THURBER ENGINEERING LTD.

July 5, 2022 File No.: 32122

Alberta Transportation
Construction and Maintenance Division
North Central Region
Box 4596, 4513 – 62 Avenue
Barrhead, Alberta
T7N 1A5

Attention: Ms. Amy Driessen, P.Eng.

ALBERTA TRANSPORTATION GRMP (CON0022163)
NORTH CENTRAL (ATHABASCA AND FORT McMURRAY DISTRICTS)
INSTRUMENTATION MONITORING RESULTS – SPRING 2022

SECTION C

SITE NC024: HWY 41:23 KEHIWIN LAKE (km 7.9)

Dear Ms. Driessen:

This report provides the results of the annual geotechnical instrumentation monitoring for the above-mentioned site as part of Alberta Transportation's Geohazard Risk Management Program for North Central – Athabasca and Fort McMurray Districts (CON0022163).

It is a condition of this letter report that Thurber's performance of its professional services will be subject to the attached Statement of Limitations and Conditions.

1. FIELD PROGRAM AND INSTRUMENTATION STATUS

Four slope inclinometers (SI02-5, SI09-1, SI09-2, and SI09-3) and three standpipe piezometers (SP02-2, SP02-3, and SP02-5) were read at the Hwy 41:23 Kehiwin Lake (NC024) site on May 26, 2022, by Mr. Niraj Regmi, G.I.T. and Mr. Jayden Del Cid, both of Thurber Engineering Ltd. SI06-3 was destroyed since the previous readings in the spring of 2021 and could not be read.

A site plan showing the approximate instrument locations is included in Appendix A.

The SIs were read using two RST Digital Inclinometer probes with 2 ft. wheelbases and RST Pocket PC readouts. Inclinometer reading depths were defined as per cable markings with respect to the top of the inclinometer casing. The standpipe piezometers were read using a Heron dipmeter.

2. DATA PRESENTATION

2.1 General

SI plots for A and B directions are presented in Appendix A and are summarized below. Where movement has been recorded the resultant plot (X direction, if applicable) and rate of movement have also been provided. Standpipe piezometer reading plots are also provided in Appendix A.

The slope inclinometer and piezometer reading summary tables are provided below. These tables also include instruments deleted from the GRMP or not read during this monitoring event for future reference.

2.2 Zones of Movement

Zones of new movement were not observed in the SIs since the previous readings in the spring of 2021.

Zones of movement are summarized in Table NC024-1 below. Table NC024-1 also provides a historical account of the total movement, the depth of movement and the maximum rate of movement that has occurred in the SIs since initialization.

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TABLE NC024-1
SPRING 2022 – HWY 41:23 KEHIWIN LAKE
SLOPE INCLINOMETER INSTRUMENTATION READING SUMMARY

Date Monitored: May 26, 2022

INSTRUMENT #	DATE INITIALIZED	TOTAL CUMULATIVE RESULTANT MOVEMENT AND DEPTH OF MOVEMENT TO DATE (mm)	MAXIMUM RATE OF MOVEMENT (mm/yr)	CURRENT STATUS OF SI	DATE OF PREVIOUS READING	INCREMENTAL MOVEMENT SINCE PREVIOUS READING (mm)	CURRENT RATE OF MOVEMENT (mm/yr)	CHANGE IN RATE OF MOVEMENT SINCE PREVIOUS READING (mm/yr)
SI02-1	*Sept. 9, 2002*	*N/A*	*30.0 in Fall 2005*	*Sheared*	*Oct. 12, 2006*	*N/A*	*N/A*	*N/A*
SI02-2	*Sept. 9, 2002*	*42.5 at 7.1 m to 9.0m depth in -6° direction*	*26.4 in Fall 2005*	*Sheared*	*Oct. 12, 2006*	*N/A*	*N/A*	*N/A*
SI02-3	*Sept. 9, 2002*	*N/A*	*15.3 in Fall 2005*	*Sheared*	*Oct. 12, 2006*	*N/A*	*N/A*	*N/A*
SI02-4	*Sept. 9, 2002*	*N/A*	*36.6 in Fall 2005*	*Sheared*	*Oct. 12, 2006*	*N/A*	*N/A*	*N/A*
SI02-5	Sept. 9, 2002	3.4 over 3.9 m to 6.9 m depth in 280° direction	8.3 in May 2009	Operational	June 24, 2021	No discernible movement	N/A	-0.1
SI06-1	*Apr. 7, 2006*	*24.3 over 2.4 m to 5.5 m depth in 280° direction*	*27.3 in Fall 2007*	*Destroyed*	*May 3, 2008*	*N/A*	*N/A*	*N/A*
SI06-2	*Apr. 6, 2006*	*42.2 over 4 m to 5.2 m depth in 282° direction*	*59 in Fall 2007*	*Sheared*	*Oct. 12, 2007*	*N/A*	*N/A*	*N/A*
SI06-3	*Apr. 7, 2006*	*5.2 over 3.7 m to 6.2 m depth in 308° direction*	*2.7 in September 2011*	*Destroyed*	*June 24, 2021*	*N/A*	*N/A*	*N/A*

Drawing 32122-NC024 in Appendix A provides a sketch of the approximate location of the monitoring instrumentation for this site

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TABLE NC024-1 – CONTINUED…
SPRING 2022 – HWY 41:23 KEHIWIN LAKE
SLOPE INCLINOMETER INSTRUMENTATION READING SUMMARY

Date Monitored: May 26, 2022

INSTRUMENT #	DATE INITIALIZED	TOTAL CUMULATIVE RESULTANT MOVEMENT AND DEPTH OF MOVEMENT TO DATE (mm)	MAXIMUM RATE OF MOVEMENT (mm/yr)	CURRENT STATUS OF SI	DATE OF PREVIOUS READING	INCREMENTAL MOVEMENT SINCE PREVIOUS READING (mm)	CURRENT RATE OF MOVEMENT (mm/yr)	CHANGE IN RATE OF MOVEMENT SINCE PREVIOUS READING (mm/yr)
SI09-1 (Pile #7)	March 31, 2009	12.1 over 0.1 m to 14.8 m depth in 296 ^{o} direction	10.2 between March 31, 2009 and May 25, 2009	Operational	June 24, 2021	No discernible movement	N/A	-0.3
SI09-2 (Pile # 18)	Reinitialized September 18, 2020	No discernible movement	N/A	Operational	June 24, 2021	N/A	N/A	N/A
SI09-3 (Pile #29)	Reinitialized September 18, 2020	No discernible movement	N/A	Operational	June 24, 2021	N/A	N/A	N/A

Drawing 32122-NC024 in Appendix A provides a sketch of the approximate location of the monitoring instrumentation for this site

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TABLE NC008-2
SPRING 2022 – HWY 41:23 KEHIWIN LAKE
STANDPIPE PIEZOMETER INSTRUMENTATION READING SUMMARY

Date Monitored: May 26, 2022

INSTRUMENT #	DATE INITIALIZED	TIP DEPTH (m)	GROUND ELEV. (m)	CURRENT STATUS	HIGHEST MEASURED GROUNDWATER LEVEL BGS (m)	CURRENT GROUNDWATER DEPTH BGS (m)	PREVIOUS GROUNDWATER DEPTH BGS (m)	CHANGE IN WATER LEVEL SINCE PREVIOUS READING (m)
SP02-1	*Sept. 9, 2002*	*8.51*	-	*Damaged*	*2.94 on May 30, 2006*	*N/A*	*N/A*	*N/A*
SP02-2	Sept. 9, 2002	10.58	-	Operational	0.85 on May 31, 2012	2.08	2.30	0.22
SP02-3	Sept. 9, 2002	16.75	-	Operational	1.85 on May 31, 2012	3.31	3.16	-0.15
SP02-4	*Sept. 9, 2002*	*8.36*	-	*Damaged*	*1.10 on Oct. 29, 2003*	*N/A*	*N/A*	*N/A*
SP02-5	Sept. 9, 2002	8.11	-	Operational	0.63 on May 30, 2006	1.66	0.90	-0.76

Drawing 32122-NC024 in Appendix A provides a sketch of the approximate location of the monitoring instrumentation for this site

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3. INTERPRETATION OF MONITORING RESULTS

3.1 Interpretation of Monitoring Results

SI02-5, installed in the east ditch of the highway, showed no discernible movement since the spring of 2021 readings.

SI09-1 showed no discernible movement since the readings in spring 2021. SI09-1 has shown a total pile head movement of 12.1 mm to date.

SI09-2 and SI09-3 were previously damaged; however, they were repaired prior to the fall of 2020 readings. When the readings from the repaired instruments were compared to previous data for the SIs, the data could not be matched, hence both SI09-2 and SI09-3 were reinitialized for the fall of 2020 readings. SI09-2 and SI09-3 showed no discernible movement since the reinitialization.

The groundwater level increased by 0.22 m in SP02-2 since the spring of 2021 readings. The groundwater level decreased in SP02-3 and SP02-5 by 0.15 m and 0.76 m, respectively, since the spring of 2021 readings. The standpipe piezometer readings are plotted on Figure NC024-1 in Appendix A.

In general, the instrumentation monitoring results indicate that the pile wall has performed well since construction completion.

4. RECOMMENDATIONS

4.1 Future Work

The instruments should be read again in the spring of 2023.

4.2 Instrumentation Repairs

No instrument repairs are required at this time.

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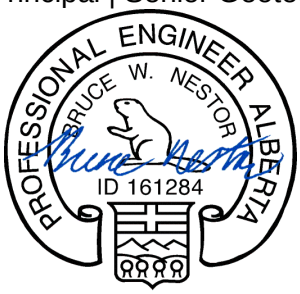
5. CLOSURE

We trust this report meets your requirements at present. If you have any questions, please contact the undersigned at your convenience.

Yours very truly,
Thurber Engineering Ltd.
Tarek Abdelaziz, Ph.D., P.Eng.
Principal | Senior Geotechnical Engineer



July 6, 2022

PERMIT TO PRACTICE
THURBER ENGINEERING LTD.
RM SIGNATURE:
RM APEGA ID #: 91085
DATE: July 7, 2022
PERMIT NUMBER: P005186
The Association of Professional Engineers and Geoscientists of Alberta (APEGA)

Bruce Nestor, P.Eng.
Geotechnical Engineer
/jf

Attachments

- Statement of Limitations and Conditions
- Appendix A
  - Field Inspector's report
  - Site Plan Showing Approximate Instrument Locations (Drawing No. 32122-NC024)
  - SI Reading Plots
  - Figure NC024-1 (Standpipe Piezometer Readings)

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STATEMENT OF LIMITATIONS AND CONDITIONS

1. STANDARD OF CARE

This Report has been prepared in accordance with generally accepted engineering or environmental consulting practices in the applicable jurisdiction. No other warranty, expressed or implied, is intended or made.

2. COMPLETE REPORT

All documents, records, data and files, whether electronic or otherwise, generated as part of this assignment are a part of the Report, which is of a summary nature and is not intended to stand alone without reference to the instructions given to Thurber by the Client, communications between Thurber and the Client, and any other reports, proposals or documents prepared by Thurber for the Client relative to the specific site described herein, all of which together constitute the Report.

IN ORDER TO PROPERLY UNDERSTAND THE SUGGESTIONS, RECOMMENDATIONS AND OPINIONS EXPRESSED HEREIN, REFERENCE MUST BE MADE TO THE WHOLE OF THE REPORT. THURBER IS NOT RESPONSIBLE FOR USE BY ANY PARTY OF PORTIONS OF THE REPORT WITHOUT REFERENCE TO THE WHOLE REPORT.

3. BASIS OF REPORT

The Report has been prepared for the specific site, development, design objectives and purposes that were described to Thurber by the Client. The applicability and reliability of any of the findings, recommendations, suggestions, or opinions expressed in the Report, subject to the limitations provided herein, are only valid to the extent that the Report expressly addresses proposed development, design objectives and purposes, and then only to the extent that there has been no material alteration to or variation from any of the said descriptions provided to Thurber, unless Thurber is specifically requested by the Client to review and revise the Report in light of such alteration or variation.

4. USE OF THE REPORT

The information and opinions expressed in the Report, or any document forming part of the Report, are for the sole benefit of the Client. NO OTHER PARTY MAY USE OR RELY UPON THE REPORT OR ANY PORTION THEREOF WITHOUT THURBER'S WRITTEN CONSENT AND SUCH USE SHALL BE ON SUCH TERMS AND CONDITIONS AS THURBER MAY EXPRESSLY APPROVE. Ownership in and copyright for the contents of the Report belong to Thurber. Any use which a third party makes of the Report, is the sole responsibility of such third party. Thurber accepts no responsibility whatsoever for damages suffered by any third party resulting from use of the Report without Thurber's express written permission.

5. INTERPRETATION OF THE REPORT

a) Nature and Exactness of Soil and Contaminant Description: Classification and identification of soils, rocks, geological units, contaminant materials and quantities have been based on investigations performed in accordance with the standards set out in Paragraph 1. Classification and identification of these factors are judgmental in nature. Comprehensive sampling and testing programs implemented with the appropriate equipment by experienced personnel may fail to locate some conditions. All investigations utilizing the standards of Paragraph 1 will involve an inherent risk that some conditions will not be detected and all documents or records summarizing such investigations will be based on assumptions of what exists between the actual points sampled. Actual conditions may vary significantly between the points investigated and the Client and all other persons making use of such documents or records with our express written consent should be aware of this risk and the Report is delivered subject to the express condition that such risk is accepted by the Client and such other persons. Some conditions are subject to change over time and those making use of the Report should be aware of this possibility and understand that the Report only presents the conditions at the sampled points at the time of sampling. If special concerns exist, or the Client has special considerations or requirements, the Client should disclose them so that additional or special investigations may be undertaken which would not otherwise be within the scope of investigations made for the purposes of the Report.

b) Reliance on Provided Information: The evaluation and conclusions contained in the Report have been prepared on the basis of conditions in evidence at the time of site inspections and on the basis of information provided to Thurber. Thurber has relied in good faith upon representations, information and instructions provided by the Client and others concerning the site. Accordingly, Thurber does not accept responsibility for any deficiency, misstatement or inaccuracy contained in the Report as a result of misstatements, omissions, misrepresentations, or fraudulent acts of the Client or other persons providing information relied on by Thurber. Thurber is entitled to rely on such representations, information and instructions and is not required to carry out investigations to determine the truth or accuracy of such representations, information and instructions.

c) Design Services: The Report may form part of design and construction documents for information purposes even though it may have been issued prior to final design being completed. Thurber should be retained to review final design, project plans and related documents prior to construction to confirm that they are consistent with the intent of the Report. Any differences that may exist between the Report's recommendations and the final design detailed in the contract documents should be reported to Thurber immediately so that Thurber can address potential conflicts.

d) Construction Services: During construction Thurber should be retained to provide field reviews. Field reviews consist of performing sufficient and timely observations of encountered conditions in order to confirm and document that the site conditions do not materially differ from those interpreted conditions considered in the preparation of the report. Adequate field reviews are necessary for Thurber to provide letters of assurance, in accordance with the requirements of many regulatory authorities.

6. RELEASE OF POLLUTANTS OR HAZARDOUS SUBSTANCES

Geotechnical engineering and environmental consulting projects often have the potential to encounter pollutants or hazardous substances and the potential to cause the escape, release or dispersal of those substances. Thurber shall have no liability to the Client under any circumstances, for the escape, release or dispersal of pollutants or hazardous substances, unless such pollutants or hazardous substances have been specifically and accurately identified to Thurber by the Client prior to the commencement of Thurber's professional services.

7. INDEPENDENT JUDGEMENTS OF CLIENT

The information, interpretations and conclusions in the Report are based on Thurber's interpretation of conditions revealed through limited investigation conducted within a defined scope of services. Thurber does not accept responsibility for independent conclusions, interpretations, interpolations and/or decisions of the Client, or others who may come into possession of the Report, or any part thereof, which may be based on information contained in the Report. This restriction of liability includes but is not limited to decisions made to develop, purchase or sell land.

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ALBERTA TRANSPORTATION GRMP (CON0022163)
NORTH CENTRAL (ATHABASCA AND FORT McMURRAY DISTRICTS)
INSTRUMENTATION MONITORING RESULTS

SPRING 2022

APPENDIX A
DATA PRESENTATION AND SITE PLANS

SITE NC024: HWY 41:23 KEHIWIN LAKE (km 7.9)

ALBERTA TRANSPORTATION
NORTH CENTRAL REGION - ATHABASCA AND FORT McMURRAY DISTRICTS
INSTRUMENTATION MONITORING FIELD SUMMARY (NC024)
SPRING 2022

Location:	Kehiwin Lake (HWY 41:23 C1 7.973)	**Readout:**	DipperT. Heron Inst.
File Number:	32122	**Casing Diameter:**	2.75"
Probe:	RST set 5R and 8R	**Temp (deg C):**	19
Cable:	RST set 5R and 8R	**Read by:**	NKR/JD

SLOPE INCLINOMETER (SI) READINGS

SI#	GPS Location (UTM 12)		Date	Stickup m	Depth from top of **casing** (ft)	Azimuth of A+ Groove	Current Bottom Depth Readings				Probe/ Reel #	Remarks
	Easting (m)	Northing (m)					A+	A-	B+	B-		
SI02-5	506780.00	5988487.00	26-May-22	0.72	33 to 3	252°	-628	647	39	-60	5R/5R	
SI06-3	506831.55	5988564.92	26-May-22	0.83	61 to 3	296°	-299	309	409	-420	5R/5R	Destroyed (See Photographs)
SI09-1	506767.00	5988498.00	26-May-22	1.07	52 to 4	286°	104	-86	-141	143	5R/5R	Pile Wall
SI09-2	506790.16	5988531.15	26-May-22	0.85	46 to 4	280	-261	276	-325	331	8R/8R	Pile Wall (Repaired / Initialized)
SI09-3	506813.80	5988480.90	26-May-22	0.47	50 to 3	283°	-695	718	293	-316	8R/8R	Pile Wall (Repaired / Initialized)

STANDPIPE PIEZOMETER (SP) READINGS

SP#	GPS Location (UTM 12)		Date	Stick-up	Reading below	Bottom Pipe Depth
	Easting (m)	Northing (m)	26-May-22	(m)	top of casing (m)	(below top of casing (m)
SP02-2	506747.63	5988506.61	26-May-22	0.92	3.00	11.49
SP02-3	506732.54	5988526.62	26-May-22	0.95	4.26	17.69
SP02-5	506773.47	5988480.84	26-May-22	0.87	2.53	8.88

INSPECTOR REPORT

SI 9-2, Probe sits at 46.0 ft. Read from 46.0 ft to 2.0 ft

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POSSIBLE TOE

KEHIWIN LAKE

WATER ELEVATION = 85.774m

NW 25-58-07-W4M

NW 30-58-06-W4M

BUSH LINE

SI02-3 SP02-3

BUSH LINE

CULVERT INVERT ELEV=91.560m

CREEK

SP02-2 SI02-2

ESTIMATED LIMITS OF SLIDE

60.96m HIGHWAY 28 RIGHT-OF-WAY TAKEN IN 1970 UNDER PLAN NO. 2813PX

29.97m

±9.65m BETWEEN ROAD SHOULDERS

±7.63m BETWEEN WHITE LINES

STA 0+015.0@P 800m x 46.5m

SI02-1 SP02-1 SI09-1

SI02-4 SP02-4 SI09-2 SI06-2 SI09-3

±9.69m BETWEEN ROAD SHOULDERS

±7.58m BETWEEN WHITE LINES

SI06-1

CULVERT INVERT ELEV=97.434m

30.28m

STA 0+177.0@P 800m x 23.6m

0+000 0+020 0+040 0+060 0+080 0+100 0+120 0+140 0+160 0+180

SI02-5 SP02-5

SI06-3

30.69m

CULVERT INVERT ELEV=95.387m

BUSH LINE

0+0,54.4 IRON PIN (R22)
OFFSET 30.774m RT
NORTHING=991,538
EASTING=1036,555
ELEV=104.171m

OFFSET 28.758m RT
0+143.1 TELUS PEDESTAL

CULVERT INVERT ELEV=98.967m

30.68m

3-STRAND BARBED WIRE FENCE

POWER LINE ROW (PLAN NO. 2055KS)

20.12m GOVERNMENT ROAD ALLOWANCE - RANGE ROAD 70

POWER LINE ROW (PLAN NO. 3697RS)

0+053.2 POWERPOLE
OFFSET 39.747m RT

0+153.0 POWERPOLE
OFFSET 37.291m RT

LEGEND

- SI — SLOPE INCLINOMETER (EXISTING)
- SP — STANDPIPE PIEZOMETER (EXISTING)
- SI — SLOPE INCLINOMETER (NON-OPERATIONAL)
- SP — STANDPIPE PIEZOMETER (NON-OPERATIONAL)
- BUSH LINE
- TELUS CABLE (APPROX. ONLY)

NOTE:
SI09-1, SI09-2, AND SI09-3 ARE LOCATED INSIDE THE PILE WALL.

0 10 20 30 40 50 60m
SCALE 1:1000

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NORTH CENTRAL (ATHABASCA AND FORT MCMURRAY DISTRICTS)

NC024: HWY 41:23 KEHIWIN LAKE SITE PLAN SHOWING APPROXIMATE INSTRUMENT LOCATIONS

DWG No. 32122-NC024

DRAWN BY	ML
DESIGNED BY	BWN
APPROVED BY	TSA
SCALE	1:1000
DATE	JUNE 2022
FILE No.	32122

THURBER ENGINEERING LTD.

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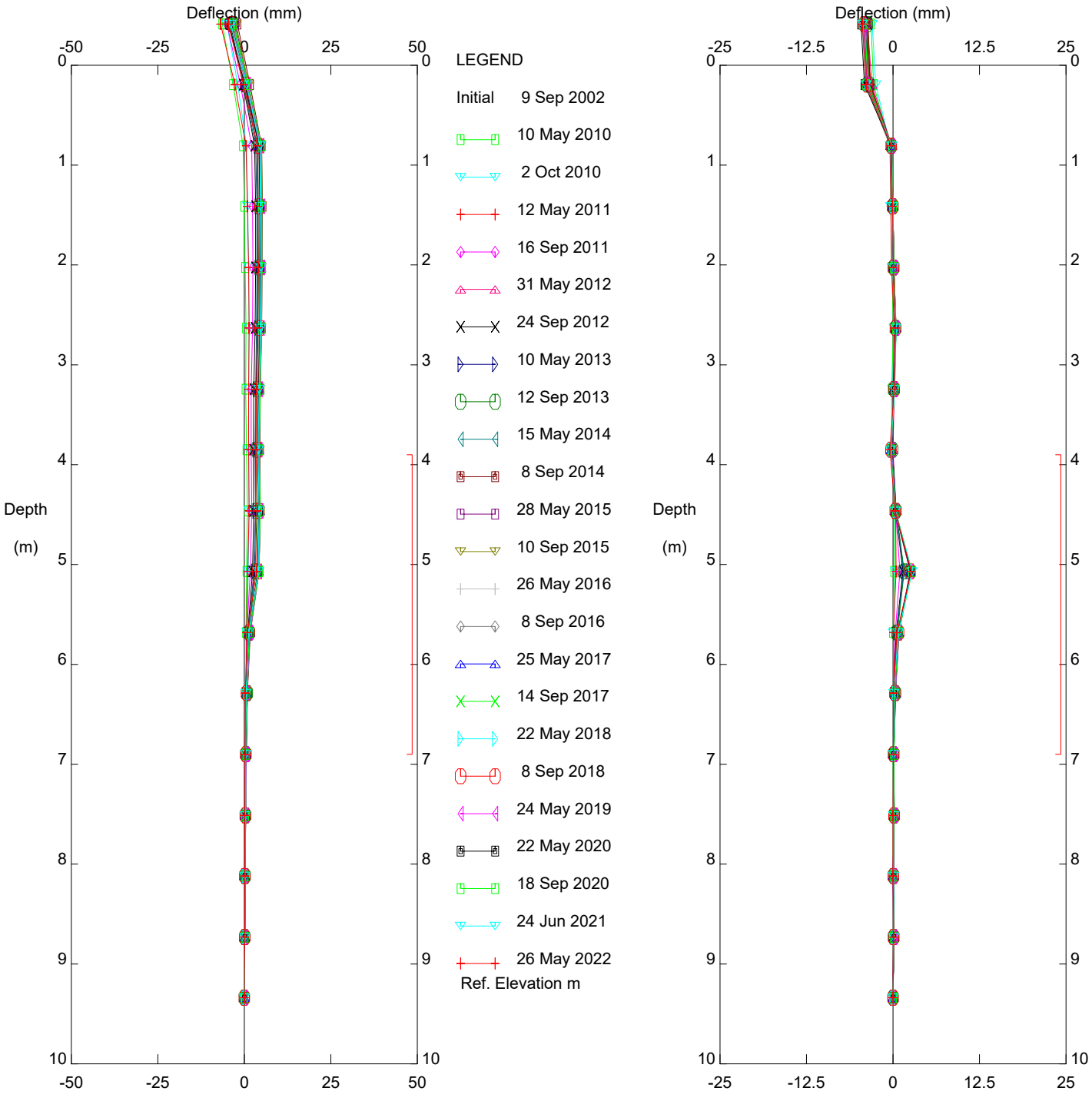

Cumulative Deflection

Direction A

Incremental Deflection

Direction A

Hwy 41:23 Kehiwin Lake (NC024), Inclinometer SI02-5

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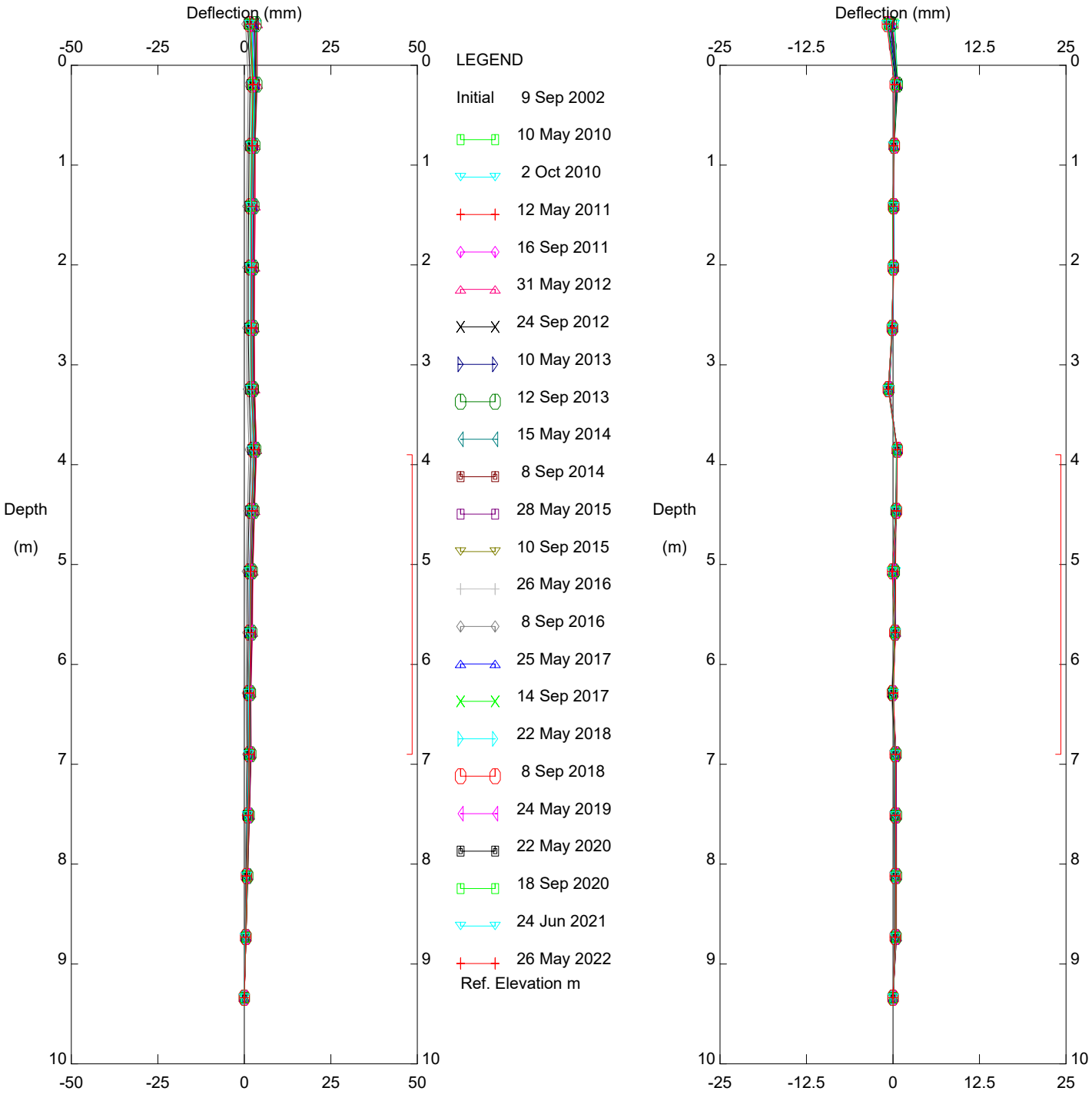

Cumulative Deflection

Direction B

Incremental Deflection

Direction B

Hwy 41:23 Kehiwin Lake (NC024), Inclinometer SI02-5

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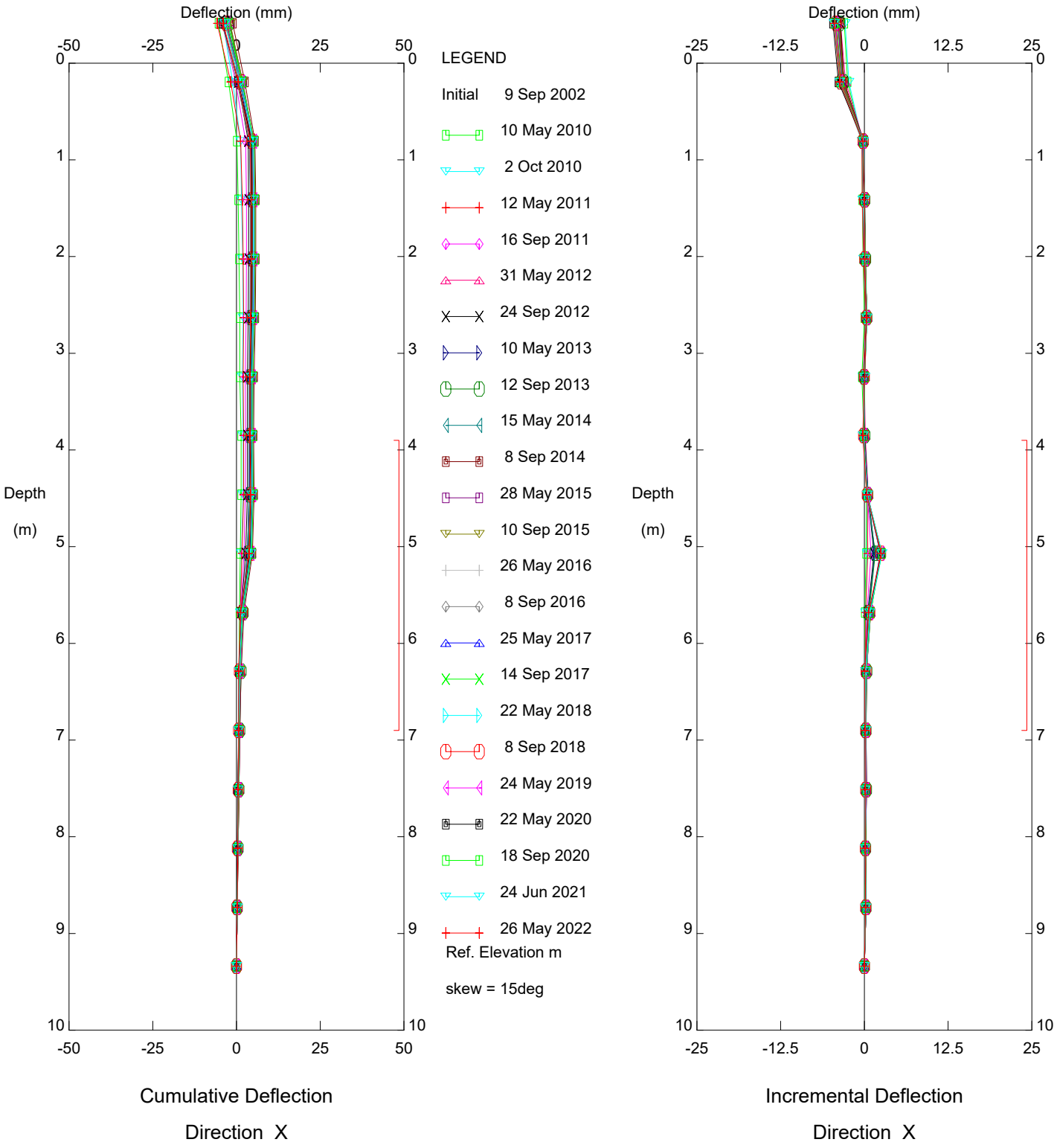

Cumulative Deflection

Direction X

Incremental Deflection

Direction X

Hwy 41:23 Kehiwin Lake (NC024), Inclinometer SI02-5

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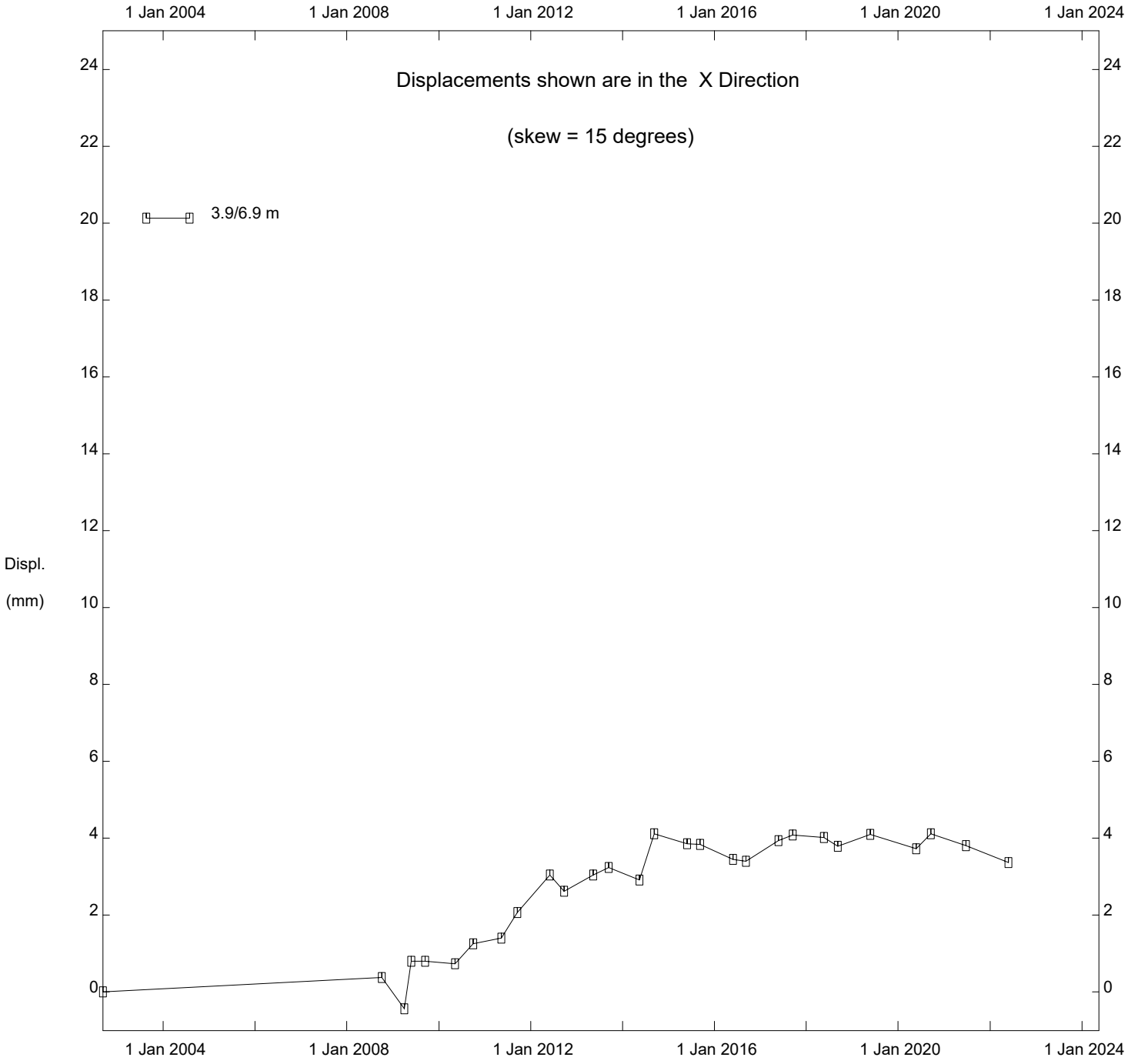

Hwy 41:23 Kehiwin Lake (NC024), Inclinometer SI02-5

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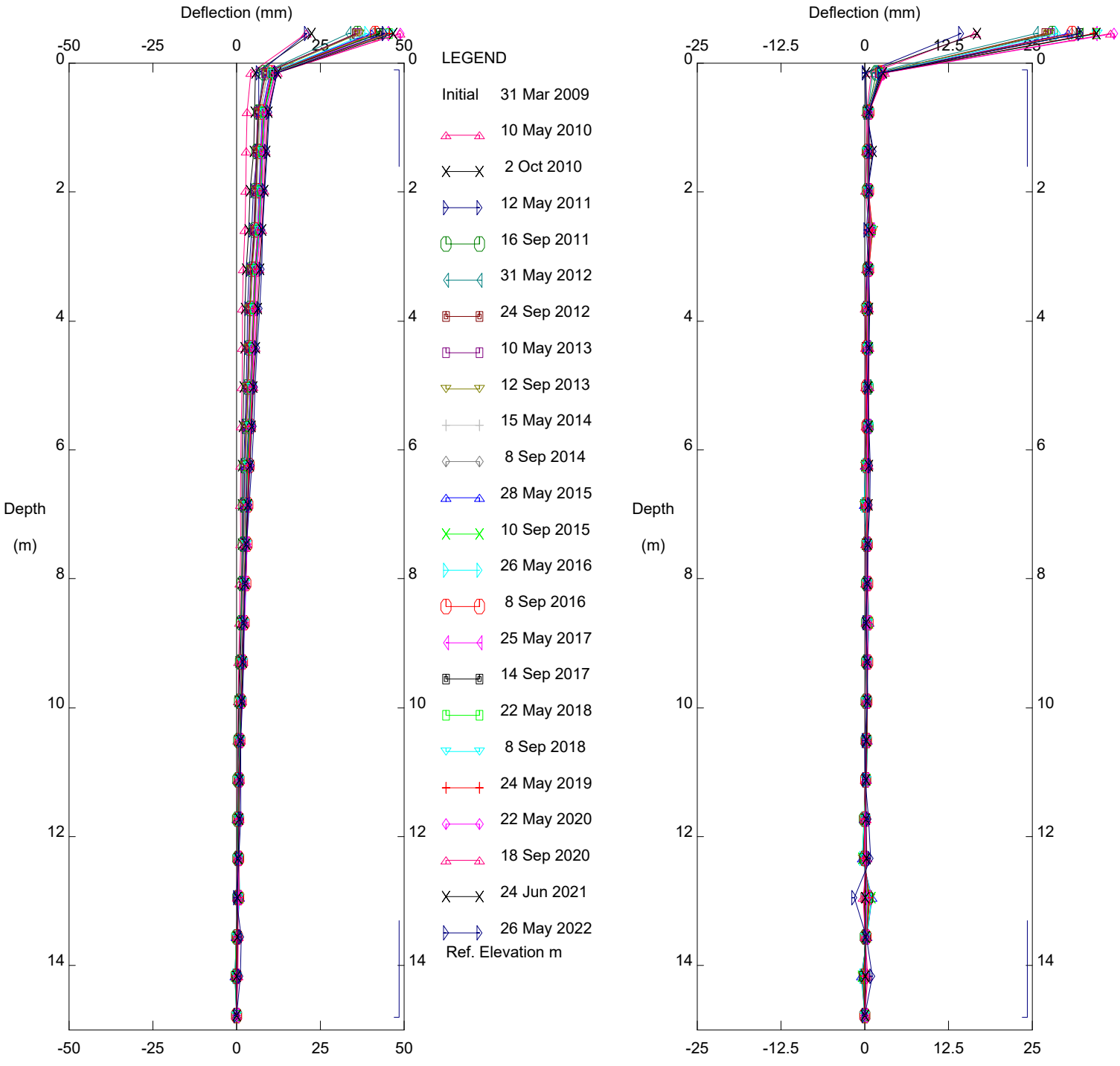

Cumulative Deflection

Direction A

Incremental Deflection

Direction A

Hwy 41:23 Kehiwin Lake (NC024), Inclinometer SI09-1

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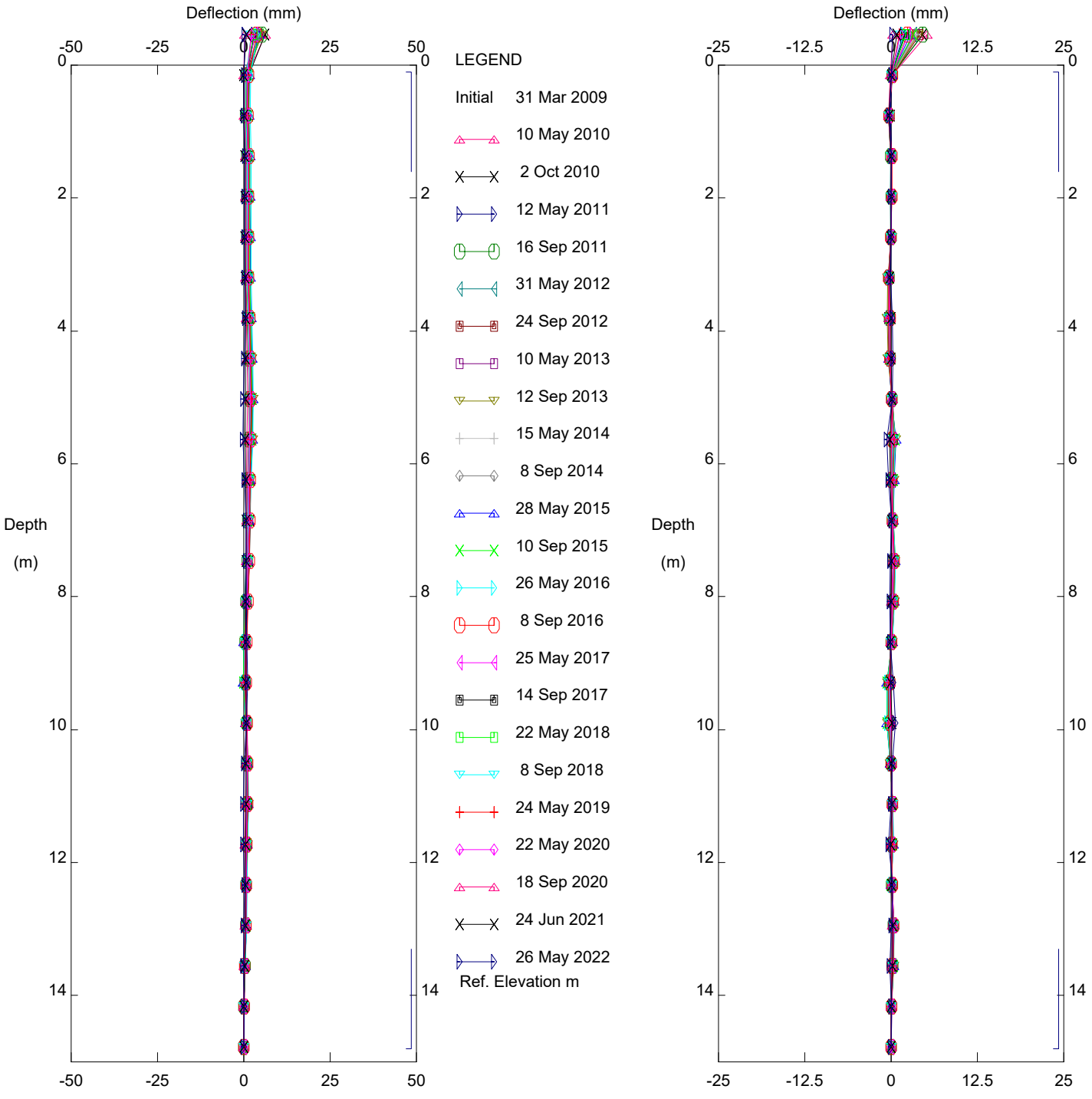

Cumulative Deflection

Direction B

Incremental Deflection

Direction B

Hwy 41:23 Kehiwin Lake (NC024), Inclinometer SI09-1

Alberta Transportation

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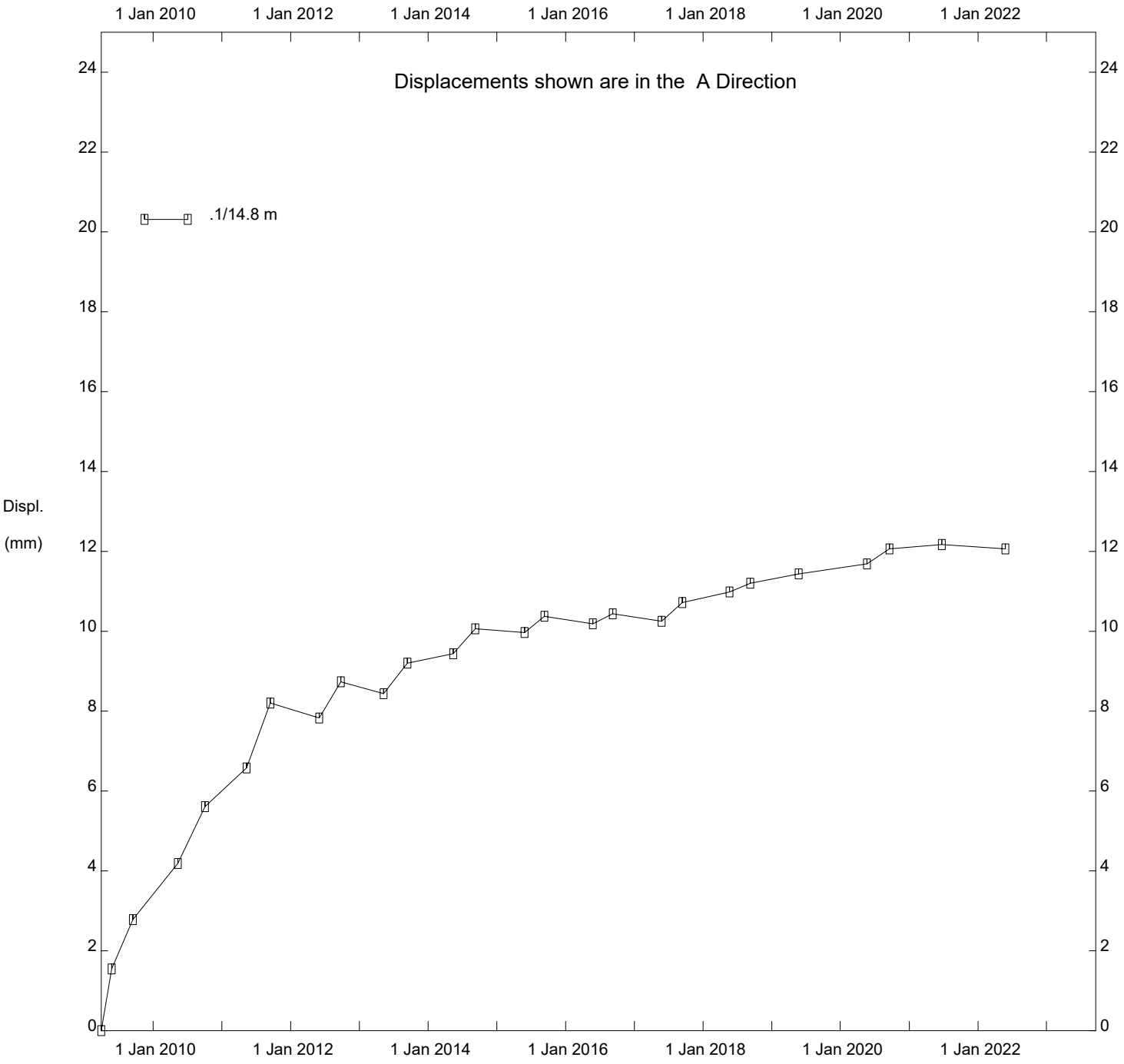

Hwy 41:23 Kehiwin Lake (NC024), Inclinometer SI09-1

Alberta Transportation

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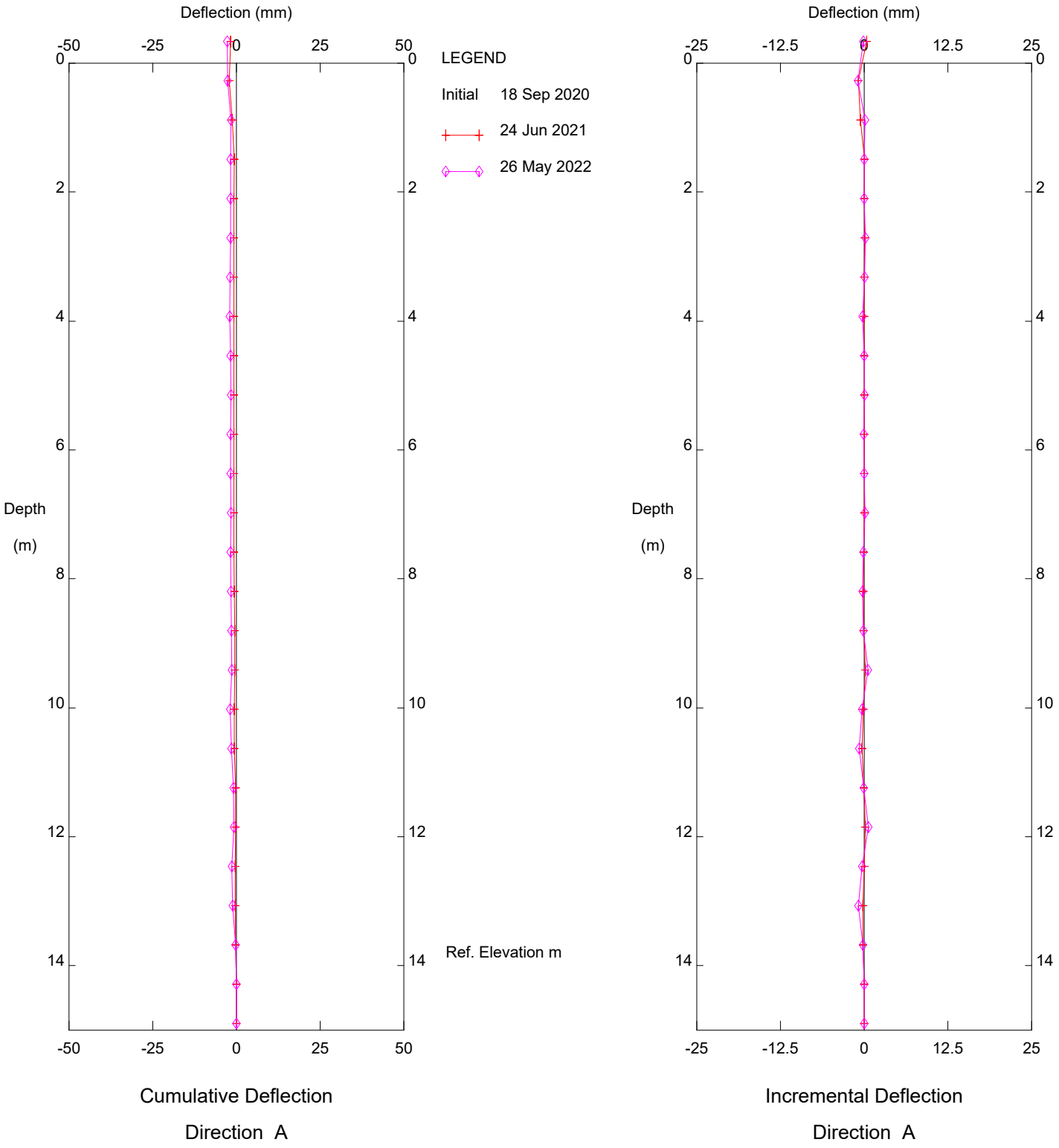

Hwy 41:23 Kehiwin Lake (NC024), Inclinometer SI09-2

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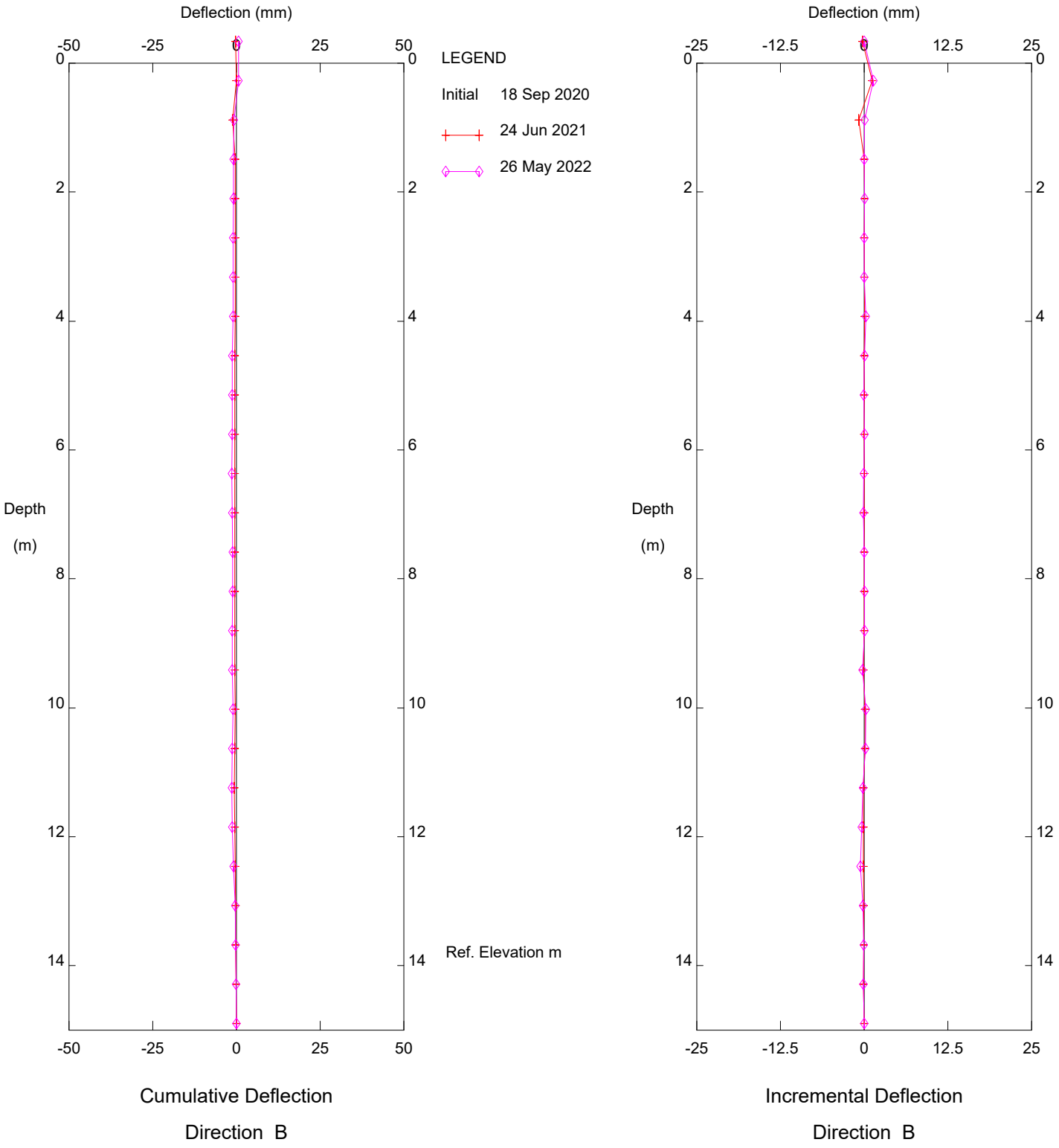

Cumulative Deflection

Direction B

Incremental Deflection

Direction B

Hwy 41:23 Kehiwin Lake (NC024), Inclinometer SI09-2

Alberta Transportation

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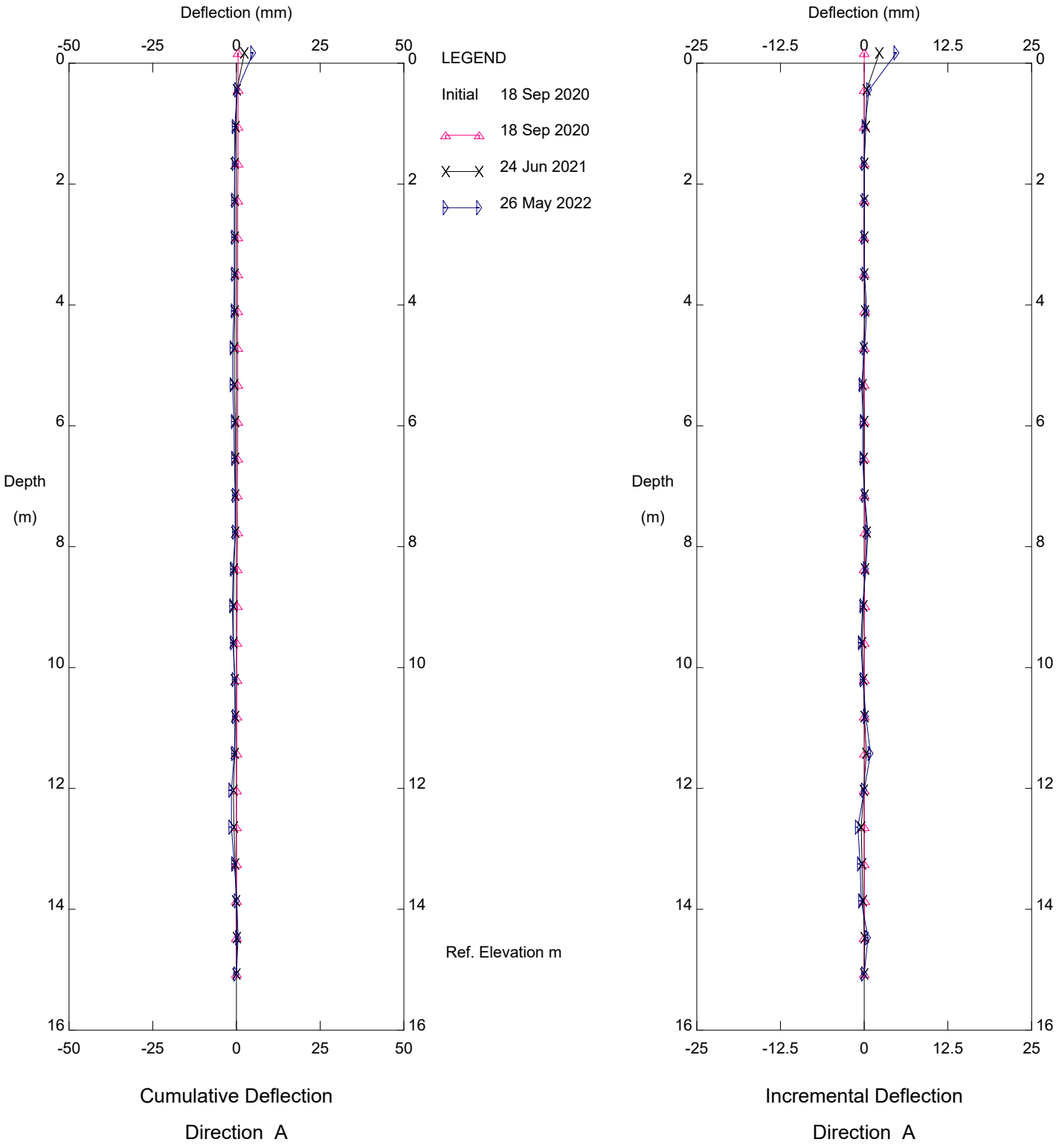
Thurber Engineering Ltd



Cumulative Deflection

Direction A

Incremental Deflection

Direction A

Hwy 41:23 Kehiwin Lake (NC024), Inclinometer SI09-3

Alberta Transportation

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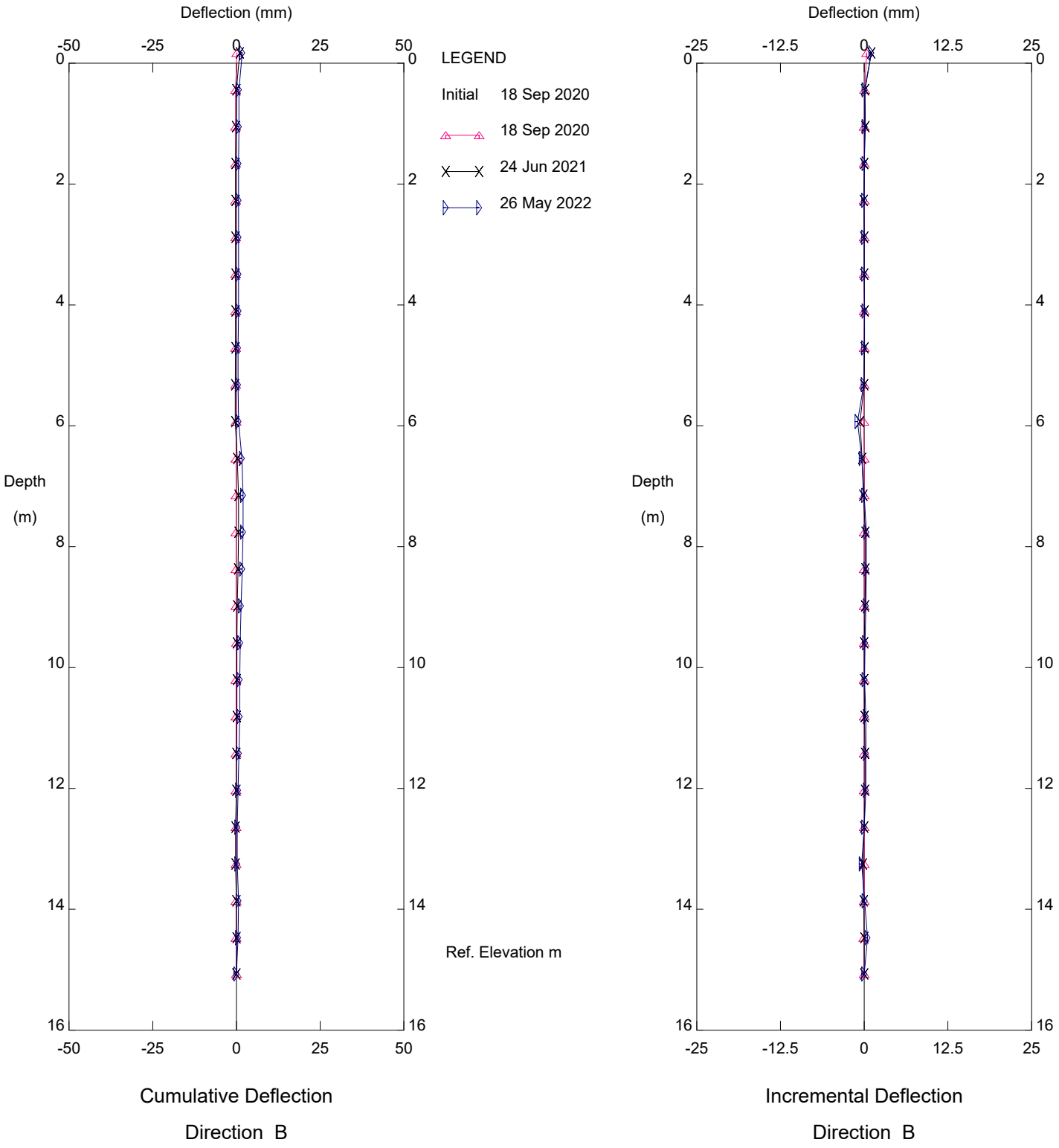
Thurber Engineering Ltd



Cumulative Deflection

Direction B

Incremental Deflection

Direction B

Hwy 41:23 Kehiwin Lake (NC024), Inclinometer SI09-3

Alberta Transportation

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FIGURE NC024-1
STANDPIPE PIEZOMETER DATA FOR NC024 KEHIWIN LAKE