

November 29, 2022

Alberta Transportation  
4<sup>th</sup> Floor, Provincial Building  
4920 – 51<sup>st</sup> Street  
Red Deer, Alberta  
T4N 6K8

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

Dear Mr. Penney:

**CON0022160 Central Region GRMP Instrumentation Monitoring  
Site C048-I; H575:04, km 14.500 Slide West of Carbon Creek  
Section C – 2022 Fall Readings**

## **1 GENERAL**

Three slope inclinometers (SIs) (SI21-C48-01 through SI21-C48-03) were read at the C048 site in the Central Region on September 9, 2022 and October 7, 2022 by Ms. Katrina Cereno and Mr. Guerin White, E.I.T., respectively, 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 575:04, km 14.500, approximately 8 km northeast of Carbon, Alberta. The approximate site coordinates are 5707780 N, 358388 E (UTM Zone 12, NAD 83). A site plan is presented in Figure 1.

The C048 site consists of two active geohazard subsites, C048-I and C048-III, along an approximate 250 m length of Hwy 575:04. Another subsite C048-II site located to the west of C048-I and C048-III was repaired in 2012 and removed from the Central Region GRMP. The geohazard at each subsite includes a shallow slide in the highway embankment fill on either the south (C048-I and C048-III) or north (C048-II) slope of Hwy 575:04.

Previous remedial actions at the C048-I site include:

- July 2010: Installation of 52 soil nails installed in four rows.
- July 2014: Construction of a 12-m deep, 48-m long H-pile wall (JP310x93) consisting of 65 piles. A “retaining wall” was also constructed behind the H-pile wall by excavating to a depth of 2 m, placing filter cloth, installing 2”x10” pressure-treated residential deck boards as lagging behind the H-piles, and then backfilling behind the deck boards with granular fill. During the 2020 annual site inspection, the pile wall was reported to be outflanked to the east and west by slide movement.
- March 2021: The existing H-pile wall was extended approximately 41 m to the west and 17 m to the east (HP360X132). A 12-m deep, 66-m long H-pile wall (HP360x132) was also installed

downslope of the existing H-pile wall. Additional pressure-treated timber lagging was placed on the existing and extended portions of the upper H-pile wall.

In 2012, the C048-III site was repaired by removing the failed material and reconstructing the slide area with granular fill. No instrumentation is installed at this site, so this site will not be discussed further herein.

In late 2020, the C048-III site was repaired by removing the failed material and reconstructing the slide area with geogrid-reinforced granular fill and two perforated-drain pipes installed at the base of the excavation. No instrumentation is installed at this site, so this site will not be discussed further herein.

In March 2019, KCB conducted a geotechnical site investigation at the C048-I and C048-III sites. Drilling was completed in the eastbound lane by Mobile Augers and Research Ltd. The encountered stratigraphy was as follows: asphalt, overlying gravel fill, overlying clay fill, overlying clay till, overlying bedrock (sandstone and mudstone). The encountered stratigraphy was consistent with the stratigraphy encountered during a 2011 drilling investigation.

## 1.1 Instrumentation

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

In November 2011, KCB installed one SI (SI11-01) and one standpipe piezometer (SP) (SP11-01) at the C048-I site to monitor depth of movement and groundwater conditions, respectively. The instruments were installed in boreholes located on the south shoulder (eastbound lane) of Hwy 575:04 and are now inoperable.

On March 25, 2021, three SIs (SI21-C48-01 through SI21-C48 -03) were installed in the H-pile walls at the C048-I site to monitor deflection of the H-pile walls. SI21-C48-01 is located approximately 20 m from the west end of the upper H-pile wall. SI21-C48-02 and SI21-C48-03 are located approximately one-third (22 m) from either end of the lower H-pile wall. Each SI was installed in the H-pile wall, in a rectangular opening created by tack-welding an L-shaped bracket (L102X102X6.4) to the web and flange of an H-pile. The space between the SI casing and rectangular opening was backfilled with fine-grained sand.

The SIs are protected by above-ground casing protectors.

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 <sup>1</sup> (m)		Ground Surface Elevation (m)	Stick Up (m)	Depth (mbgs <sup>2</sup> )	Condition
			Northing	Easting				
SI11-01	SI	Nov. 22, 2011	5707782	358492	825	Unknown	20.5	Inoperable
SI21-C48-01	SI	Mar. 25, 2021	5707781	358444	Unknown	0.5	11.3	Operable
SI21-C48-02	SI	Mar. 25, 2021	5707773	358468	Unknown	0.8	11.0	Operable
SI21-C48-03	SI	Mar. 25, 2021	5707771	358491	Unknown	0.5	11.3	Operable
SP11-01	SP	Nov. 22, 2011	5707782	358492	Unknown	Unknown	13.0	Inoperable

**Notes:**

<sup>1</sup> Coordinates were obtained by KCB with a handheld GPS during installation with a horizontal accuracy of ± 5 m.

<sup>2</sup> Meters below ground surface (mbgs).

## 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 perpendicular to the highway in the direction of anticipated maximum movement (i.e., in the downslope direction).

The SI data plots are included in Appendix I and a summary of the SI data is provided in Table 2.1.

### 2.2 Zones of Movement

Before the instrument became inoperable, movement was being recorded in SI11-01 at an approximate depth of 2 m below ground surface in the highway embankment fill.

The lowest depth of movement being recorded in SI21-C48-01 (upper H-pile wall) is approximately 10 m below ground surface. The lowest depth of movement being recorded in SI21-C48-02 and SI21-C48-03 (lower H-pile wall) is approximately 8.5 m below ground surface. The H-pile walls are 12 m deep, and the SIs are approximately 11.0 m to 11.3 m deep.

### 2.3 Interpretation of Monitoring Results

Based on the stratigraphy encountered during the 2011 and 2019 drilling investigations, and the blows counted during H-pile wall construction in 2021, the upper and lower H-pile walls are likely driven into firm clay fill and/or hard clay till, respectively. Discussions in the spring of 2021 with a former resident of the Town of Drumheller familiar with local engineering work revealed that the highway embankment was constructed using end-dumped fill with little compaction.

The depth of movement being recorded in the pile-wall SIs appears to be occurring approximately 2 m above the base of the H-pile walls. This indicates that the H-pile walls have intercepted the failure surface and are continuing to deflect, transferring load to depths below the failure plane as the piles stabilize the slide mass.

**Table 2.1 Slope Inclinometer Reading Summary**

Instrument ID	Location	Date				Ground Surface Elevation (m)	Depth of Movement (mbgs <sup>1</sup> )	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-C48-01	Upper H-Pile Wall	Apr. 21, 2021	Sep. 17, 2021	Jun. 25, 2022	Sep. 09, 2022	Unknown	0.0 – 11.3	A-Direction	19.0	2.0	31.1	13.3	5.1
SI21-C48-02	Lower H-Pile Wall	Apr. 21, 2021	Sep. 17, 2021	Jun. 25, 2022	Sep. 09, 2022	Unknown	0.0 – 11.0	A-Direction	24.6	4.5	27.8	21.8	8.7
SI21-C48-03	Lower H-Pile Wall	Apr. 21, 2021	Sep. 17, 2021	Jun. 25, 2022	Oct. 07, 2022	Unknown	0.0 – 9.3	A-Direction	36.6	8.3	59.1	29.1	19.4

**Note:**

<sup>1</sup> Meters below ground surface (mbgs).

The September 2022 data obtained from the pile-wall SIs indicates that the tops of the upper and lower H-pile walls have deflected up to approximately 19 mm and 37 mm, respectively, since installation. In the spring of 2021, shortly after construction of the H-pile walls, the maximum rate of movement recorded in these SIs was between 28 mm/year and 59 mm/year. The rate of movement has since decreased and is now less than 30 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.

Between June and September 2022, an increased rate of movement (between approximately 13 mm/year and 29 mm/year) was recorded in the pile-wall SIs likely in response to wet weather in June and July 2022. The previous year and the spring of 2022 were relatively dry. More data is needed to assess long-term trends for the pile-wall SIs installed in 2021. Increased movement or additional displacements of the H-pile walls may occur in response to heavy or prolonged rainfall or freshet infiltration, resulting in higher groundwater conditions.

Distributed movement (i.e., from top to bottom of casing) up to approximately 12 mm has also recorded in the B-direction of the SIs. It is unknown if this movement is due to post installation SI casing flexure, shifting in the steel pocket the SIs are installed in, or flexure/twist of the H-piles that is occurring due to the H-pile wall picking up load and stabilizing the sliding mass. The rate of movement being recorded in the B-direction (between approximately 10 mm/year and 20 mm/year) is slower than the rate of movement being recorded in the A-direction (between approximately 10 mm/year and 30 mm/year).

### **3 RECOMMENDATIONS**

#### **3.1 Future Work**

All operable instruments should continue to be read twice per year (spring and fall) until movements attenuate, and the rate of pavement cracking and deformation decreases.

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.

The length of Hwy 575:04 that crosses the C048-I site is scheduled for a pavement overlay and some approach and intersection work. AT should allow for inclusion of a drainage trench in the north ditch to attempt to divert groundwater from seeping into the highway embankment with the goal of slowing down movements being recorded in the SIs.

#### **3.2 Instrument Repairs and Maintenance**

No instrument repairs are required.

An above-ground casing protector was installed during the fall 2022 readings to protect SI21-C48-01.

Periodic MCI site visits should continue to assess if voids are still opening between the web and flanges of the H-piles. Additional sand backfill should be placed in any surface voids that develop.

## 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 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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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.**



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

James Lyons, P.Eng.  
Civil Engineer

JL:bb

**ATTACHMENTS**

Figure  
Appendix I      Instrumentation Plots

## FIGURE

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**Legend**

- ▣ Slope Inclinometer    ✕—✕ Fence    ▄▄▄▄▄ Top of Slope    ▄▄▄▄ Scarp
- ~~~~~ Crack    ▄—▄ H-Pile Wall    → Flow Direction
- Power Pole    ■—■ Guardrail    ▄▄▄▄ Toe Roll

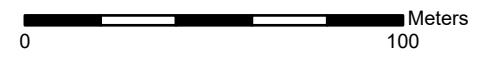
**NOTES:**  
 1. HORIZONTAL DATUM: NAD83  
 2. GRID ZONE: UTM Zone 12N  
 3. IMAGE SOURCE: World Imagery, ESRI ArcGIS Online  
 Source date July 2020  
 4. Instrument locations are approximate (not surveyed).  
 5. Strikethrough indicates the instrument is inoperable.

CLIENT

*Alberta*

**Klohn Crippen Berger**

PROJECT CENTRAL REGION GEOHAZARD RISK MANAGEMENT PROGRAM		
TITLE Site Plan C048 - I and -III Slides Hwy 575:04, km 14.5		
SCALE 1:2,000	PROJECT No. A05116A02	FIG No. 1

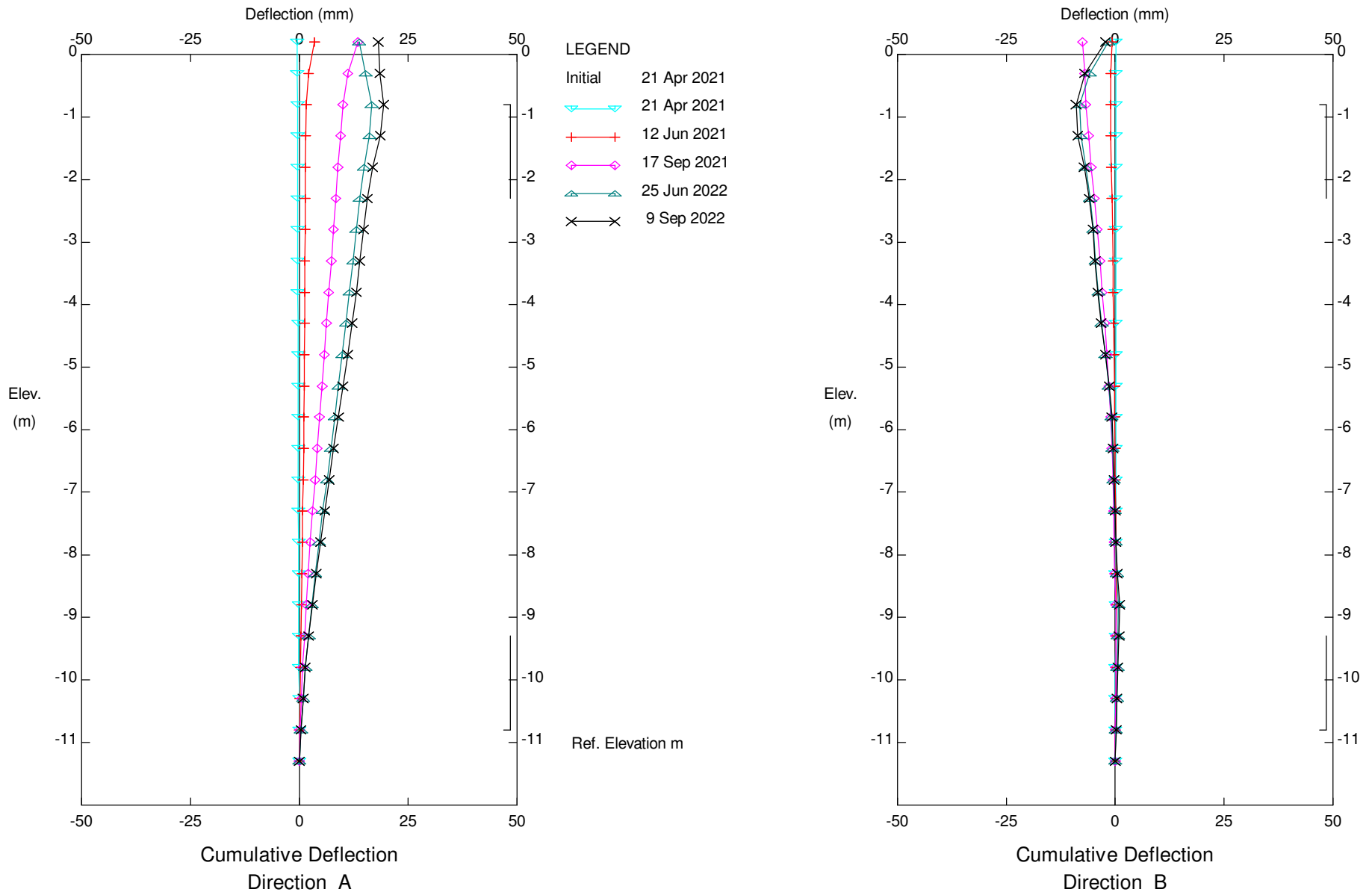


# APPENDIX I

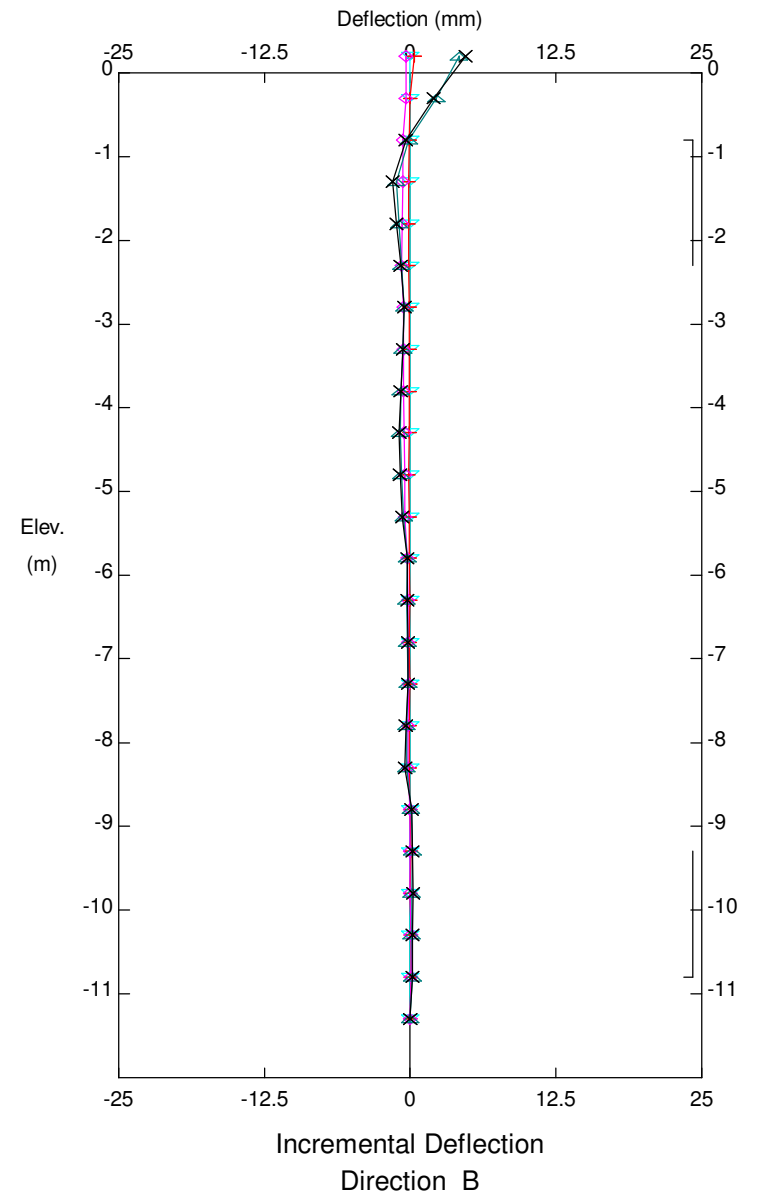
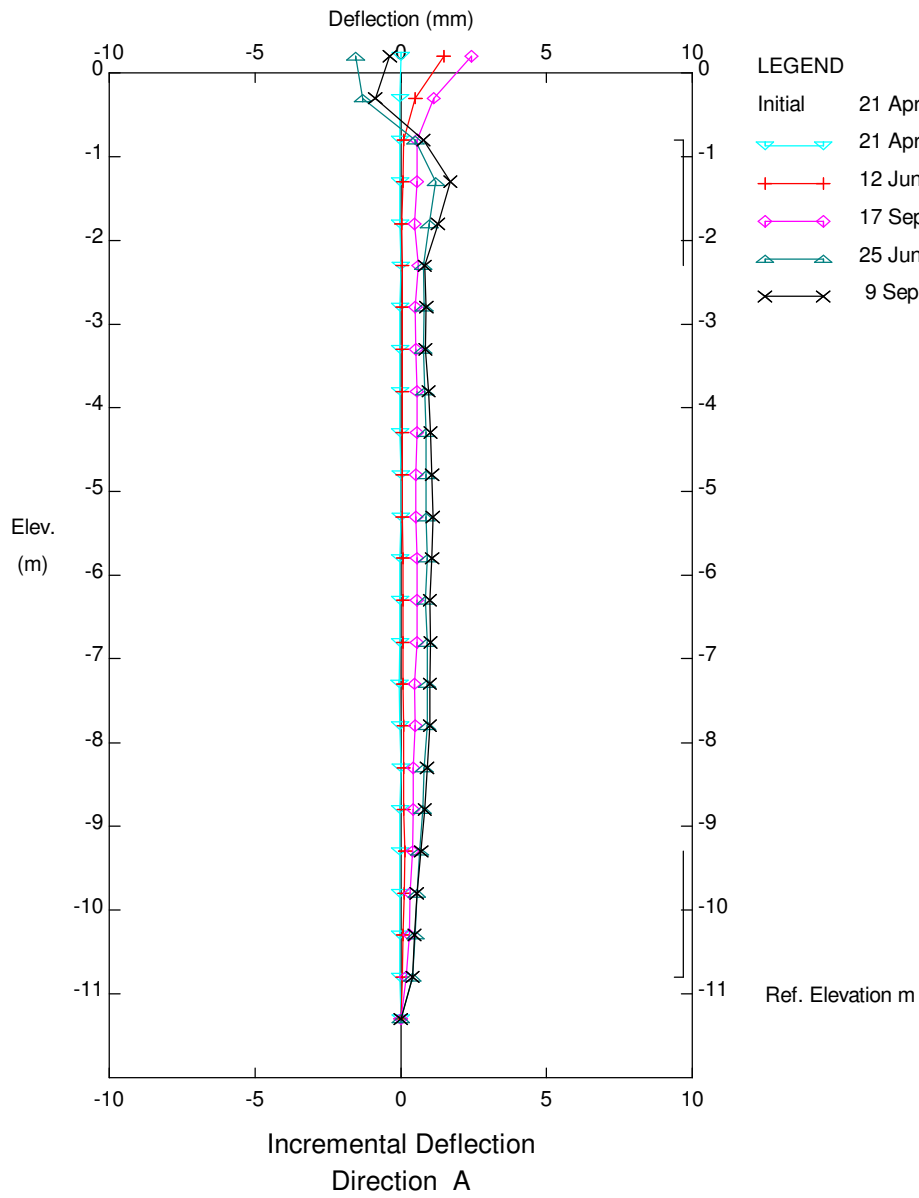
## Instrumentation Plots

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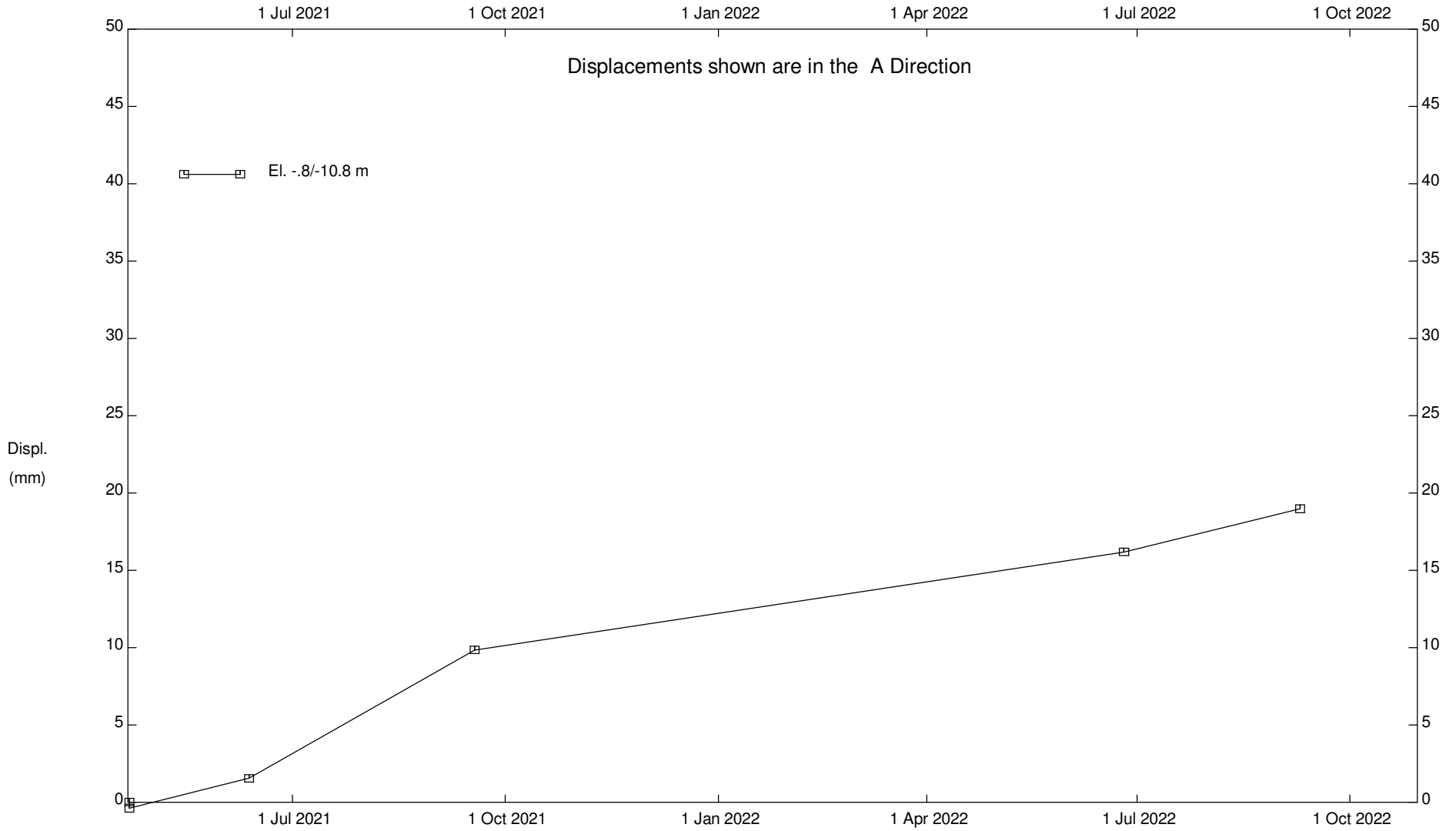
# Klohn Crippen Berger - Calgary



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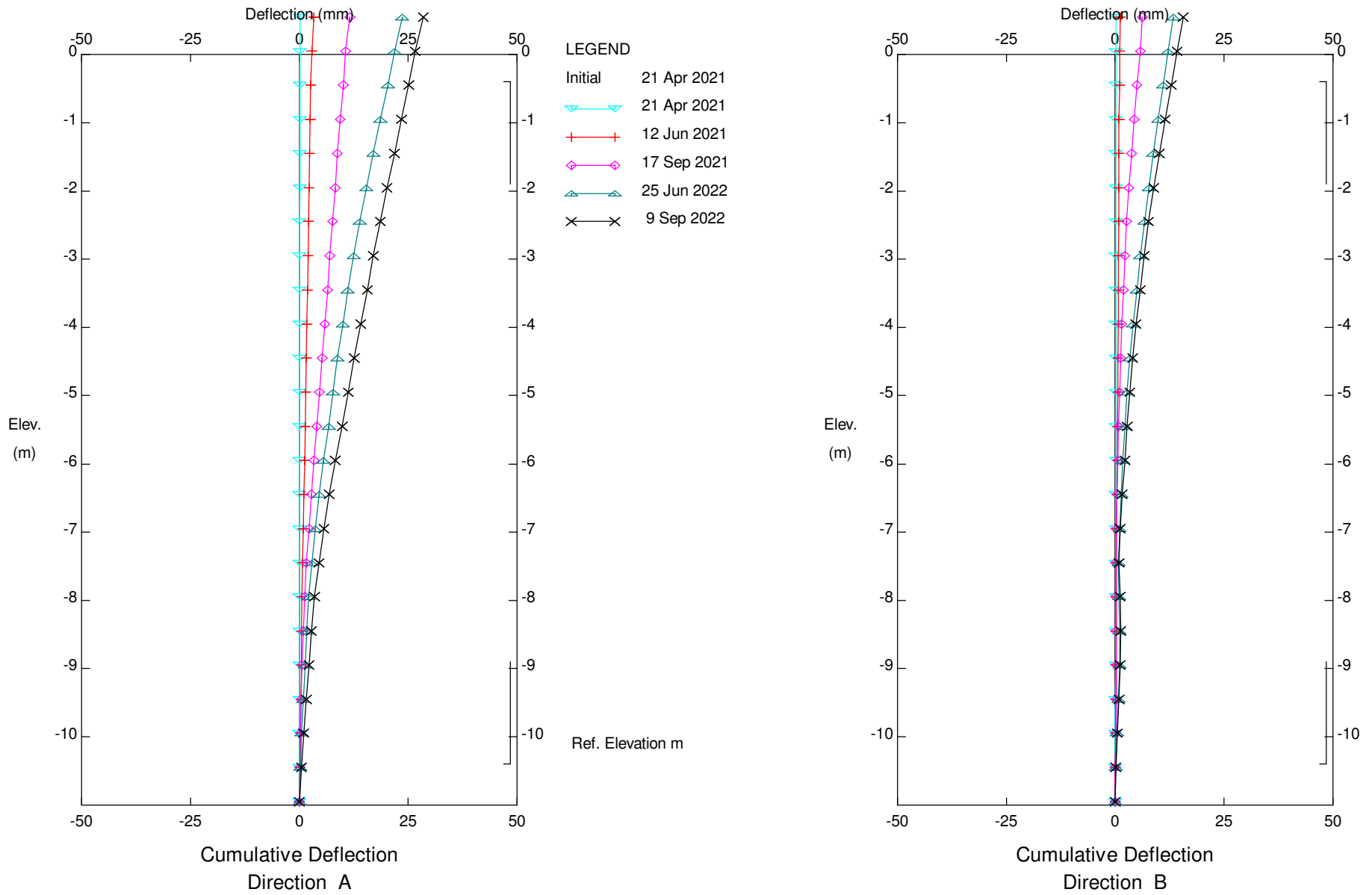
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C048; H575:04; Slide W of Carbon Creek, Inclinator SI21-C48-01

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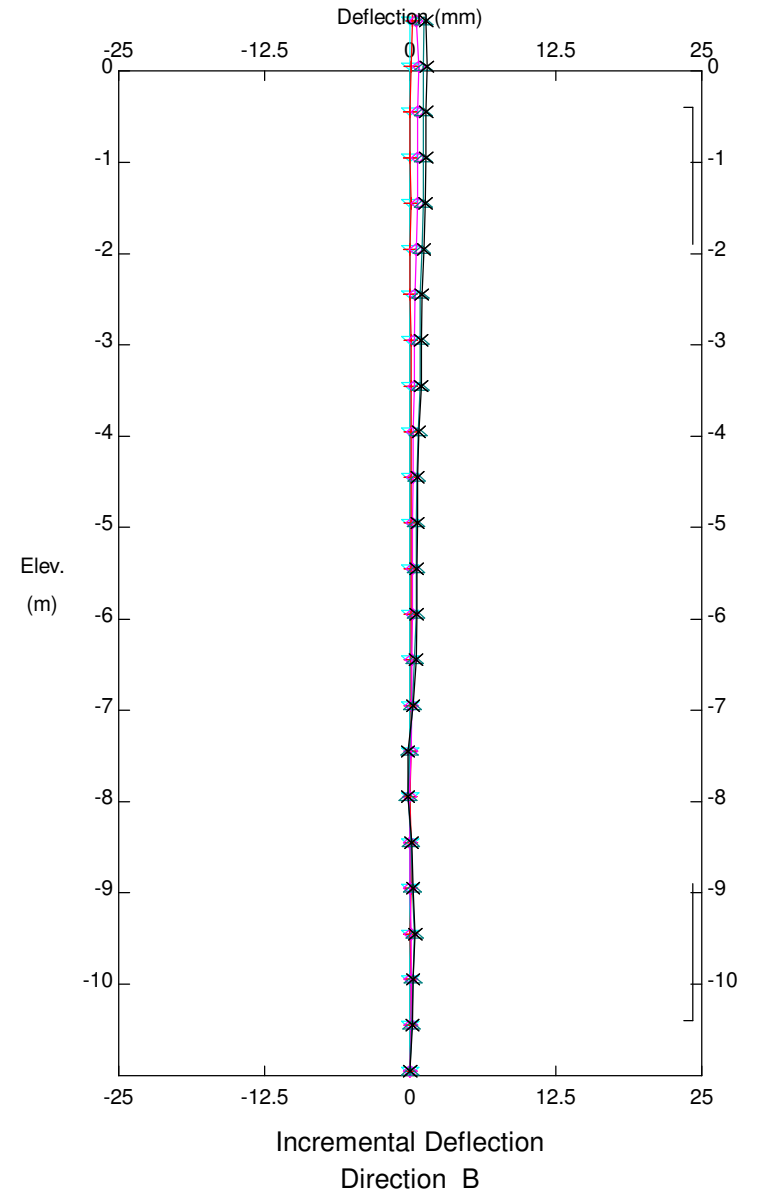
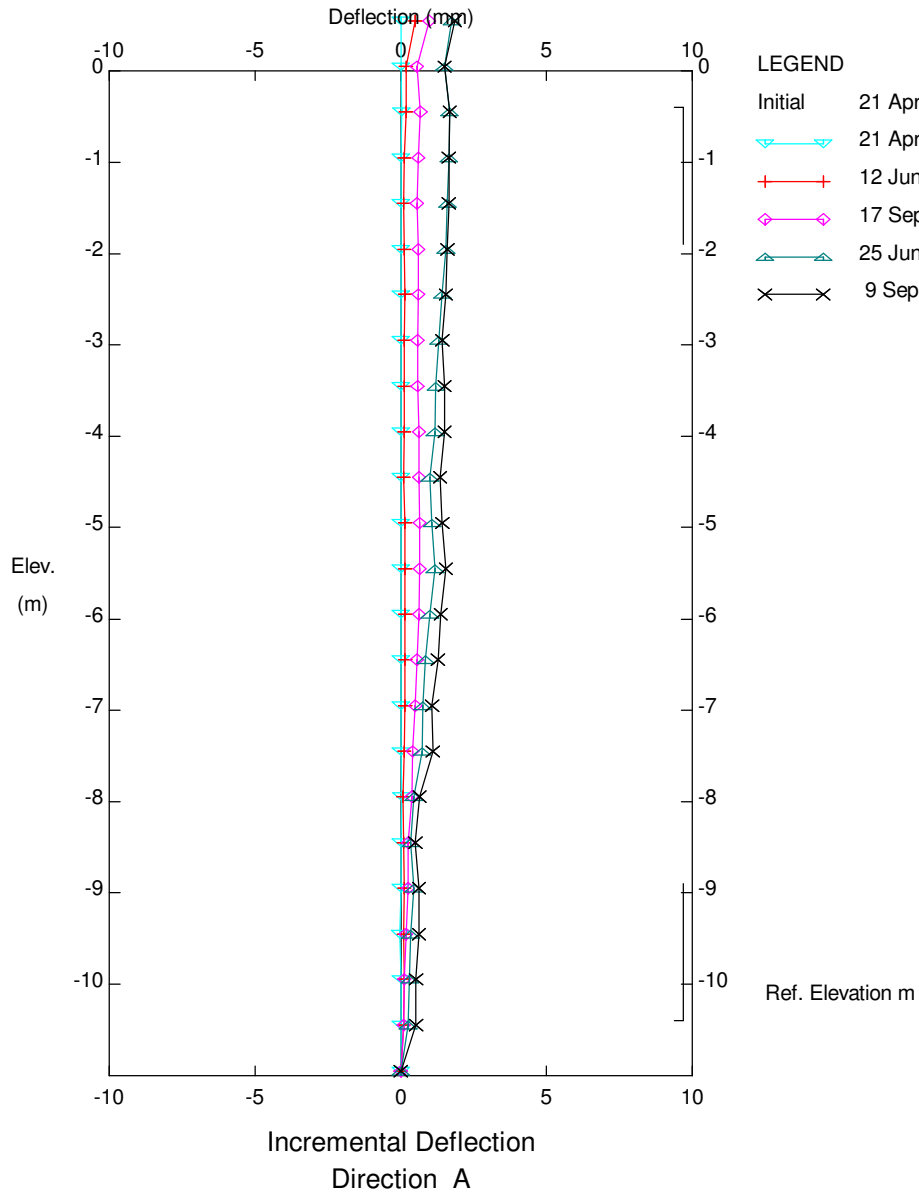
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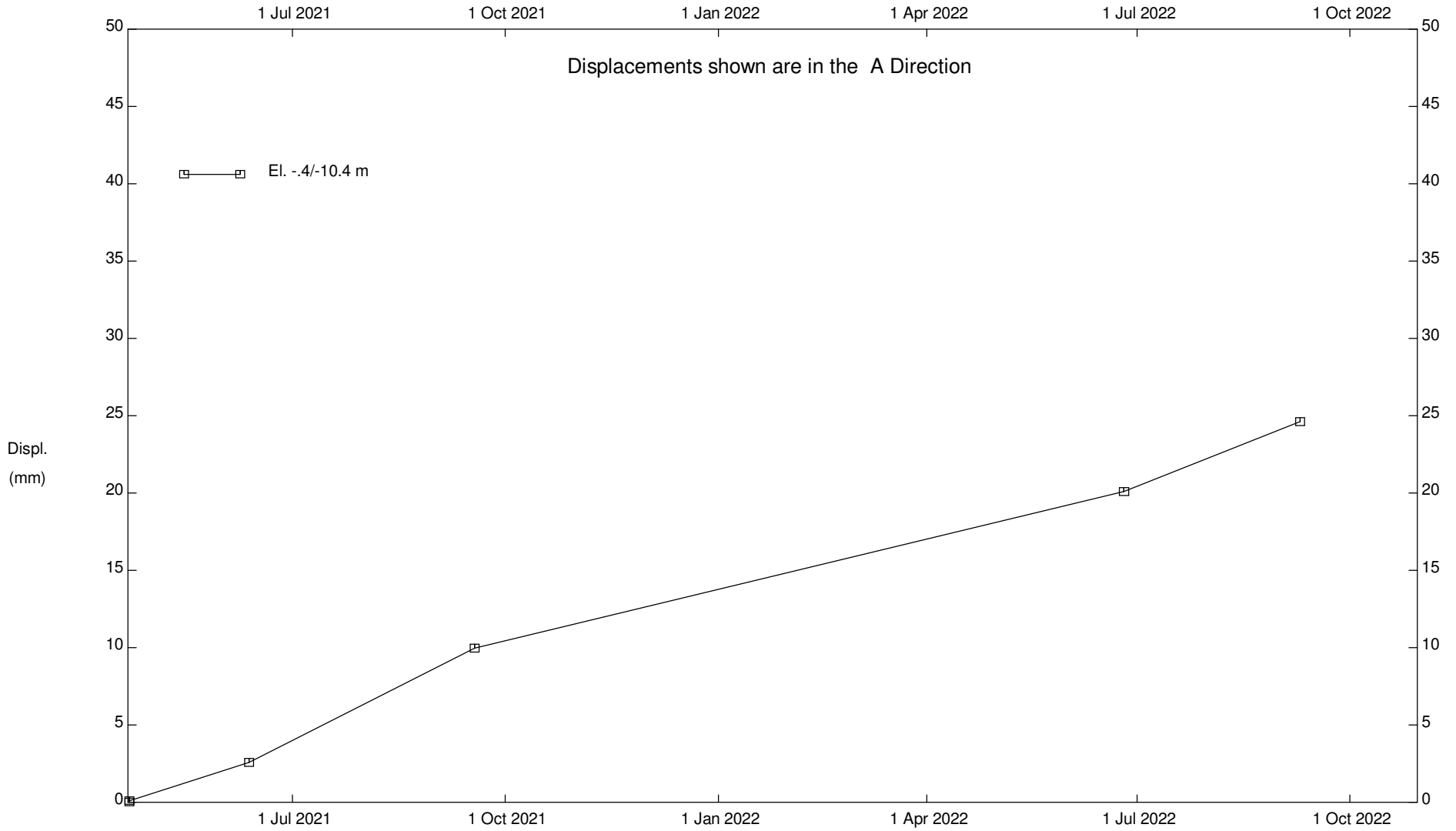
C048; H575:04; Slide W of Carbon Creek, Inclinometer SI21-C48-02

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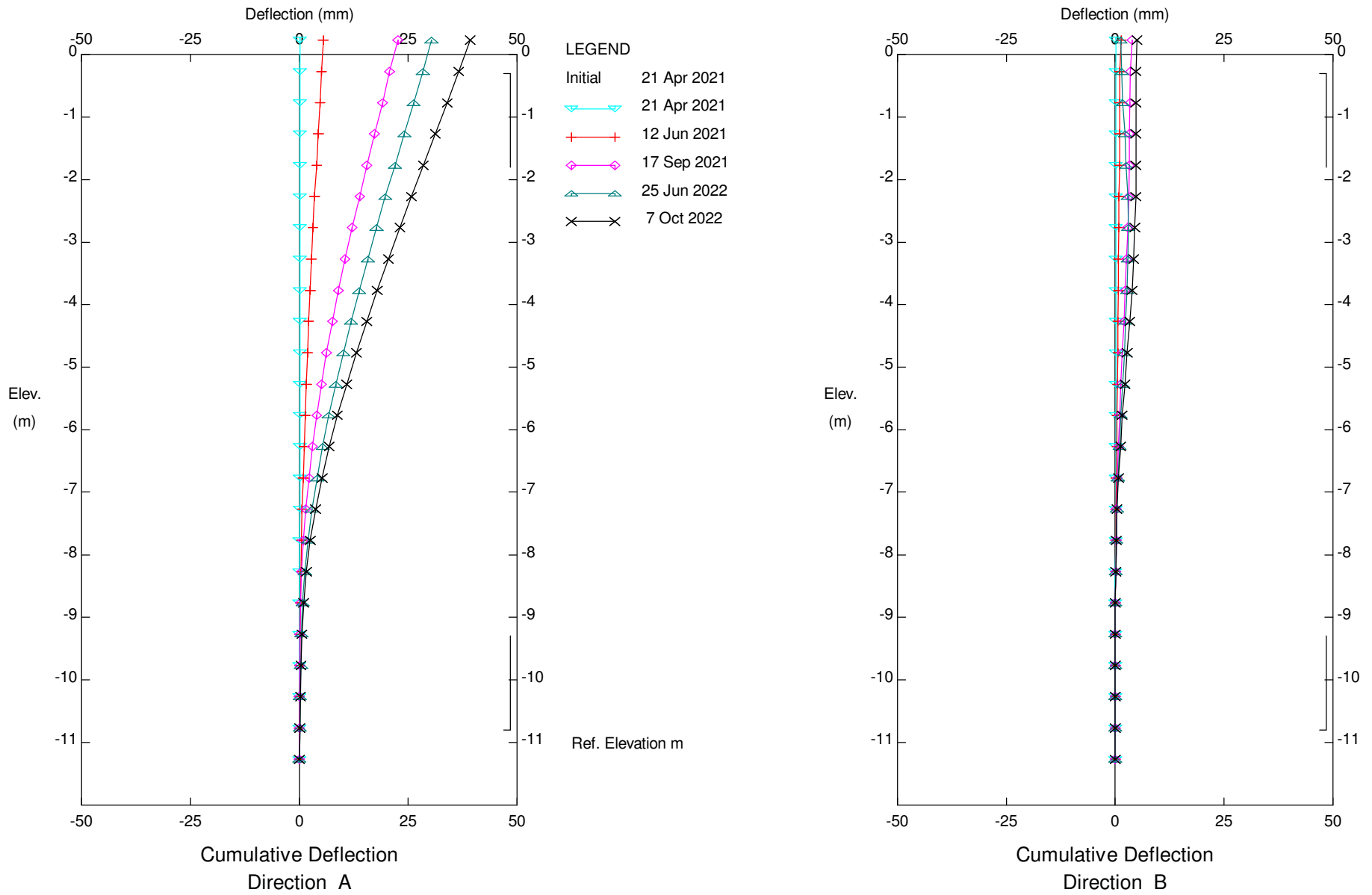


C048; H575:04; Slide W of Carbon Creek, Inclinator SI21-C48-02

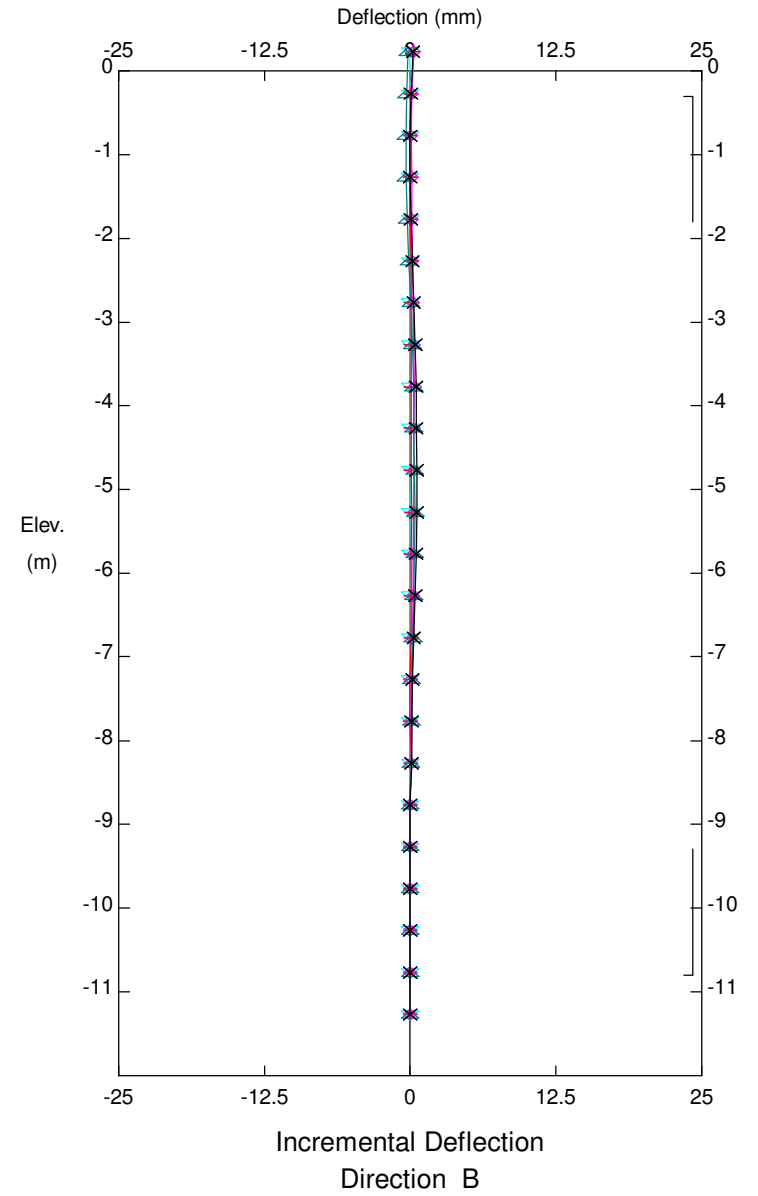
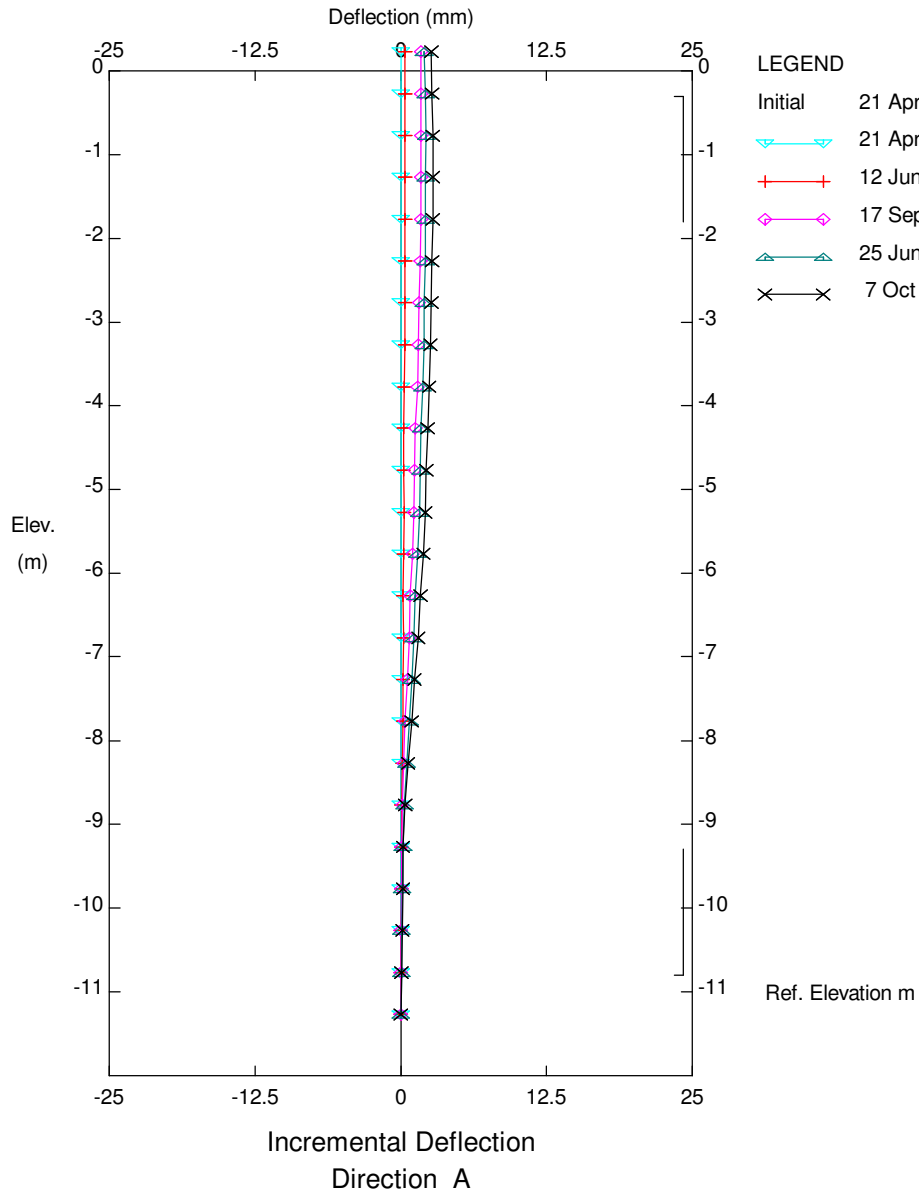
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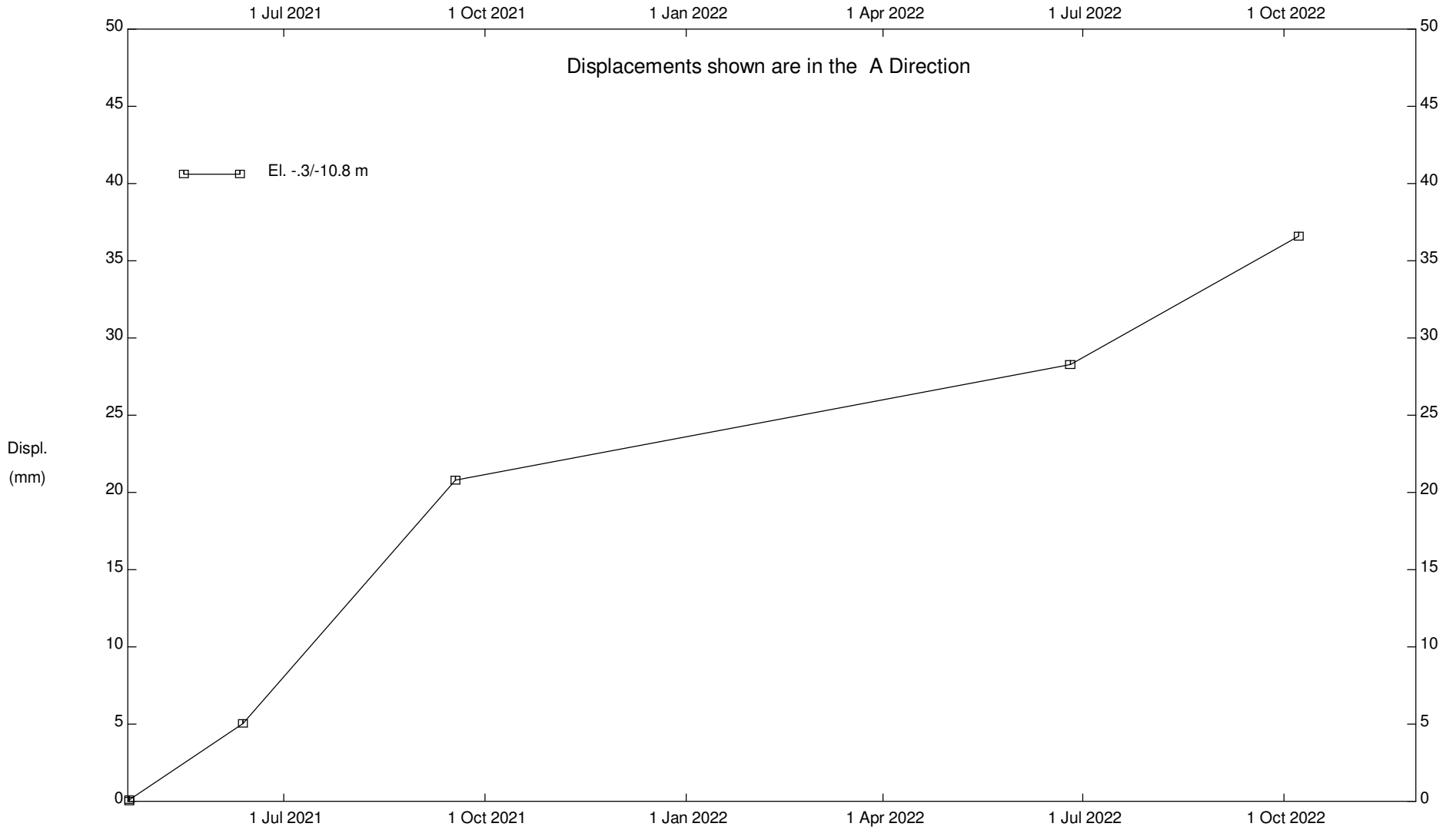
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C048; H575:04; Slide W of Carbon Creek, Inclinator SI21-C48-03

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