July 15, 2024

Alberta Transportation and Economic Corridors
Main Floor, Provincial Building
9621 96 Avenue
Peace River, Alberta
T8S 1T4

Robert Senior
Construction Technologist

Dear Mr. Senior:

CON0022166 Peace Region (Grande Prairie District – South) GRMP Instrumentation Monitoring Site GP003; H40:38, km 52.134 Cutbank River (South) Roseham Creek
Section C – 2024 Spring Readings

1 GENERAL

One slope inclinometer (SI) (SI-2) and two pneumatic piezometers (PNs) (PN-3 and PN-5) were read at the GP003 site in the Peace Region (Grande Prairie District – South) (GP South Region) on May 24, 2024, by Tim Hillman, 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 40:38, km 52.134, south of the Cutbank River bridge. The approximate site coordinates are 6054593 N, 391085 E (UTM Zone 11, NAD 83). A site plan is presented on Figure 1.

The geohazard at the GP003 site consists of a series of slides/slope failures between Hwy 40:36 and Roseham Creek. Slide movements are exacerbated by creek erosion at the toe of the slope, a high groundwater table, seepage, and low-strength glacio-lacustrine deposits.

Previous remedial actions completed at the GP003 site include:

- 1996 – construction of a berm;
- 1997 – realignment of the highway into the backslope in combination with lightweight “hog fuel-wood waste” used as fill;
- 2000 – re-construction of the slope to remove the hog fuel-wood waste (due to perceived environmental reasons), and install a drainage layer at the base and edge drains at the sides of the slope;
- 2003 – addition of rock weir barriers and live stakes along the creek channel, which were subsequently washed out, with a subdrain installed along the west (northbound) highway ditch and possibly a catchwater ditch (location unknown);
- 2016 – an overlay in the location of a tension crack; and,

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- 2019 and 2020 – cut back and flattening of the backslope to widen the highway for a passing/climbing lane.

Between 1994 and 1998, several geotechnical site investigations, which included installing instruments, were completed at the GP003 site by the previous consultants. The encountered stratigraphy has not been provided to KCB.

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 on Figure 1. Any instruments not included in Table 1.1 or shown on Figure 1 are assumed to be inoperable and are not presented or discussed herein.

Between 1994 and 1998, six SIs and three piezometers were installed at the site by the previous consultants to monitor movement and groundwater conditions, respectively. Some of these instruments are now inoperable (e.g., destroyed, sheared, or lost), including SI-1, SI-3, and SI-11.

The operable instruments are protected by above-ground casing protectors.

SI-2 was read using the same metric RST Digital MEMS Inclinometer System that has been used to read the SI since KCB took over the readings in June 2021. The PNs were read using an RST C109 pneumatic piezometer readout box.

Table 1.1 Instrumentation Installation Details[1]

Instrument ID	Instrument Type	Date Installed	UTM Coordinates (m)		Ground Surface Elevation (m)	Stick Up (m)	Depth (mbgs[2])	Condition
			Northing	Easting				
~~SI-1~~	~~SI~~	~~Dec. 14, 1997~~	~~Unknown~~	~~Unknown~~	~~Unknown~~	~~Unknown~~	~~Unknown~~	~~Inoperable~~
SI-2	SI	Dec. 13, 1997	6054137	391025	763.1	0.7	11.1	Operable
~~SI-3~~	~~SI~~	~~Dec. 14, 1997~~	~~6054221~~	~~390991~~	~~763.7~~	~~0.6~~	~~19.2~~	~~Inoperable~~
~~SI-11~~	~~SI~~	~~Oct. 05, 1997~~	~~Unknown~~	~~Unknown~~	~~Unknown~~	~~Unknown~~	~~Unknown~~	~~Inoperable~~
PN-3	PN	May 22, 1998	6054221	390991	763.1	N/A	9.1	Operable
PN-5	PN	May 22, 1998	6054193	391005	764.6	N/A	7.6	Operable

Notes:
[1] Instrument installation details were taken from reports and data files prepared or provided by the previous consultant(s) or TEC. Ground surface elevations were not provided for the SIs, so the ground surface elevation from the adjacent instruments/piezometer tips were used if available. 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 reading depth for SIs, and tip depth for piezometers.

2 INTERPRETATION

2.1 General

For SI-2, the cumulative displacement, incremental displacement, and displacement-time data was plotted in the A-direction (i.e., the direction of the A0-grooves) and the X-direction (i.e., the direction of maximum movement obtained at a skew angle from the A0-grooves). SI-2 has a skew angle of 340°, 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 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. The SI data plots presented herein include data for readings taken with both the previous consultants' and KCB's SI reading equipment.

2.2 Zones of Movement

In SI-2, distributed movement is recorded from ground surface to an approximate depth of 3.6 m below ground surface (elevation 763.1 m to 759.6 m). Distributed movement is also being recorded in this instrument at an approximate depth of 4 m to 11 m below ground surface (elevation 759 m to 752 m).

In the spring of 2022, SI-3 could not be read below an approximate depth of 1.7 m below ground surface. It is assumed the instrument has sheared at this depth despite no defined zones of discernible movement previously being recorded in this instrument.

2.3 Interpretation of Monitoring Results

The bottom of distributed movement recorded in SI-2, which is located approximately 30 m from the toe of the highway embankment, is at approximately the same elevation as Roseham Creek, which is located at the toe of the highway embankment.

The rate of movement being recorded in SI-2 was relatively slow (less than 1 mm/year) between 1997 and 2015 before increasing to an approximate rate of 20 mm/year in late 2019. The increased rate of movement was also observed on site when a larger-than-typical asphalt crack was observed during the 2015 Section B inspection. The increased rate of movement may have been caused by creek erosion at the toe of the highway embankment and groundwater seeping through the embankment fill.

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-2[3]	Dec. 13, 1997	Jun. 26, 2023	Jun. 06, 2023	May 24, 2024	763.1	2.6 - 4.6	X-Direction, 340°	25.3	-0.1	19.1	-0.1	-0.6

Notes:
[1] Meters below ground surface (mbgs).
[2] Skew angle of the X-direction measured clockwise from the A-direction. The azimuth of the A0-grooves in the SI was measured by KCB with a magnetic compass in spring 2022.
[3] There was a small data shift between the fall 2020 and spring 2021 readings, likely due to KCB changing the SI reading equipment when we took over readings from the previous consultant.

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-3	9367	May 22, 1998	Jun. 06, 2023	May 24, 2024	763.4	9.1	4.7	5.1	-0.4
PN-5	9378	May 22, 1998	Jun. 06, 2023	May 24, 2024	764.6	7.6	7.3	7.3	0.0

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

In the mid-2010s, an approximate 0.5 m to 1.0 m increase in porewater pressure was recorded in PN-3 and PN-5, and the rate of movement recorded in SI-2 correspondingly increased from less than 1 mm/year to an approximate rate of 20 mm/year. Since the mid- to late-2010s, an approximate 0.8 m decrease in porewater pressure has been recorded in PN-3 and PN-5. The rate of movement recorded in SI-2 also began to decrease in 2019/2020 and, since June 2022, has been less than 1 mm/year. This decrease in porewater pressures and movement rates, could be attributed to:

- possible seasonal variation in precipitation or freshet infiltration, or runoff or creek flow eroding the toe of the slope;
- cutting back the backslope to widen the highway for a passing lane in 2019 and 2020, reducing infiltration into the highway embankment and foundation and decreasing shear stresses applied to the foundation; and/or
- improving highway drainage to more effectively convey water downslope away from the slide.

Overall, the spring 2024 readings were consistent with recent readings for the instruments.

3 RECOMMENDATIONS

3.1 Future Work

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

The site should continue to be inspected by the Maintenance Contract Inspector (MCI) and as part of the Peace 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 and Economic Corridors (Client) for the specific application to the 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.

Yours truly,

KLOHN CRIPPEN BERGER LTD.

PROFESSIONAL ENGINEER ALBERTA
COURTNEY E. MULHALL
2024 Jul. 15
APEGA ID#: 153449

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Geotechnical Engineer-in-Training

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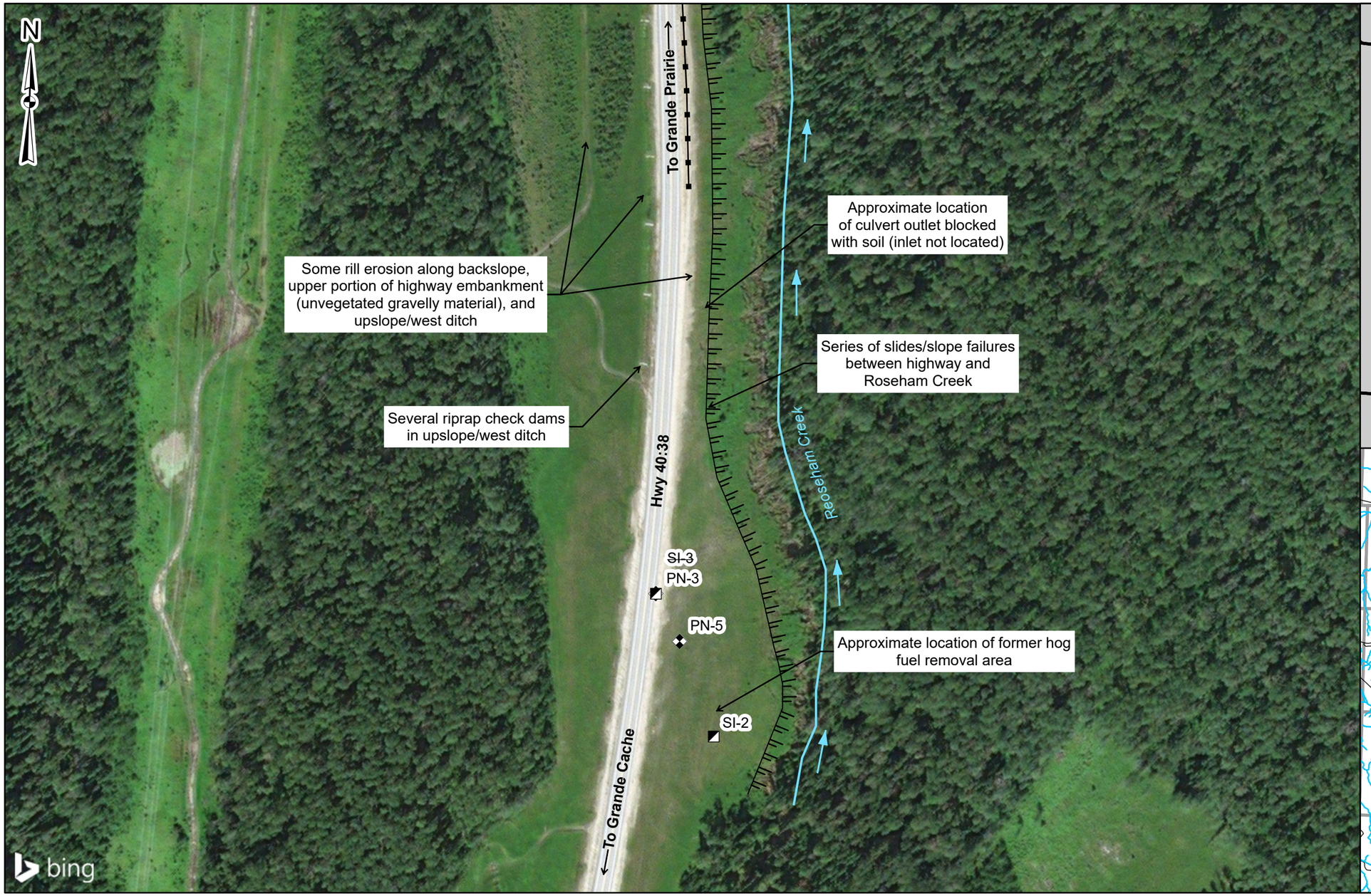
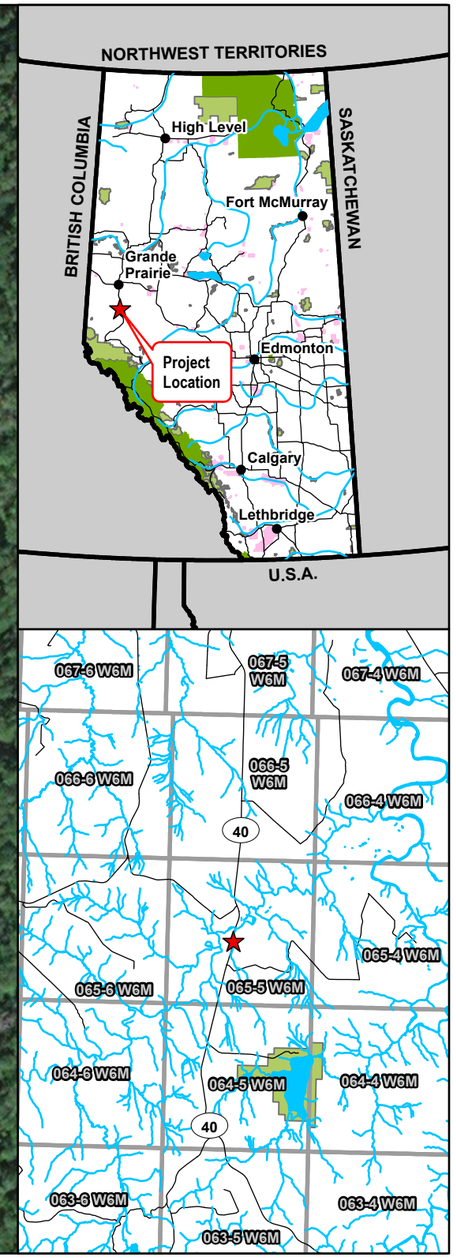
KLOHN CRIPPEN BERGER LTD.
RM SIGNATURE:
RM APEGA ID #: 58463
DATE: July 16 2024
PERMIT NUMBER: P009196
The Association of Professional Engineers and Geoscientists of Alberta (APEGA)

ATTACHMENTS
Figure
Appendix I Instrumentation Plots

FIGURE





Legend

- Pneumatic Piezometer (PN)
- Slope Inclinometer (SI)
- Flow Direction
- Watercourse
- Scarp
- Guardrail

0 100 Metres

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

CLIENT: Alberta

Klohn Crippen Berger

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

TITLE: Site Plan
GP003 Cutbank River (South) Roseham Creek
Hwy 40:38, km 52.134

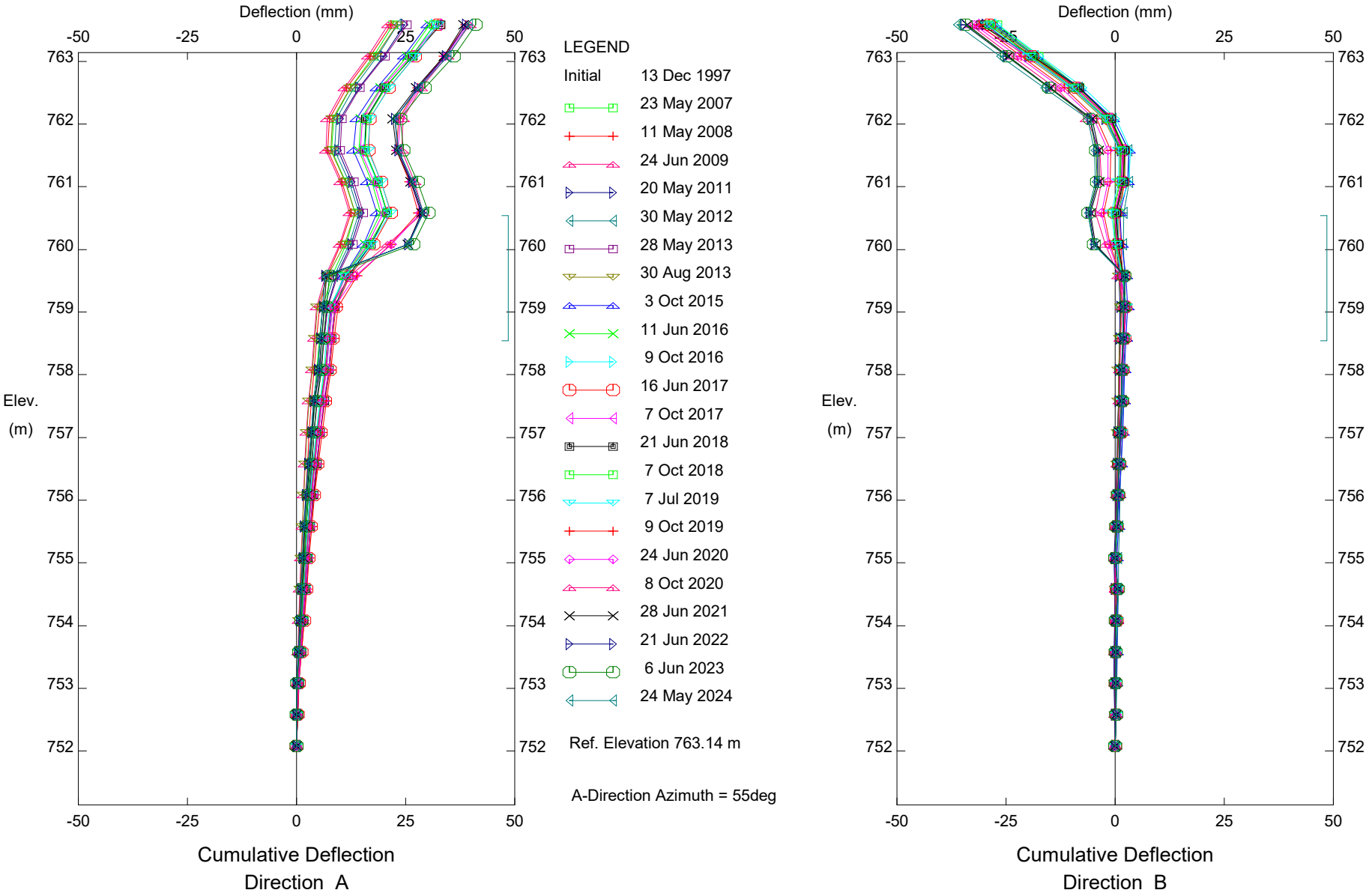
SCALE	PROJECT No.	FIG No.
1:2,500	A05116A01	1

File: Z:\AEDM\A05116A01 ABT Grande Prairie South GRMP\400 Drawings\GIS\MXD\2024\Section C\ABT_GPSouth_SectionC_240711\ABT_GPSouth_SectionC_240711.aprx Date: Time: Creator: : AHarrison

APPENDIX I

Instrumentation Plots

Klohn Crippen Berger - Calgary



GP003; H40:38, Cutbank River (South), Inclinometer SI-02

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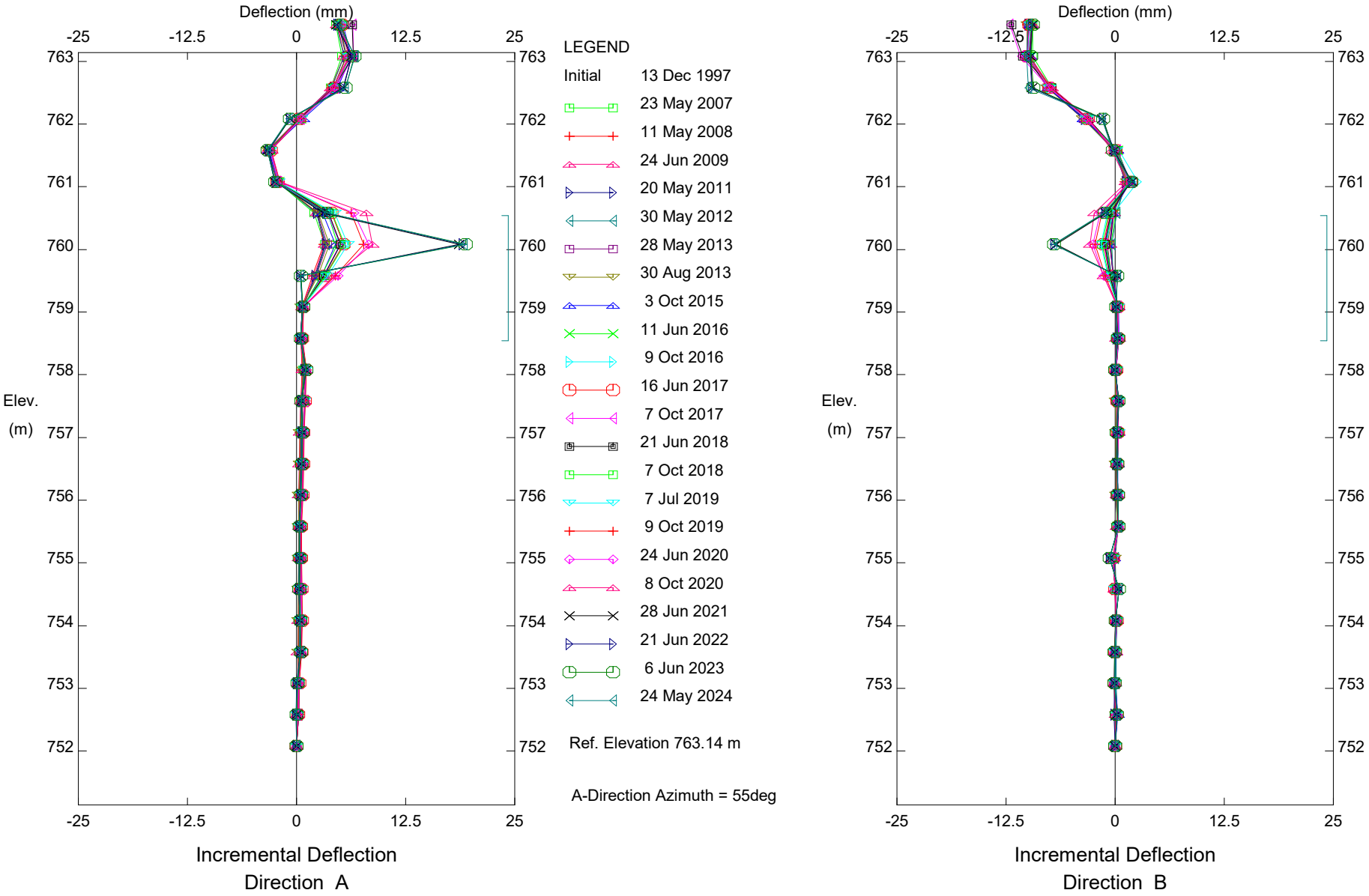

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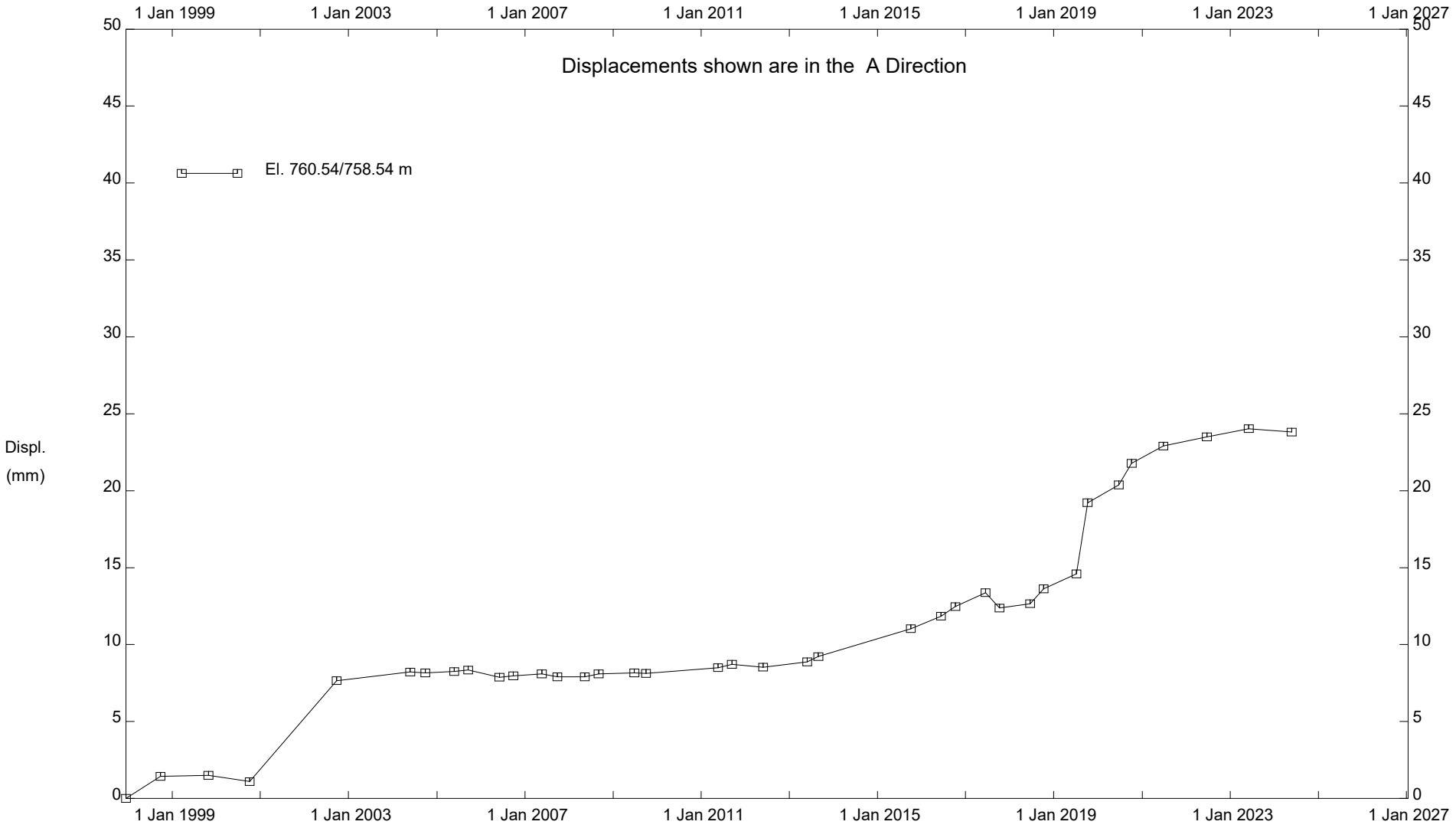

GP003; H40:38, Cutbank River (South), Inclinometer SI-02

Alberta Transportation

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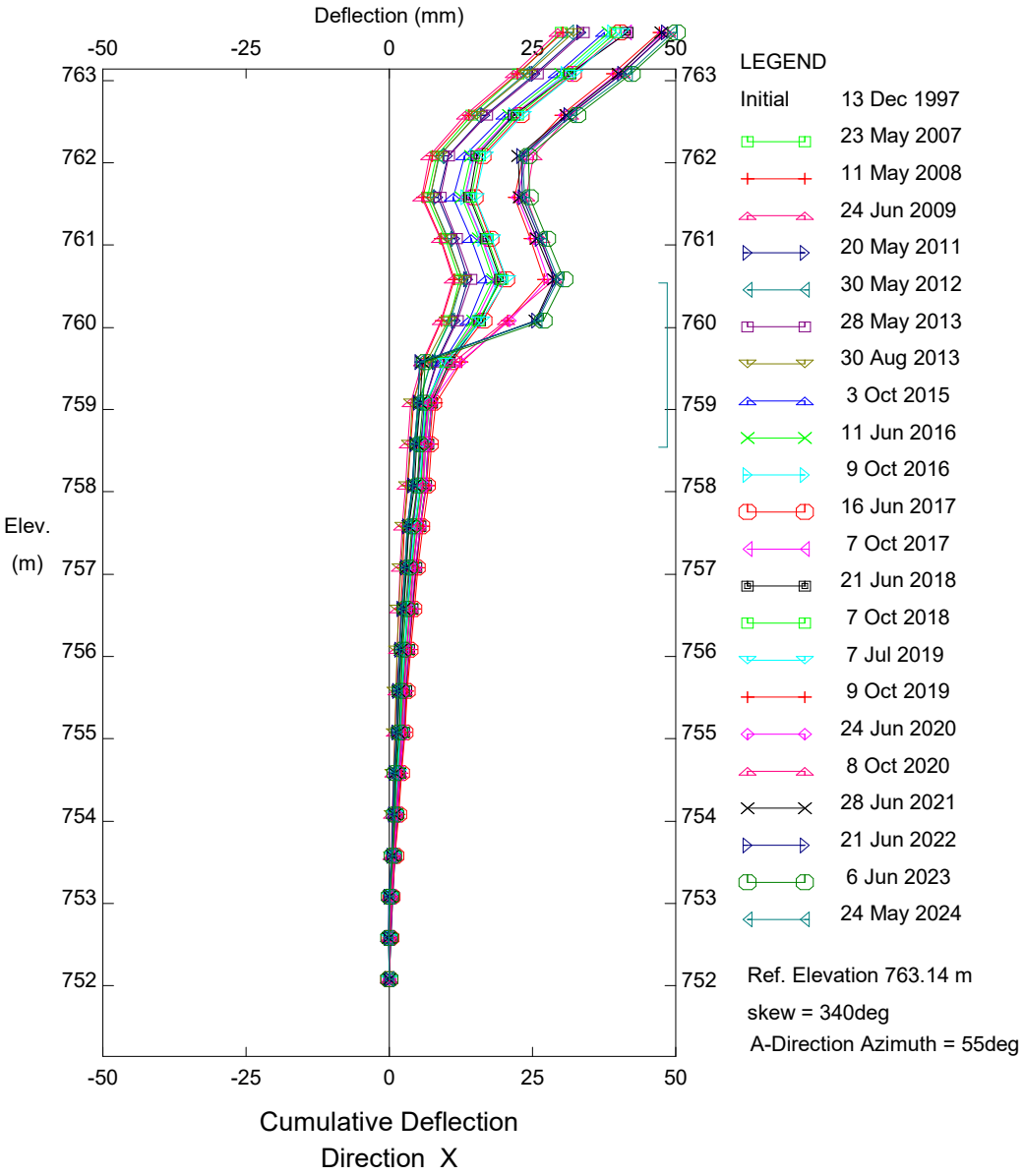

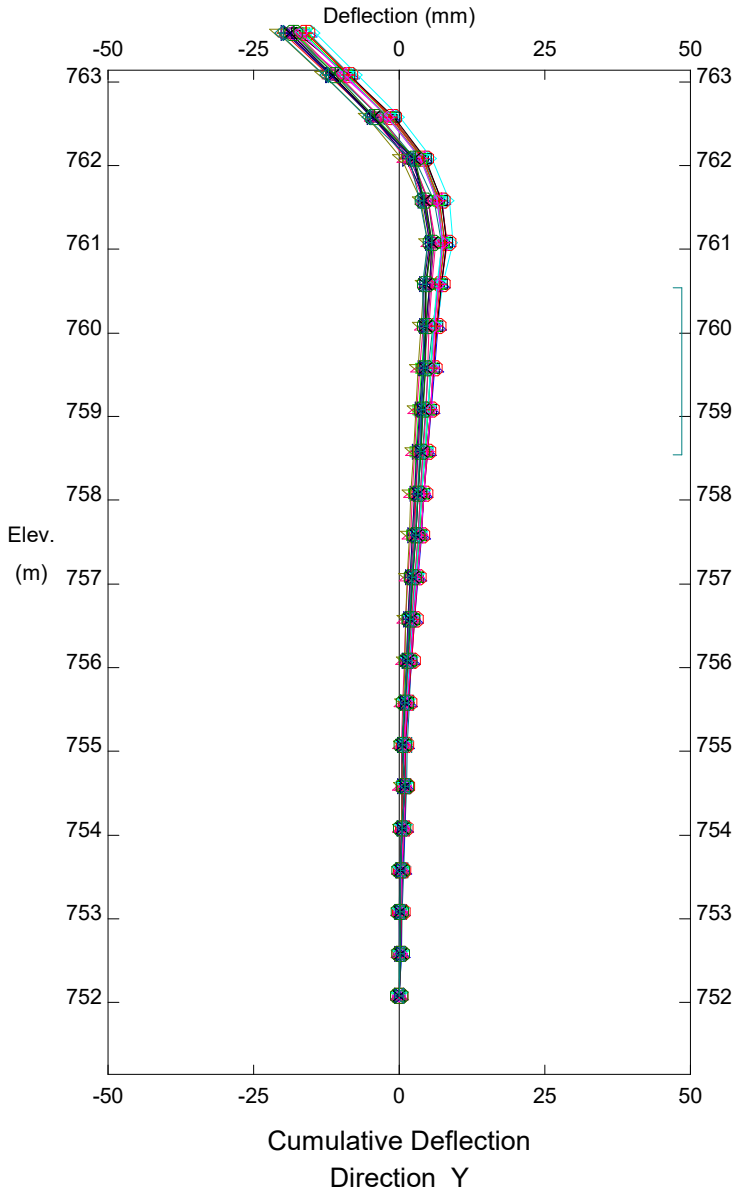

GP003; H40:38, Cutbank River (South), Inclinometer SI-02

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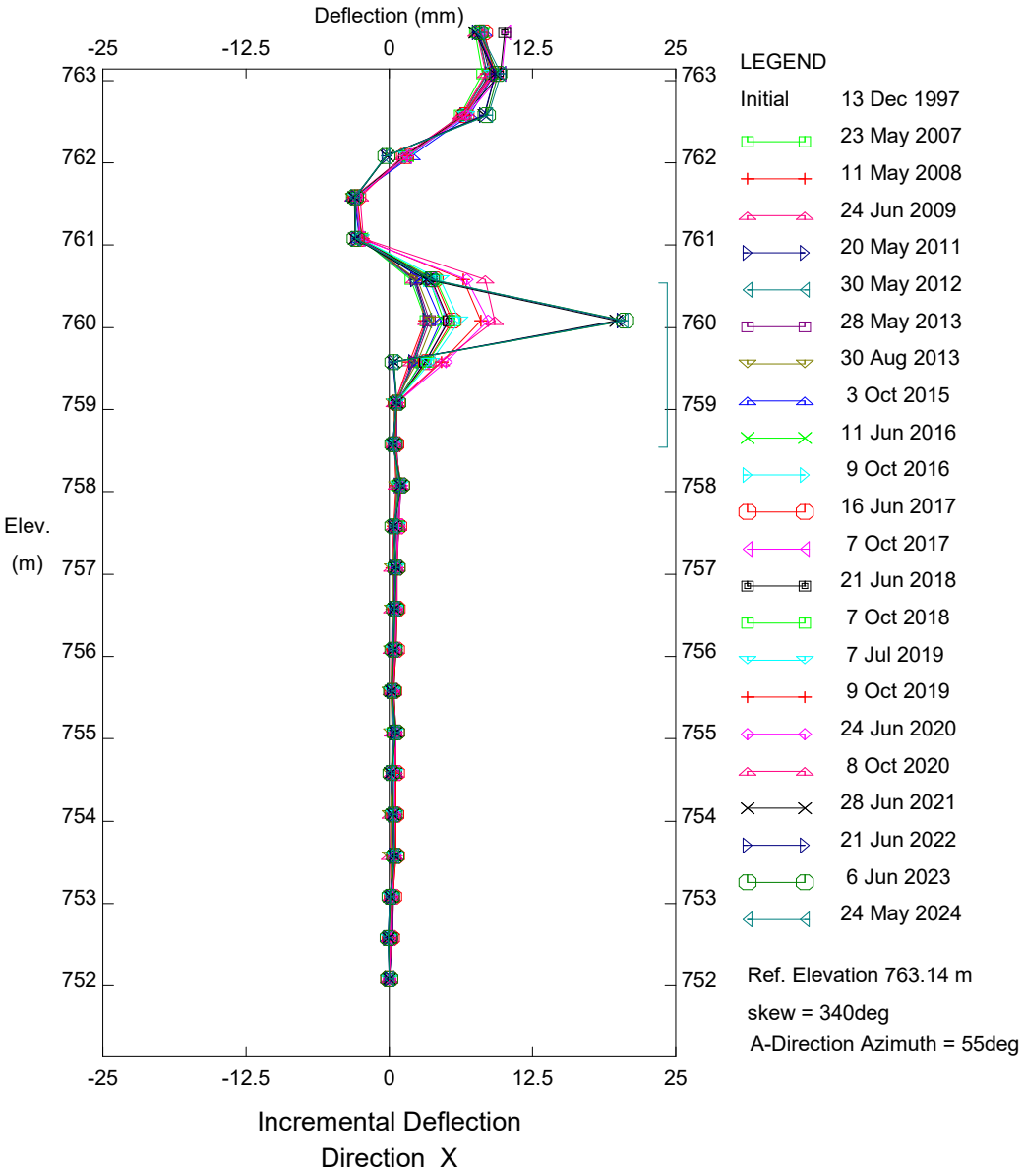

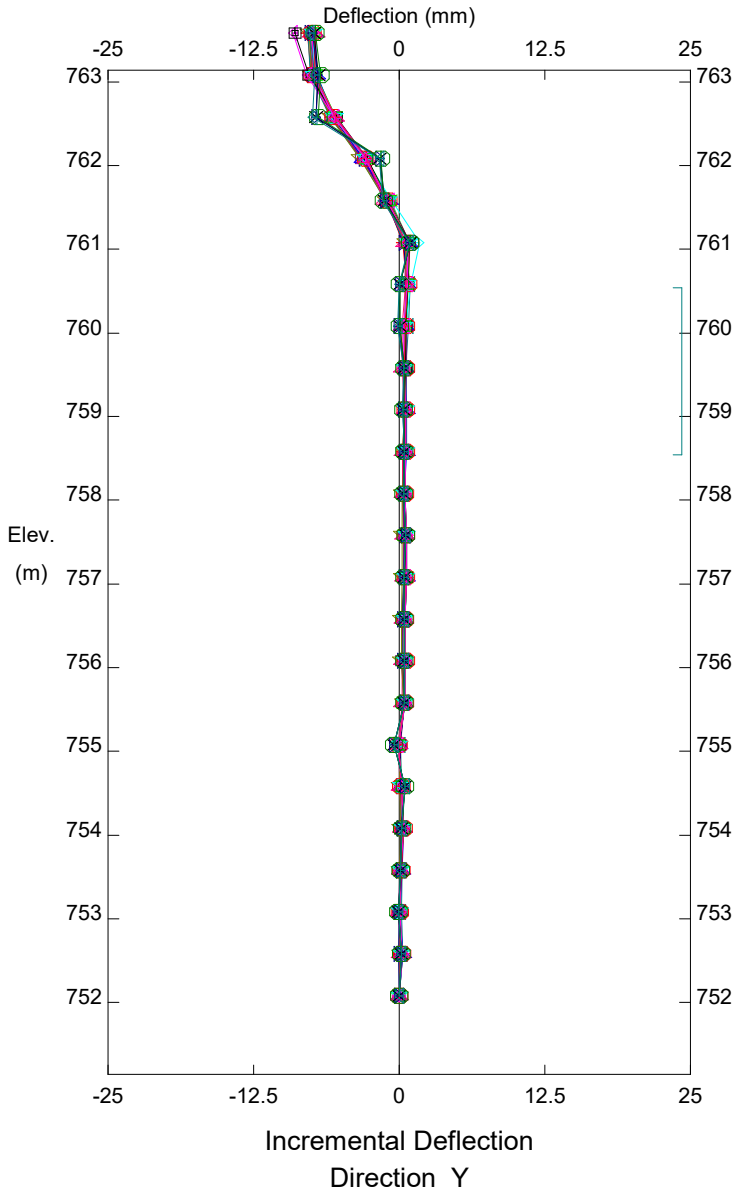

GP003; H40:38, Cutbank River (South), Inclinometer SI-02

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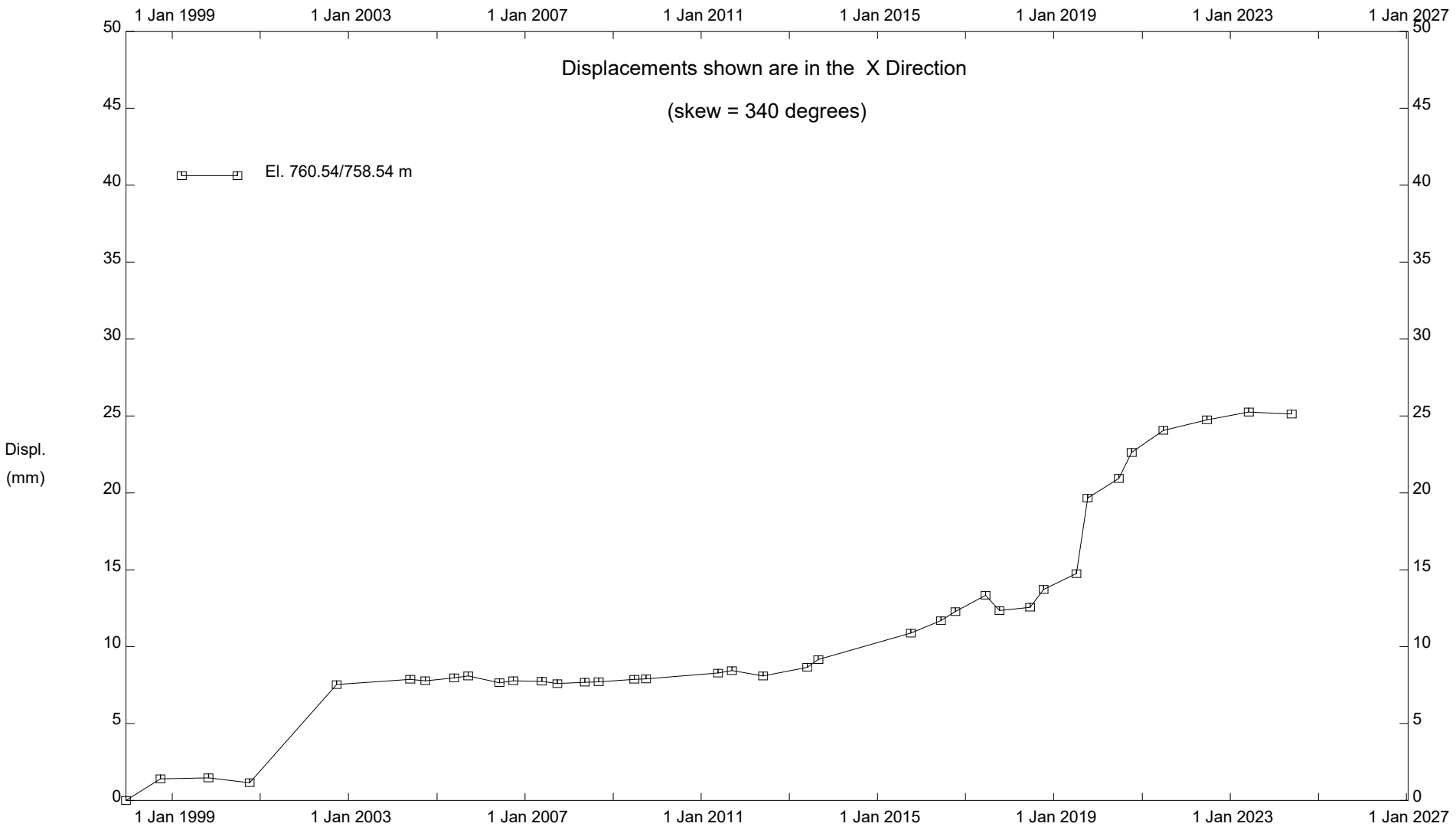

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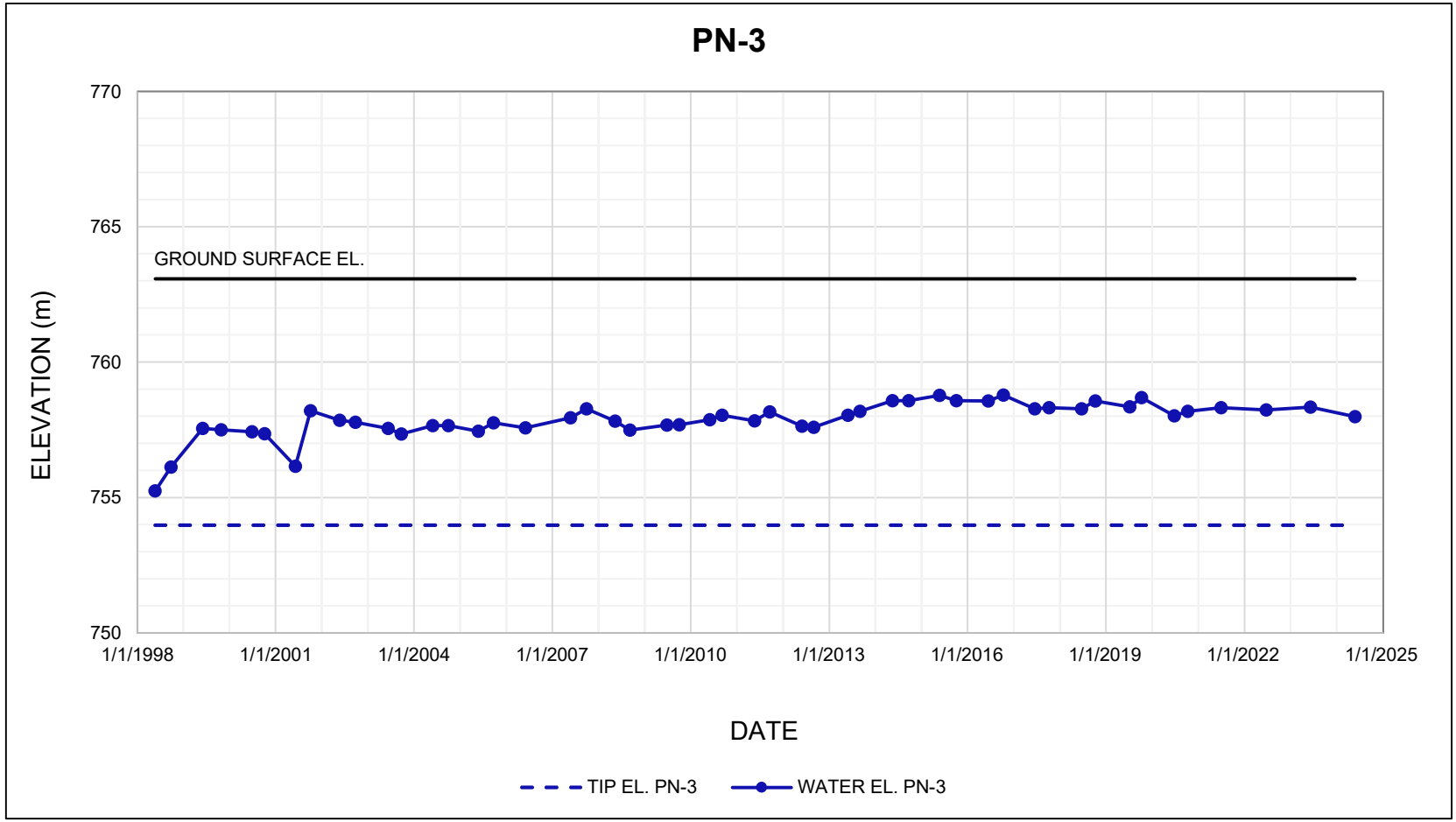
Alberta Transportation



NOTES:
1. PIEZOMETER DATA OBTAINED BEFORE JUNE 28, 2021, PROVIDED TO KLOHN CRIPPEN BERGER LTD. BY ALBERTA TRANSPORTATION AND ECONOMIC CORRIDORS ON JUNE 25, 2021.

CLIENT
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Klohn Crippen Berger

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

TITLE
Piezometer Data
GP003 - Cutbank River (South) Roseham Creek
Hwy 40:38, km 52.134

SCALE	PROJECT No.	FIG No.
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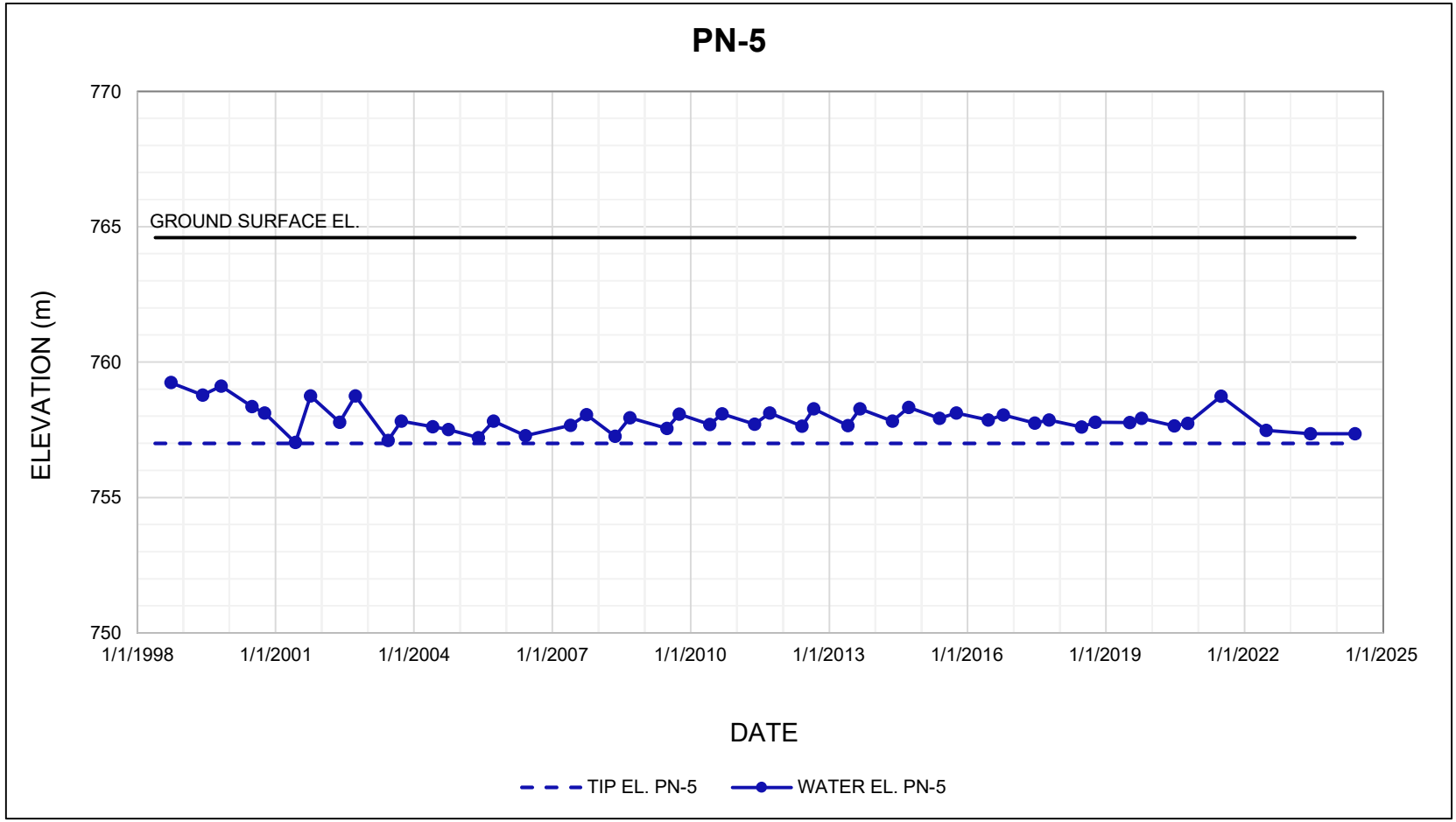

NOTES:
1. PIEZOMETER DATA OBTAINED BEFORE JUNE 28, 2021, PROVIDED TO KLOHN CRIPPEN BERGER LTD. BY ALBERTA TRANSPORTATION AND ECONOMIC CORRIDORS ON JUNE 25, 2021.

CLIENT
Alberta
Klohn Crippen Berger

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

TITLE
Piezometer Data
GP003 - Cutbank River (South) Roseham Creek
Hwy 40:38, km 52.134

SCALE	PROJECT No.	FIG No.
--	A05116A01	