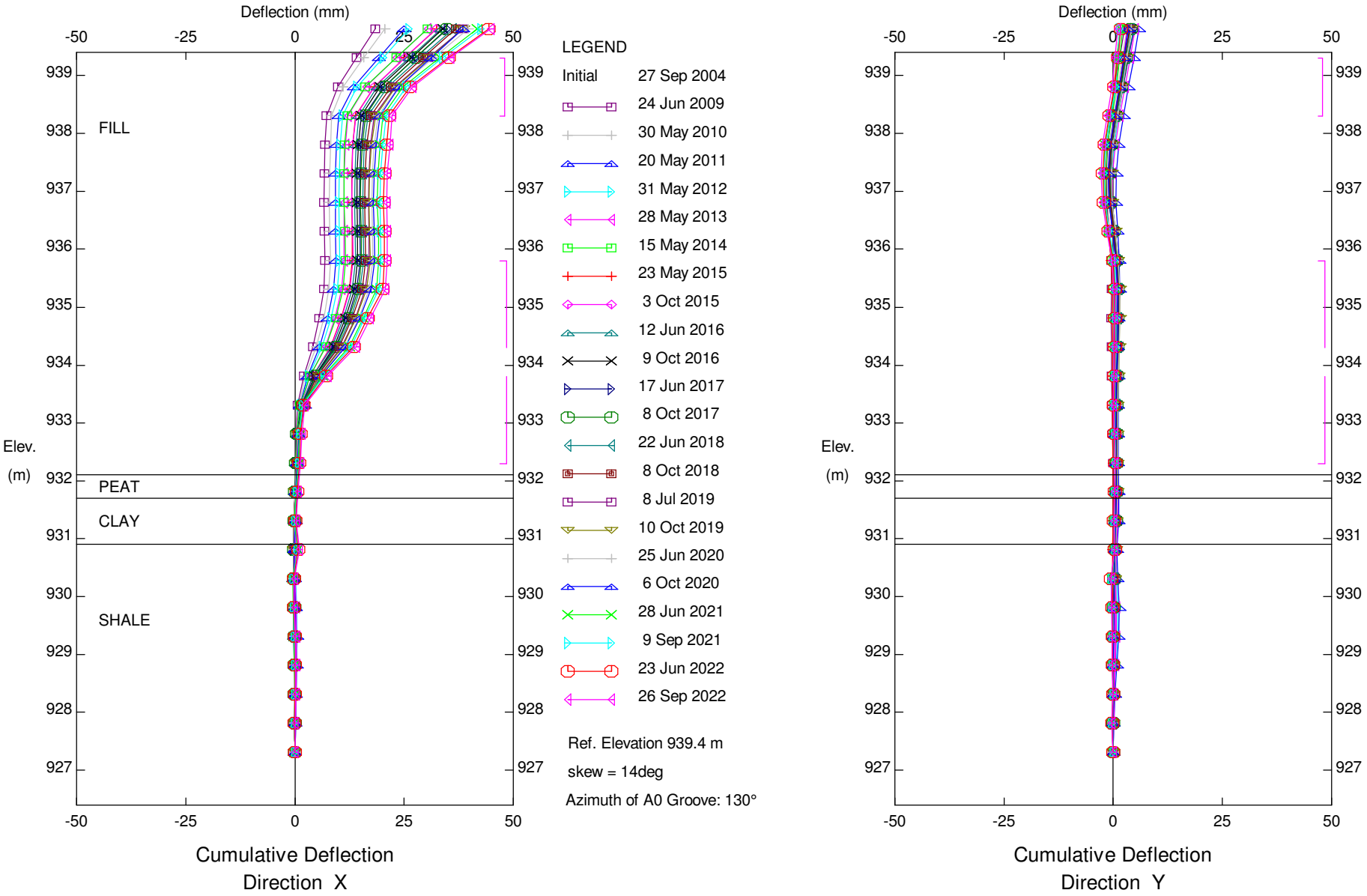

GP008; H40:36, Road Surface Slumping, Inclinometer SI-1

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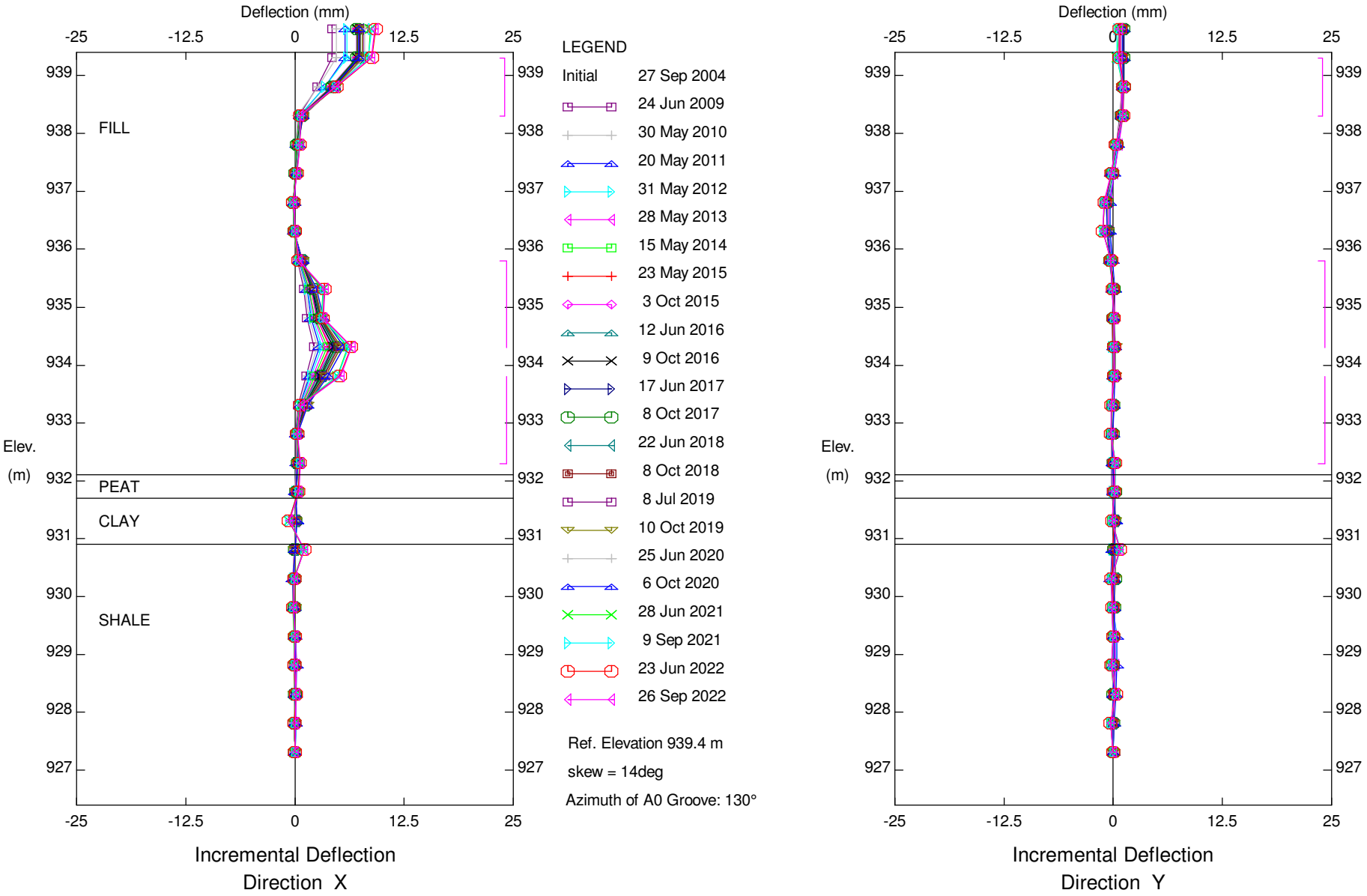
Klohn Crippen Berger - Calgary



GP008; H40:36, Road Surface Slumping, Inclinometer SI-1

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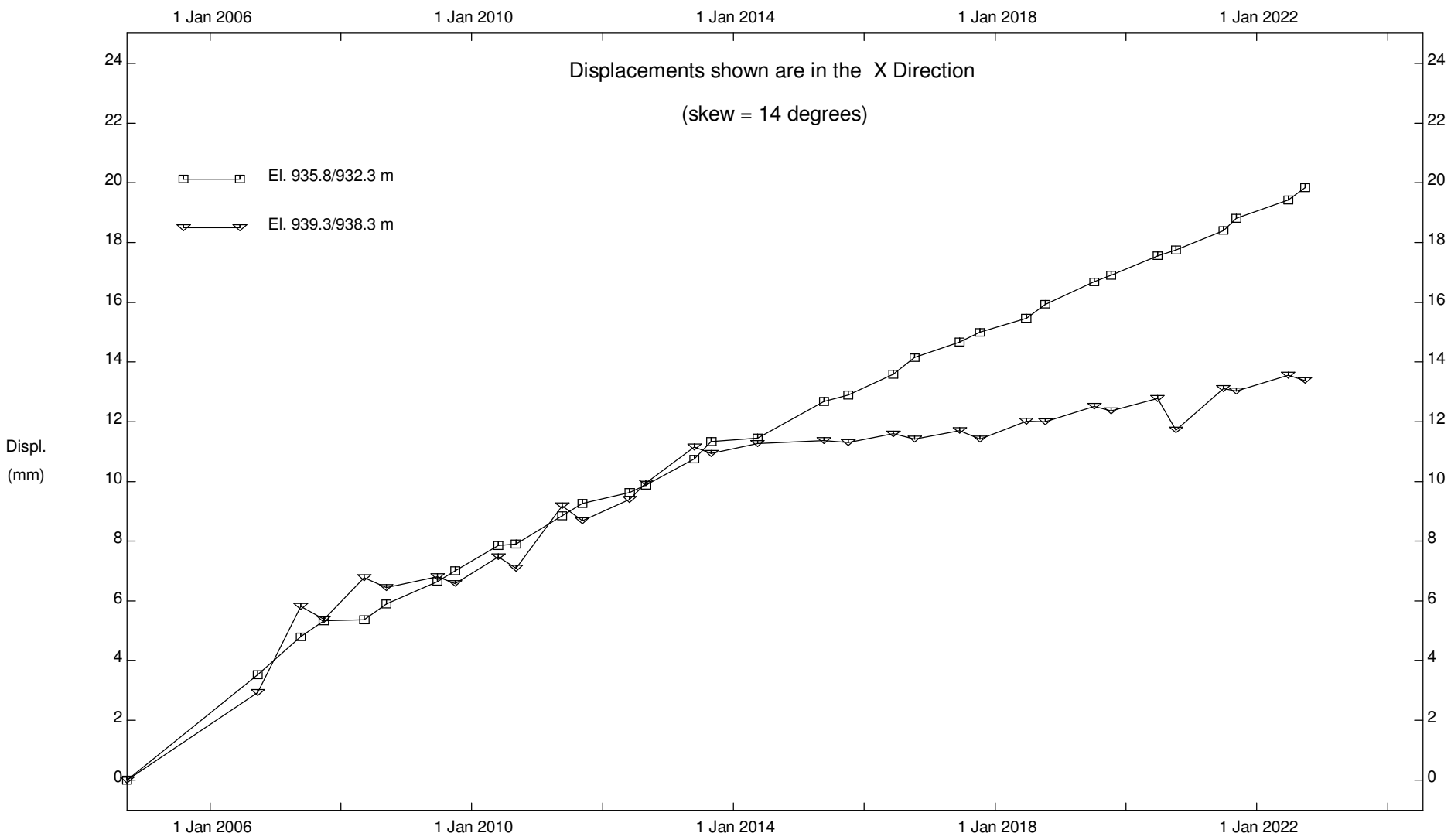

GP008; H40:36, Road Surface Slumping, Inclinometer SI-1

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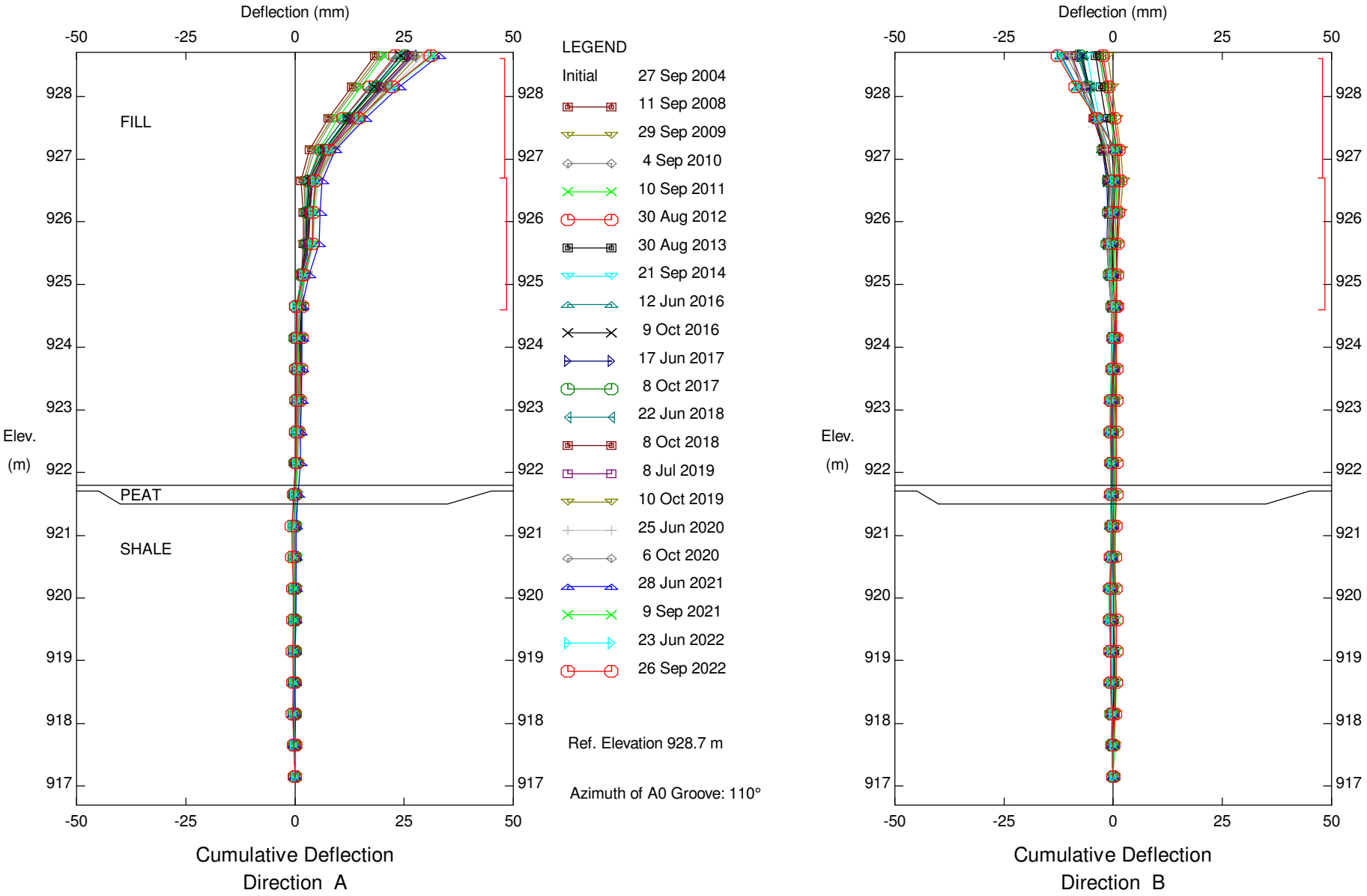

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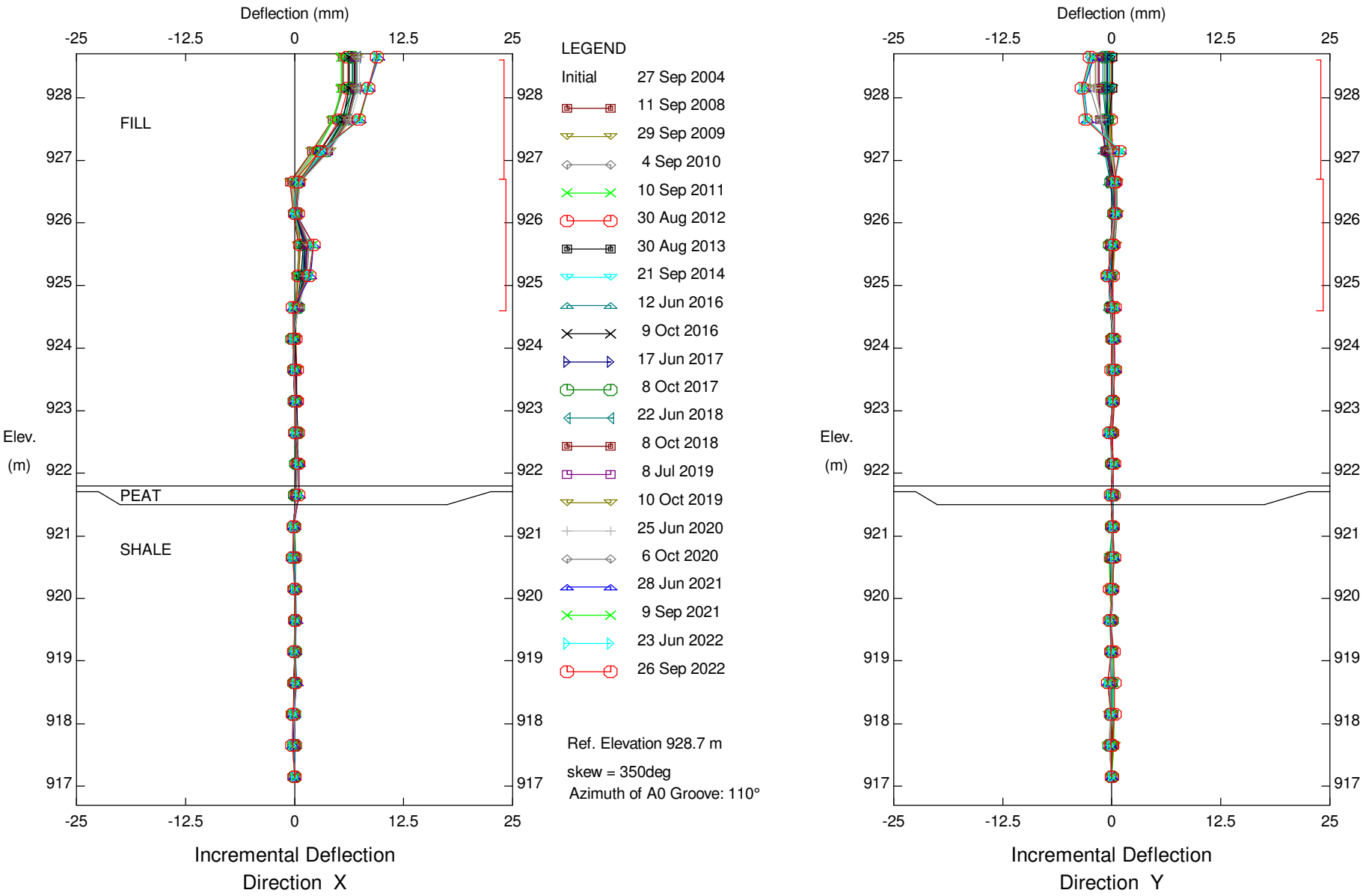

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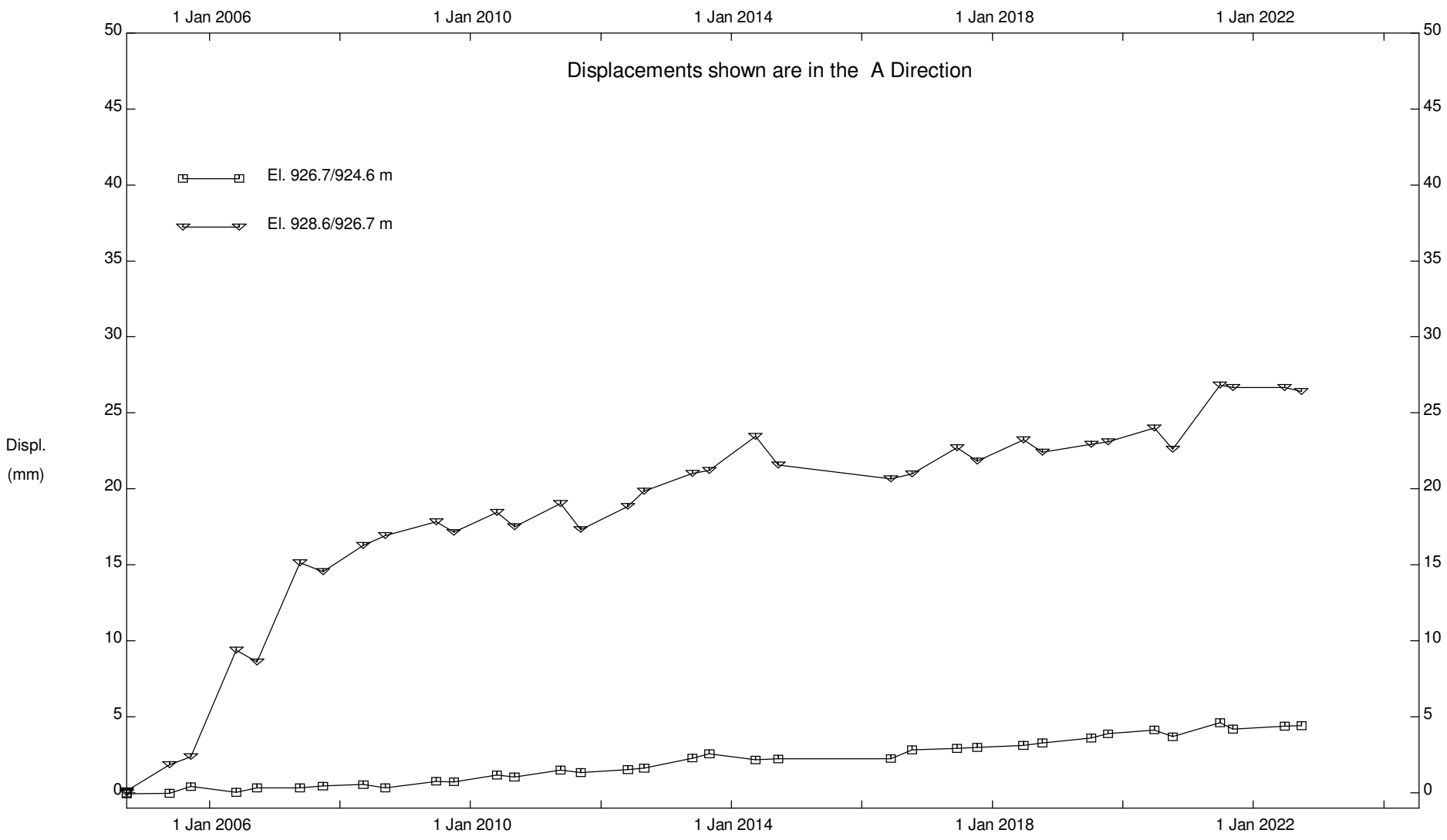

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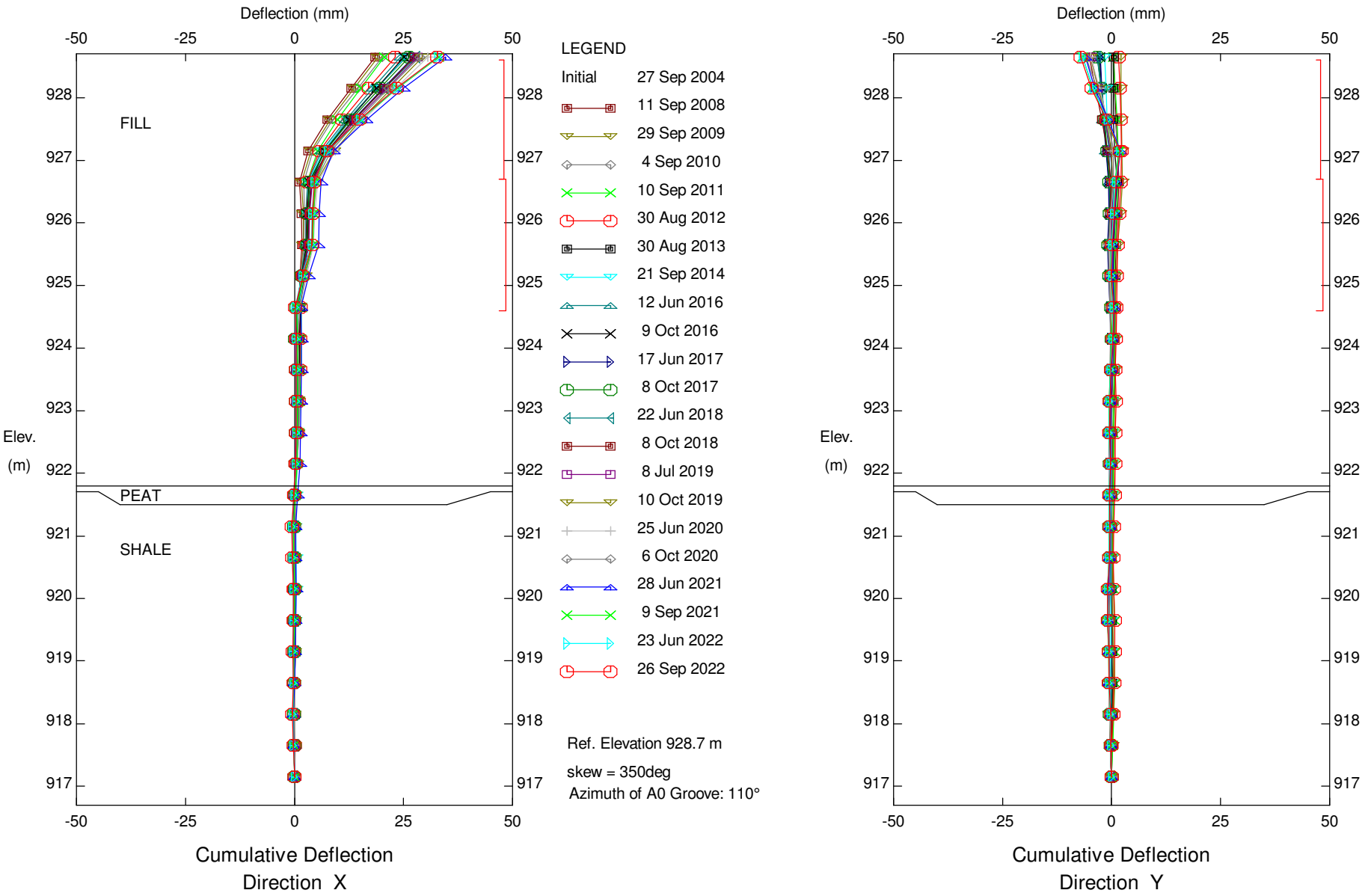

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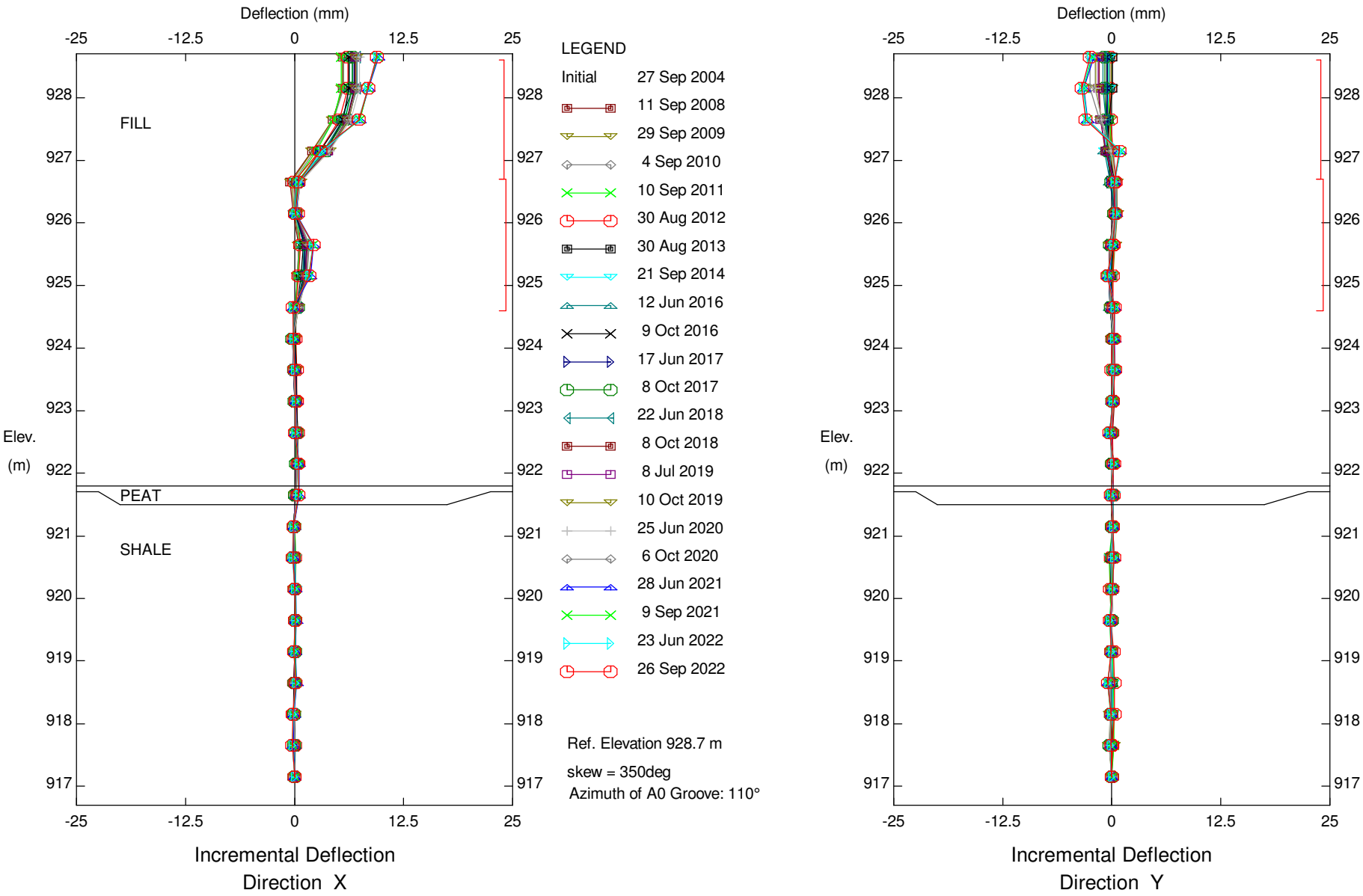

GP008; H40:36, Road Surface Slumping, Inclinometer SI-2

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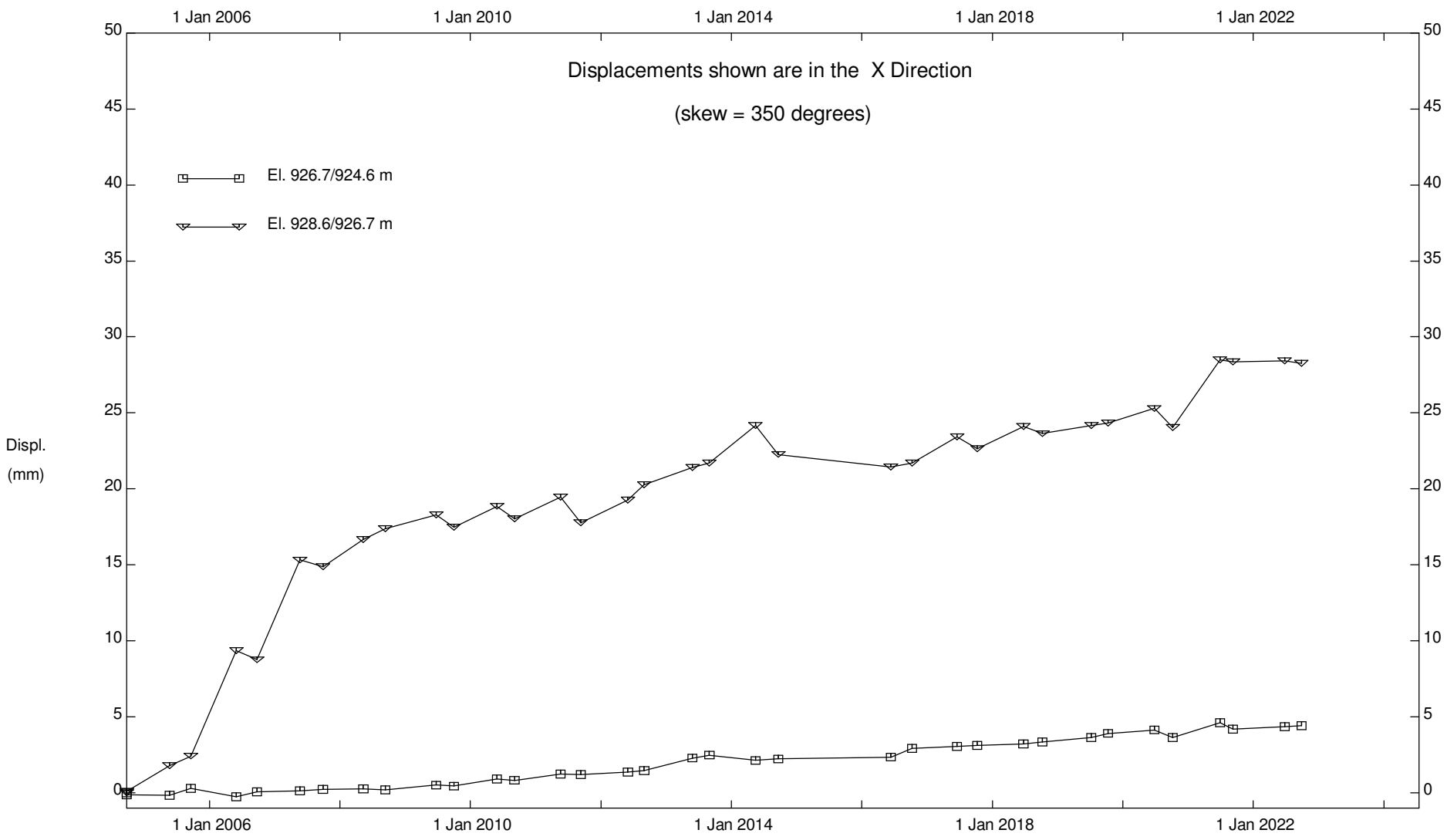

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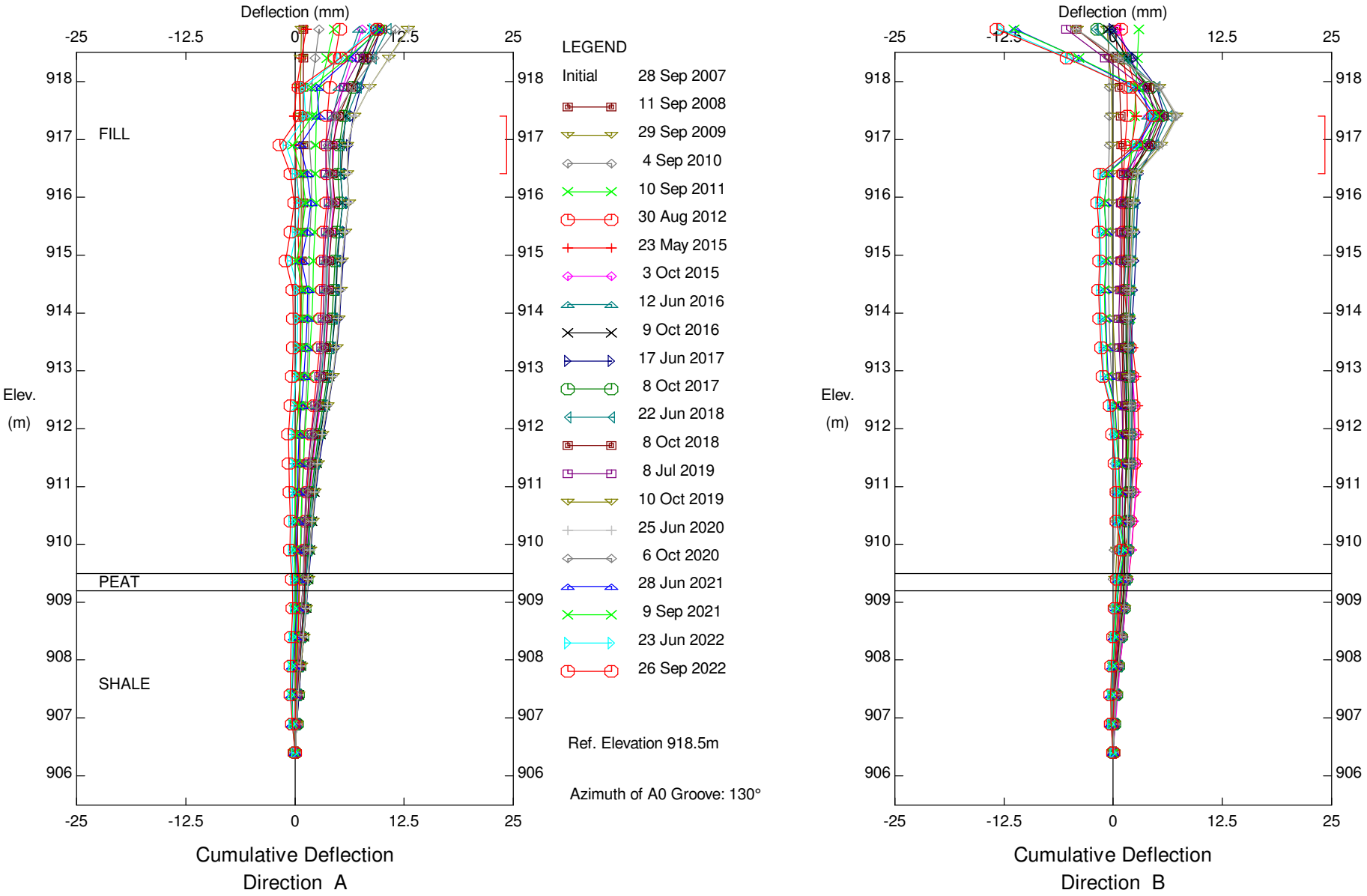

GP008; H40:36, Road Surface Slumping, Inclinometer SI-3

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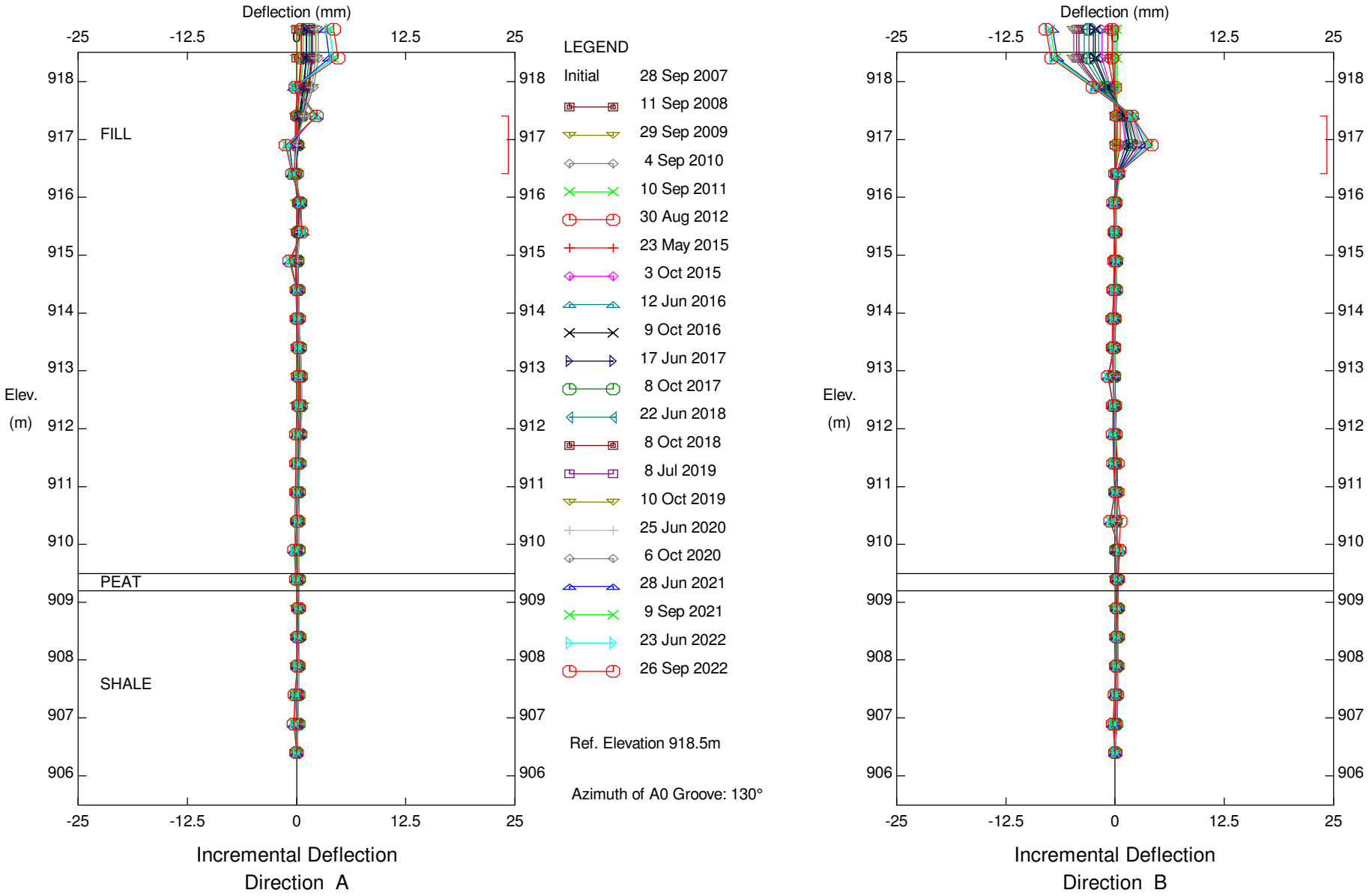

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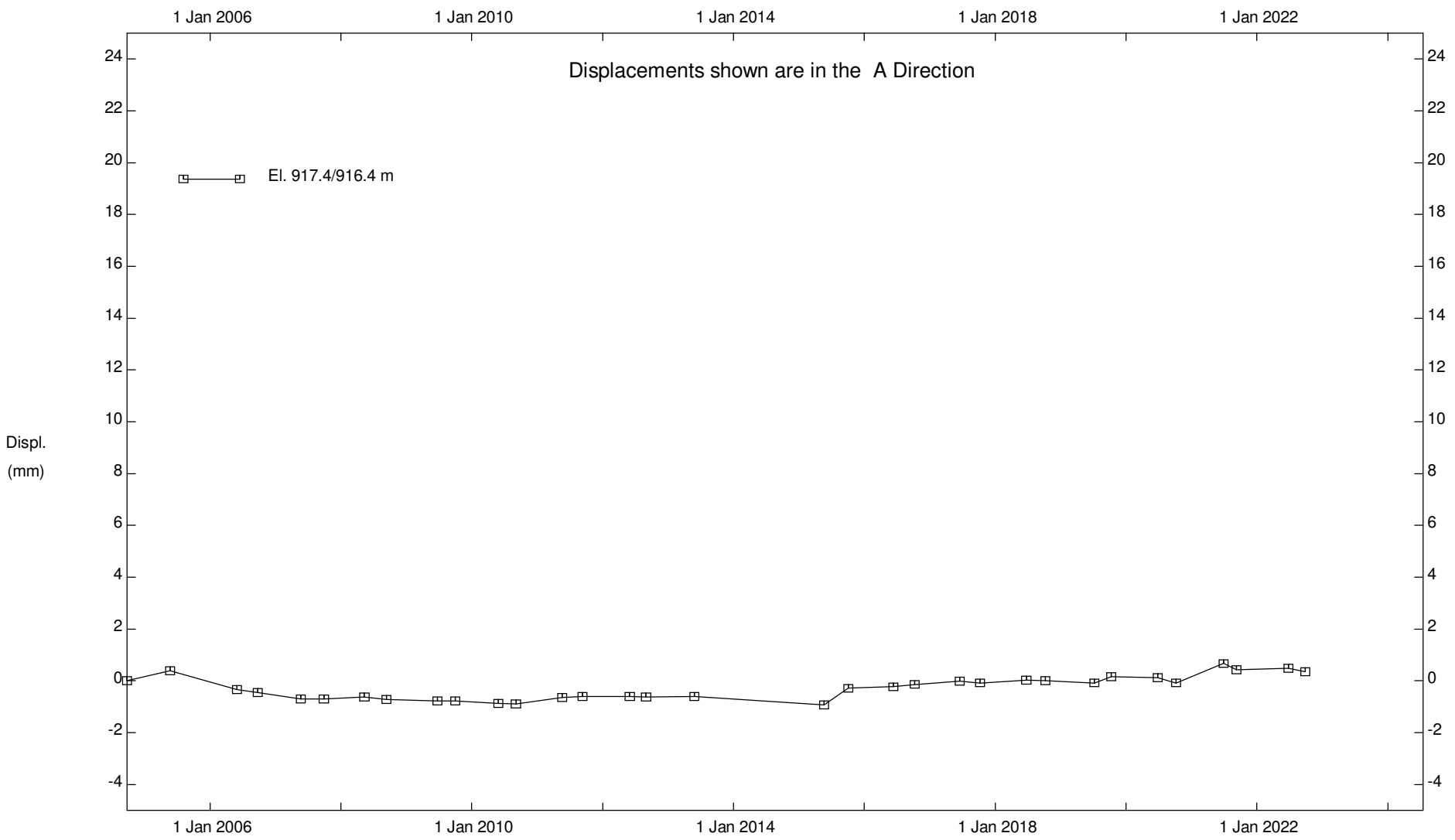

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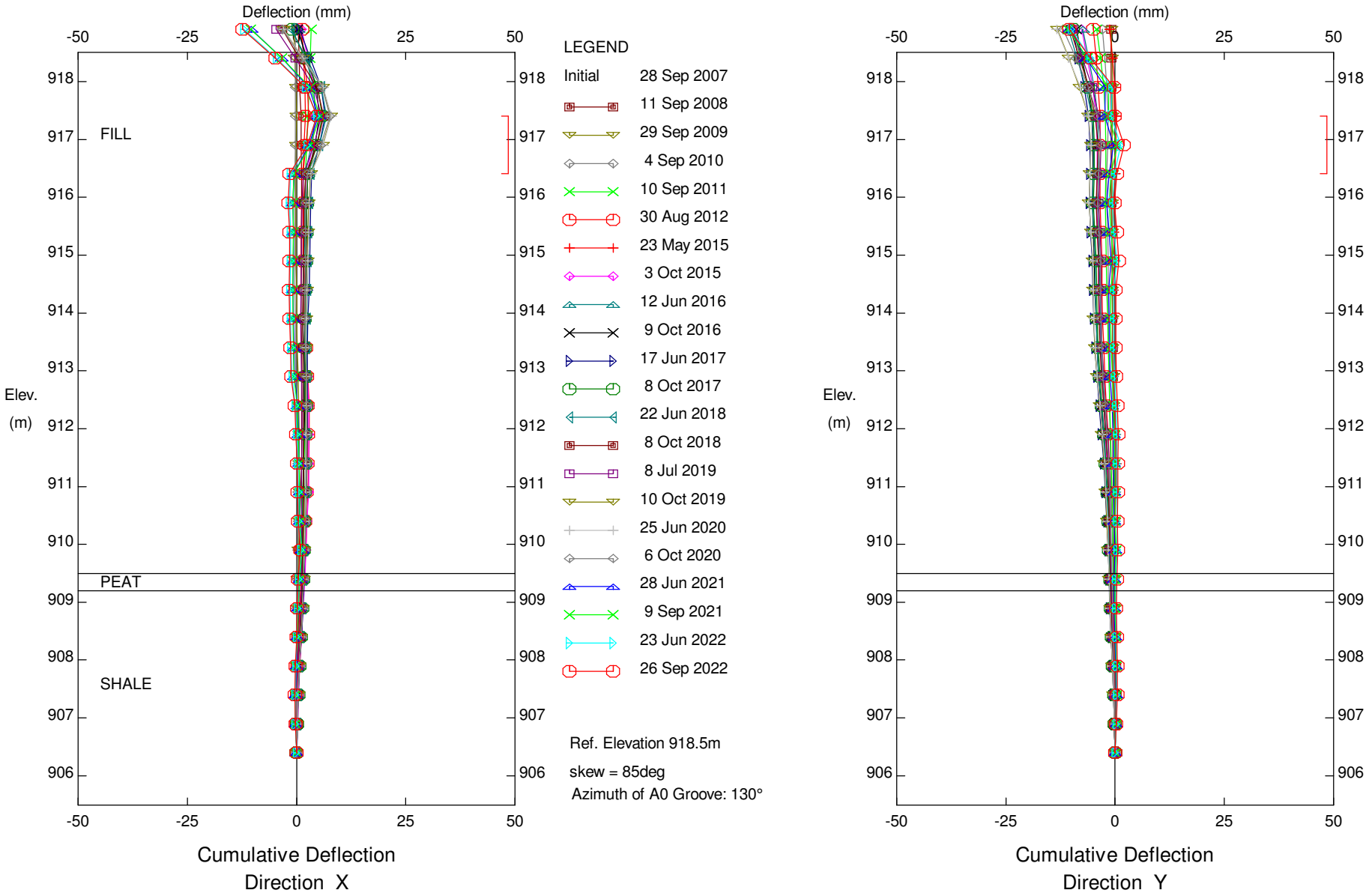

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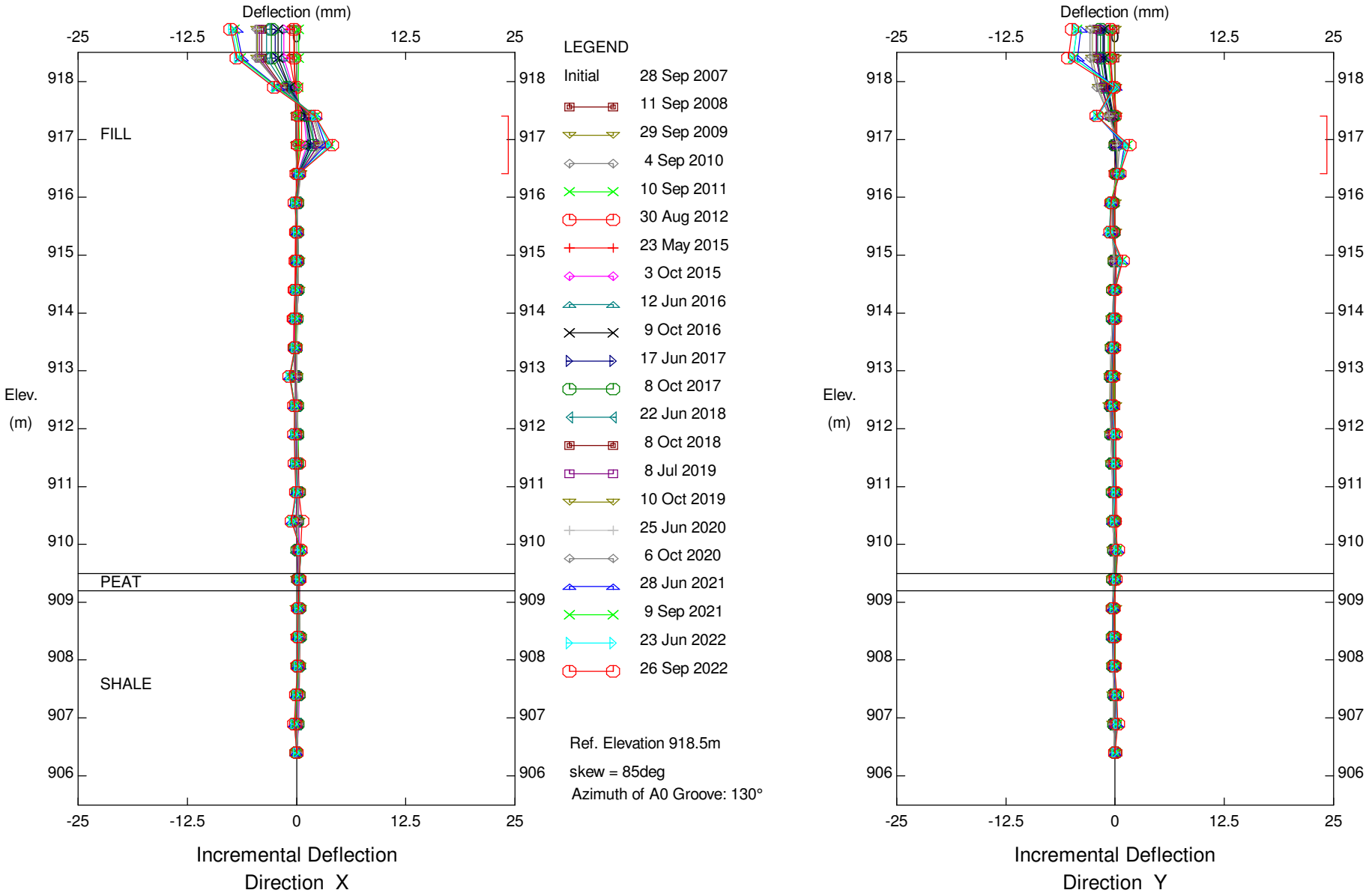

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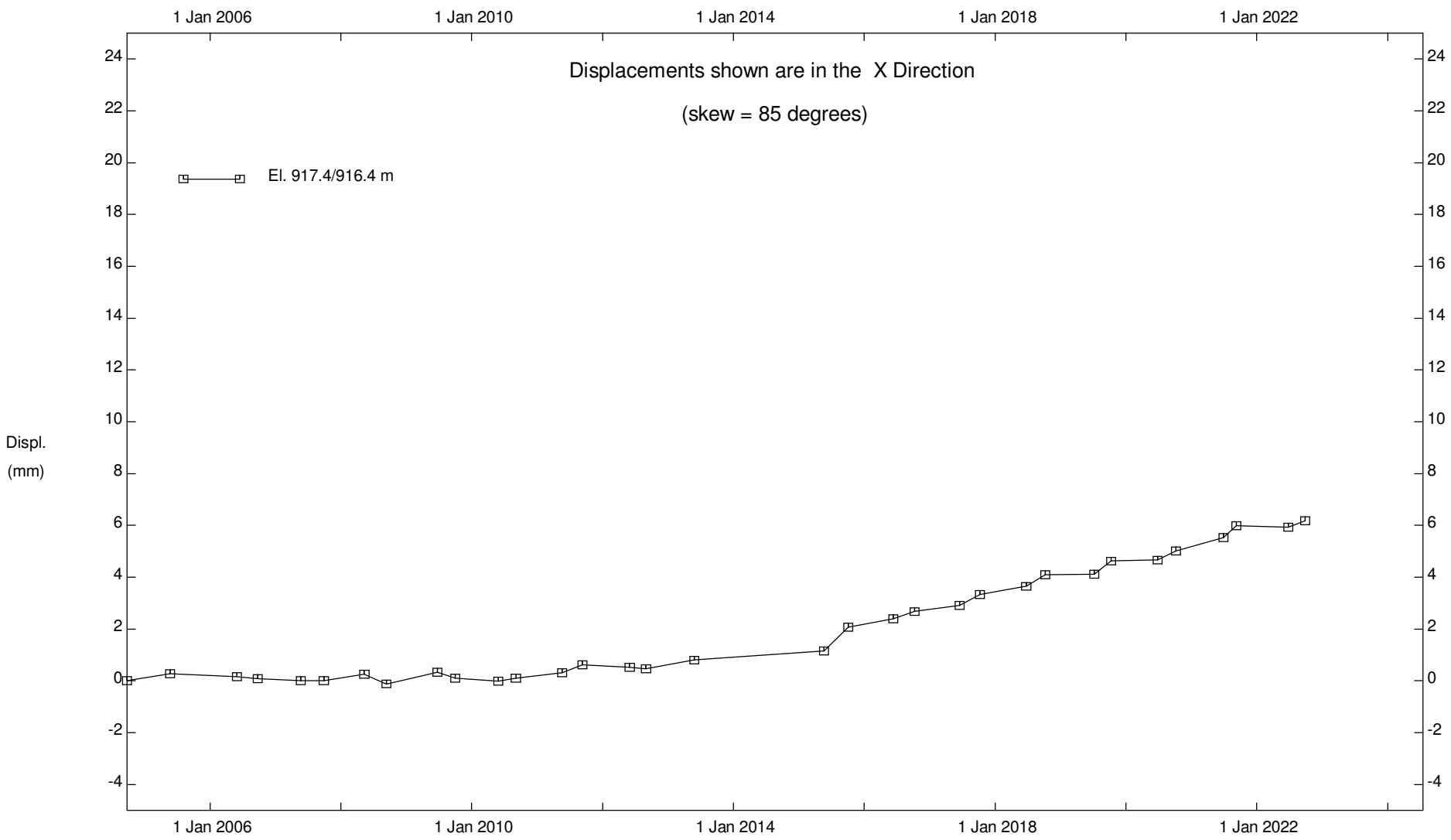

GP008; H40:36, Road Surface Slumping, Inclinometer SI-3

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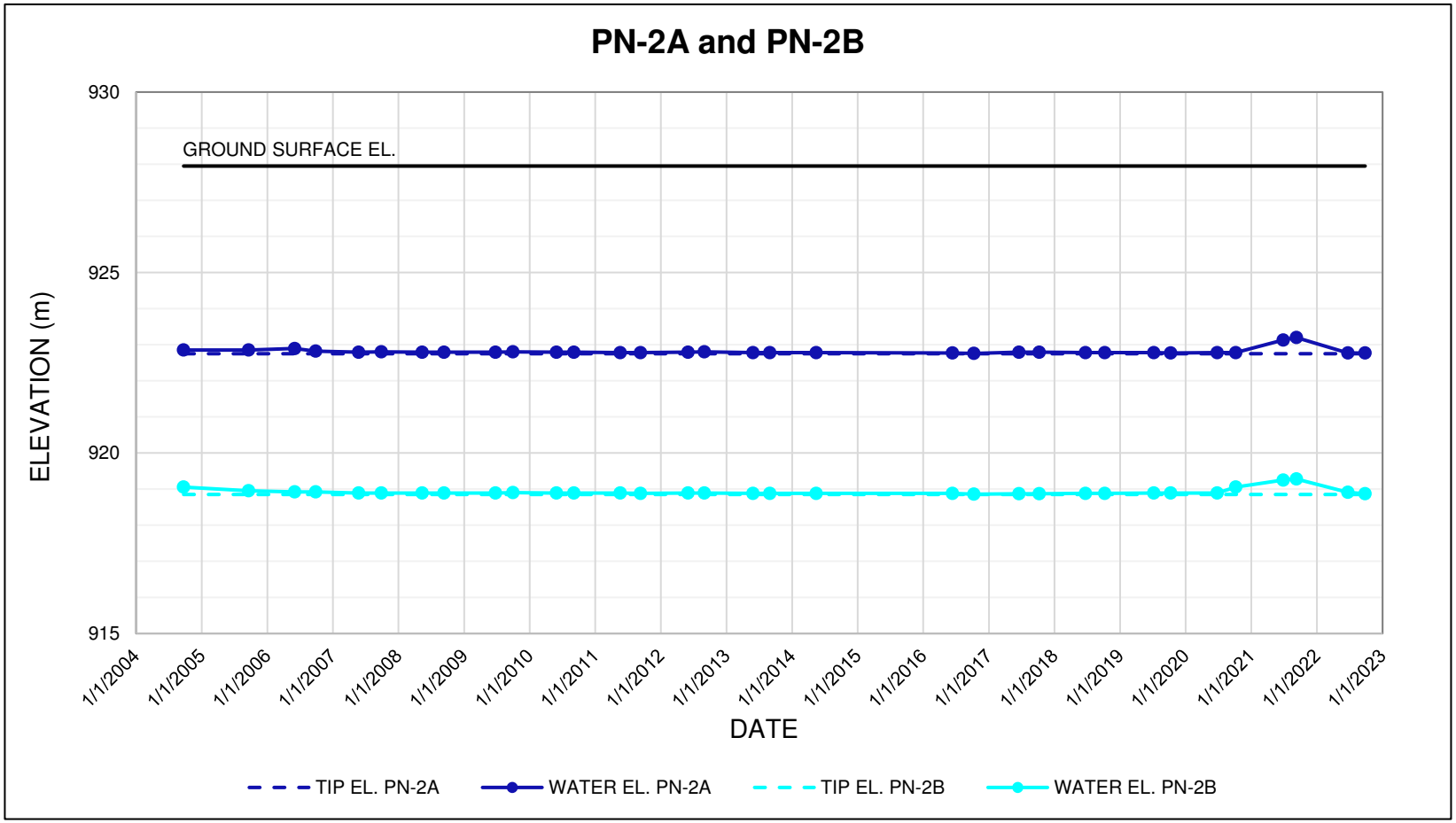

Notes:
1. Piezometer data obtained before the June 28, 2021 readings was provided to Klohn Crippen Berger Ltd. by Alberta Transportation on June 25, 2021.

CLIENT
Alberta
Klohn Crippen Berger

PROJECT
PEACE REGION (GRANDE PRAIRIE DISTRICT - SOUTH)
GEOHAZARD RISK MANAGEMENT PROGRAM

TITLE
Piezometer Data
GP008 - Road Surface Slumping (2.5 km North of McIntyre Mine)
Hwy 40:36, km 16.365

SCALE	PROJECT No.	FIG No.
AS SHOWN	A05116A01	