



THURBER ENGINEERING LTD.

July 14, 2023

File No.: 32121

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

Attention: Mr. Max Shannon

**ALBERTA TRANSPORTATION AND ECONOMIC CORRIDORS GRMP (CON0022164)
PEACE REGION (PEACE RIVER DISTRICT)
INSTRUMENTATION MONITORING RESULTS – SPRING 2023**

SECTION C

SITE PH009: OLD HWY 2:02 SHOP SLIDE

Dear Mr. Shannon:

This report provides the results of the bi-annual geotechnical instrumentation monitoring for the above-mentioned site as part of Alberta Transportation and Economic Corridor's Geohazard Risk Management Program (GRMP) for Peace Region – Peace River District (CON0022164).

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

Five slope inclinometers (SI05-1, SI09-3, SI09-4, SI11-1, and SI19-5), eight standpipe piezometers (SP11-06, SP05-1, SP05-4, SP05-5, SP09-8 to SP09-10 and SP19-3), two pneumatic piezometers (PN19-5A and PN19-5B) and two vibrating wire piezometers (VW09-3 and VW09-4) were monitored at the Old Hwy 2:02 Shop Slide site by Mr. Niraj Regmi, G.I.T. and Mr. Omar Elshimi, both of Thurber. The readings from PN19-5A were fluctuating when the instrument was read, indicating damage to the instrument.

The SIs were read using a RST Digital Inclinometer probe with a 2 feet wheelbase and a RST Pocket PC readout. Inclinometer reading depths were defined as per cable markings with respect to the top of the inclinometer casing. A DGSI dipmeter was used to read the standpipe piezometers. The vibrating wire piezometers were read using a GEOKON GK-404 vibrating wire readout. The pneumatic piezometers were read using a RST C108 pneumatic piezometer readout.

Construction of landslide stabilization measures at this site was completed in June 2022. The site was remediated with a 250 m-long pile wall consisting of cast-in-place concrete piles and a concrete waler with 30 m-long tie-backs installed in the north portion. Embedded steel H-piles in



the waler were installed to support a timber lagging retaining structure for the upper 3 m to 4 m of the wall. Downslope of the wall, up to 6.5 m of soil was removed and new rip-rap drainage channels installed to control surface runoff. Other grading improvements were also done in the vicinity such as repair of the upslope ditch and of the sinkhole over the 760 mm SWSP culvert.

The Type 1 and Type 2 wall sections used 1.2 m diameter tangent piles and 1 row of tie-backs. The Type 3 wall used 1.5 m diameter slightly spaced cantilever piles. Slope offloading resulted in a bench level located at about 6.5 m, 4.5 m and 3 m for Type 1, 2 and 3, respectively, below the top of the lagged wall section.

Three shape accelerometer arrays (SAAs) and strain gauges were installed in one representative pile in each of the three wall sections (Type 1, Type 2, and Type 3). Load cells were installed on five of the tie-back anchors. The SAAs, strain gauges and load cells were wired to a Campbell Scientific CR6 datalogger which was programmed to take readings every 6 hours. The datalogger was also connected to a modem to allow for remote downloading of data via Loggernet software.

2. DATA PRESENTATION

2.1 General

SI and SAA plots for A and B directions are included in Appendix A. Where movement has been recorded, the resultant plot (X direction, if applicable) and rate of movement have also been provided. Piezometer, strain gauge and load cell reading plots are also included in Appendix A.

The SAAs were read manually during construction. Before the SAAs were wired to the datalogger at the end of construction, the top portion of each instrument was unintentionally unlocked by the Contractor, and the SAAs had to be reset in their respective piles. As a result, the manual SAA readings cannot be matched to the data collected to the datalogger. Separate plots of the manual SAA readings, taken between November 24, 2021, and April 13, 2022, and of the SAA readings from the datalogger, taken after May 27, 2022, are provided in Appendix A.

Slope inclinometer and piezometer reading summary tables are provided below.

2.2 Zones of Movement

No new zones of movement were observed in the SIs since the fall of 2022 readings. Zones of movement in the SAAs were defined over the length of their respective piles.

Zones of movements are summarized in Tables PH009-1 (SIs) and PH009-2 (SAAs) below. Tables PH009-1 and PH009-2 also provide a historical account of the total movement, the depth of movement and the maximum rate of movement that has occurred in the SIs and SAAs since initialization.



SIs that are no longer active at the site are summarized in Table PH009-1A, for reference.

It should be noted that the ground elevations and stickups of several of the SIs (SI09-4, SI11-1, and SI19-5) were affected by the grading work during construction, and the reported zones of movement have been adjusted to reflect these changes.



**TABLE PH009-1
 SPRING 2023 – OLD HWY 2:02 SHOP SLIDE
 SLOPE INCLINOMETER INSTRUMENTATION READING SUMMARY**

Date Monitored: June 13, 2023

INSTRUMENT #	DATE INITIALIZED	TOTAL CUMULATIVE RESULTANT MOVEMENT AT NOTED DEPTH SINCE INITIAL READING (mm)	MAXIMUM RATE OF MOVEMENT (mm/yr)	CURRENT STATUS	DATE OF PREVIOUS READING	INCREMENTAL MOVEMENT SINCE PREVIOUS READING	CURRENT RATE OF MOVEMENT (mm/yr)	CHANGE IN RATE OF MOVEMENT SINCE PREVIOUS READING (mm/yr)
SI05-1	Jun.6, 2005	34.3 mm over 0.0 m to 3.0 m depth in 56° direction	21.0 mm/yr between Sept. 2010 and May 2011	Operational	September 29, 2022	No discernible movement	No discernible movement	32.4
SI09-3	August 20, 2009	No discernible movement	N/A	Operational	September 29, 2022	N/A	N/A	N/A
SI09-4	June 13, 2020 (Reinitialized)	6.1 mm over 8.6 m to 10.5 m depth in 54° direction	6.9 mm/yr in October 2021	Operational	September 29, 2022	0.2	0.2	-1.0
		3.5 mm over 11.7 m to 13.5 m depth in 54° direction	13.0 mm/yr in October 2021			0.3	0.4	-0.1
SI11-01	May 21, 2015	15.6 mm over 13.9 m to 16.3 m depth in 81° direction	34.3 mm/yr in June 14, 2022	Operational	September 29, 2022	2.9	4.1	-1.1
SI19-5	June 25, 2019	8.5 mm over 8.2 m to 11.2 m depth in 111° direction	8.8 mm/yr in September 2023	Operational	September 29, 2022	No discernible movement	N/A	-4.3
		10. mm over 17.9 m to 19.7 m depth in 111° direction	12.4 mm/yr in July 2021			0.2	0.2	-2.9

Drawings 32121-PH009-1 through 32121-PH009-3 in Appendix A provide a sketch of the approximate location of the monitoring instrumentation for this site



**TABLE PH009-1A
 SPRING 2023 – OLD HWY 2:02 SHOP SLIDE
 SLOPE INCLINOMETER INSTRUMENTATION READING SUMMARY (INACTIVE INSTRUMENTS)**

Date Monitored: Not monitored

INSTRUMENT #	DATE INITIALIZED	TOTAL CUMULATIVE RESULTANT MOVEMENT AT NOTED DEPTH SINCE INITIAL READING (mm)	MAXIMUM RATE OF MOVEMENT (mm/yr)	CURRENT STATUS	DATE OF PREVIOUS READING	INCREMENTAL MOVEMENT SINCE PREVIOUS READING	CURRENT RATE OF MOVEMENT (mm/yr)	CHANGE IN RATE OF MOVEMENT SINCE PREVIOUS READING (mm/yr)
SI05-2	Jun. 6, 2005	70.6 mm over 0.2 m to 11.8 m depth in 20° direction	33.9 mm/yr between Oct. 2007 and May 2008	Sheared at 10.7 m depth	May 27, 2009	N/A	N/A	N/A
		73.0 mm over 8.7 m to 11.8 m depth in 20° direction	36.4 mm/yr between May and Oct. 2007			N/A	N/A	N/A
SI05-3	Jun. 6, 2005	3.8 mm over 0.2 m to 2 m depth in 15° direction	9.2 mm/yr between May 2009 and Sept. 2009	Sheared at 17.5 m depth	September 23, 2009	N/A	N/A	N/A
		8.0 mm over 8.1 m to 10 m depth in 15° direction	6.1 mm/yr between May and Oct. 2007			N/A	N/A	N/A
		11.2 mm over 11.8 m to 14.2 m depth in 15° direction	9.1 mm/yr between May and Oct. 2007			N/A	N/A	N/A
		23.8 mm over 15.5 m to 17.9 m depth in 15° direction	11.6 mm/yr between May and Oct. 2007			N/A	N/A	N/A
		4.2 mm over 19.7 m to 22.2 m depth in 15° direction	2.7 mm/yr between Jun. and Aug. 2005			N/A	N/A	N/A

Drawings 32121-PH009-1 through 32121-PH009-3 in Appendix A provide a sketch of the approximate location of the monitoring instrumentation for this site



**TABLE PH009-1A – CONTINUED...
 SPRING 2023 – OLD HWY 2:02 SHOP SLIDE
 SLOPE INCLINOMETER INSTRUMENTATION READING SUMMARY (INACTIVE INSTRUMENTS)**

Date Monitored: Not monitored

INSTRUMENT #	DATE INITIALIZED	TOTAL CUMULATIVE RESULTANT MOVEMENT AT NOTED DEPTH SINCE INITIAL READING (mm)	MAXIMUM RATE OF MOVEMENT (mm/yr)	CURRENT STATUS	DATE OF PREVIOUS READING	INCREMENTAL MOVEMENT SINCE PREVIOUS READING	CURRENT RATE OF MOVEMENT (mm/yr)	CHANGE IN RATE OF MOVEMENT SINCE PREVIOUS READING (mm/yr)
SI05-4	Jun. 6, 2005	53.8 mm over 5.2 m to 8.3 m depth in 47° direction	21 mm/yr between May and Oct. 2007	Sheared at 6.7 m depth	June 9, 2012	N/A	N/A	N/A
SI09-1	August 20, 2009	152.1 mm over 0.3 m to 2.2 m depth in 50° direction	215.6 mm/yr in May 2011	Sheared at 1.8 m depth	June 1, 2011	N/A	N/A	N/A
		3.4 mm over 7.1 m to 8.3 m depth in 50° direction	5.8 mm/yr in September 2009			N/A	N/A	N/A
		10.6 mm over 11.9 m to 13.8 m depth in 50° direction	29.0 mm/yr in September 2009			N/A	N/A	N/A
SI09-2	August 20, 2009	156.4 mm over 0.1 m to 3.8 m depth in 25° direction	270.4 mm between May 2009 and September 2010	Destroyed	September 21, 2010	N/A	N/A	N/A

Drawings 32121-PH009-1 through 32121-PH009-3 in Appendix A provide a sketch of the approximate location of the monitoring instrumentation for this site



**TABLE PH009-2
 SPRING 2023 – OLD HWY 2:02 SHOP SLIDE
 SHAPE ACCELEROMETER ARRAY INSTRUMENTATION READING SUMMARY**

Date Monitored: June 13, 2023

INSTRUMENT #	DATE INITIALIZED	TOTAL CUMULATIVE RESULTANT MOVEMENT AT NOTED DEPTH SINCE INITIAL READING (mm)	CURRENT STATUS	DATE OF PREVIOUS READING	INCREMENTAL MOVEMENT SINCE PREVIOUS READING (mm)	AVERAGE RATE OF MOVEMENT⁽¹⁾ (mm/yr)	CHANGE IN AVERAGE RATE OF MOVEMENT SINCE PREVIOUS READING (mm/yr)
Manual Readings November 24, 2021 – April 13, 2022⁽¹⁾							
SAA-P34	November 24, 2021	13.0 over 1.8 m to 20.8 m depth	Operational	April 13, 2022	N/A	33.8	N/A
SAA-P77	November 24, 2021	18.4 over 1.8 m to 20.8 m depth	Operational	January 19, 2022 ⁽²⁾	N/A	119.7	N/A
SAA-P113	February 2, 2022	3.9 over 1.4 m to 25.9 m depth	Operational	April 13, 2022	N/A	20.1	N/A
Datalogger Readings May 27, 2022 - Current							
SAA-P34	May 27, 2022	6.0 over 1.8 m to 20.8 m depth	Operational	November 24, 2022	2.7	4.9	-1.8
SAA-P77	May 27, 2022	1.6 over 1.8 m to 20.8 m depth	Operational	November 24, 2022	0.0	0.0	-3.2
SAA-P113	May 27, 2022	9.3 over 1.4 m to 25.9 m depth	Operational	November 24, 2022	2.7	4.9	-8.4

Drawings 32121-PH009-1 through 32121-PH009-3 in Appendix A provide a sketch of the approximate location of the monitoring instrumentation for this site
 Notes:

- 1) Average rate of movement for manual readings is the average movement rate for entire monitoring period from November 24, 2021 to April 13, 2022. The average movement rate for the data logger readings is the average movement rate between November 24, 2022 and June 13, 2023.



**TABLE PH009-3
 SPRING 2023 – OLD HWY 2:02 SHOP SLIDE
 VIBRATING WIRE STRAIN GAUGE INSTRUMENTATION READING SUMMARY**

Date Monitored: June 13, 2023

DEPTH FROM TOP OF PILE (m)	GAUGE #	TOTAL MICROSTRAIN (µε)	CHANGE IN MICROSTRAIN SINCE PREVIOUS READINGS* (µε)	MEASURED TEMPERATURE (°c)	GAUGE #	TOTAL MICROSTRAIN (µε)	CHANGE IN MICROSTRAIN SINCE PREVIOUS READINGS* (µε)	MEASURED TEMPERATURE (°c)
PILE P34								
UPSLOPE PILE FACE					DOWNSLOPE PILE FACE			
1.2	SR1854	-37.6	40.0	13.8	SR1853	24.5	72.9	16.9
2.0	SE1017 (2 Tapes)	46.9	52.3	14.4	SE1017 (3 Tapes)	-79.2	25.1	11.1
3.3	SR1851	-73.0	14.9	7.5	SR1849	13.3	18.8	8.5
4.1	SE1017 (0 Tapes)	-85.3	3.8	6.1	SE1017 (1 Tape)	-19.1	6.1	6.6
5.1	SR1846	-57.5	7.0	5.5	SR1845	-20.9	-10.6	5.5
7.2	SR1843	45.7	12.1	6.3	SR1842	-118.6	-21.5	6.2
9.3	SR1841	121.4	14.5	7.5	SR1840	-202.1	-26.6	7.4
11.1	SR1839	107.3	12.8	7.9	SR1838	-130.0	-8.5	7.9
13.2	SR1837	48.3	7.0	8.1	SR1835	-61.6	0.2	8.0
15.0	SR1834	12.0	4.5	8.1	SR1832	-39.4	0.8	8.1
17.2	SR1831	-1.0	3.8	7.9	SR1829	-14.2	3.5	7.9

Drawings 32121-PH009-1 through 32121-PH009-3 in Appendix A provide a sketch of the approximate locations of the monitoring instrumentation for this site.
 * Previous readings on November 24, 2022



**TABLE PH009-3 – CONTINUED...
 SPRING 2023 – OLD HWY 2:02 SHOP SLIDE
 VIBRATING WIRE STRAIN GAUGE INSTRUMENTATION READING SUMMARY**

Date Monitored: June 13, 2023

DEPTH FROM TOP OF PILE (m)	GAUGE #	TOTAL MICROSTRAIN (µε)	CHANGE IN MICROSTRAIN SINCE PREVIOUS READINGS* (µε)	MEASURED TEMPERATURE (°c)	GAUGE #	TOTAL MICROSTRAIN (µε)	CHANGE IN MICROSTRAIN SINCE PREVIOUS READINGS* (µε)	MEASURED TEMPERATURE (°c)
PILE P77								
UPSLOPE PILE FACE					DOWNSLOPE PILE FACE			
1.00	SR1865	-15.5	19.6	8.3	SR1861	-47.3	19.7	9.6
2.85	SR1857	-10.9	6.3	5.5	SR1856	-57.4	-7.0	5.8
5.00	SR1855	-30.2	2.5	5.8	SR1852	-99.8	-15.9	5.6
7.10	SR1850	-3.4	2.9	6.7	SR1848	-135.7	-13.1	6.5
8.95	SR1847	-2.5	4.4	7.6	SR1844	-129.1	-6.3	7.4
11.05	SR1836	-30.0	3.8	7.9	SR1833	-98.6	-2.0	7.9
12.90	SR1830	-37.7	0.9	8.0	SR1828	-78.5	-1.8	8.0
15.00	SR1827	-24.5	0.2	7.9	SR1826	-51.5	0.2	7.9
17.10	SR1825	-31.4	0.8	7.7	SR1824	-44.4	-0.4	7.8

Drawings 32121-PH009-1 through 32121-PH009-3 in Appendix A provide a sketch of the approximate locations of the monitoring instrumentation for this site.

* Previous readings on May 27, 2022



**TABLE PH009-3 – CONTINUED...
 SPRING 2023 – OLD HWY 2:02 SHOP SLIDE
 VIBRATING WIRE STRAIN GAUGE INSTRUMENTATION READING SUMMARY**

Date Monitored: June 13, 2023

DEPTH FROM TOP OF PILE (m)	GAUGE #	TOTAL MICROSTRAIN (µε)	CHANGE IN MICROSTRAIN SINCE PREVIOUS READINGS* (µε)	MEASURED TEMPERATURE (°c)	GAUGE #	TOTAL MICROSTRAIN (µε)	CHANGE IN MICROSTRAIN SINCE PREVIOUS READINGS* (µε)	MEASURED TEMPERATURE (°c)
PILE P113								
UPSLOPE PILE FACE					DOWNSLOPE PILE FACE			
1.0	SR1820	<i>Not functioning</i>	<i>N/A</i>	7.4	SR1821	-69.1	7.5	8.0
2.8	SR1822	-17.6	2.0	5.4	SR1823	-92.4	-8.8	8.4
4.9	SR1806	-27.0	-0.3	6.2	SR1807	-76.3	-8.7	6.1
6.9	SR1808	-21.6	0.6	6.6	SR1809	-60.3	-1.8	7.0
9.0	SR1810	-26.0	-0.3	7.8	SR1811	<i>Not functioning</i>	<i>N/A</i>	7.8
11.2	SR1812	-8.4	0.4	8.1	SR1813	-66.9	1.5	8.0
13.3	SR1814	27.8	6.0	8.1	SR1815	-64.7	3.8	8.1
15.3	SR1816	68.5	9.3	8.1	SR1817	-78.9	1.0	8.1
17.0	SR1818	5.6	7.9	8.0	SR1819	-92.9	-1.7	8.0
19.0	SR1858	-20.0	1.9	7.9	SR1859	-119.0	-6.3	7.8
21.2	SR1860	-60.5	1.6	7.7	SR1862	-100.1	-3.9	7.7
23.2	SR1863	42.9	13.5	7.4	SR1864	-14.0	5.8	7.4

Drawings 32121-PH009-1 through 32121-PH009-3 in Appendix A provide a sketch of the approximate locations of the monitoring instrumentation for this site.

* Previous readings on May 27, 2022



**TABLE PH009-4
 SPRING 2023 – OLD HWY 2:02 SHOP SLIDE
 VIBRATING WIRE LOAD CELL INSTRUMENTATION READING SUMMARY**

Date Monitored: June 13, 2023

ANCHOR NUMBER	LOAD CELL SERIAL #	WALL SECTION	SLS DESIGN LOAD / LOCK-OFF LOAD (kN)	MAXIMUM RECORDED LOAD (kN)	RECORDED LOAD ⁽¹⁾ (JUNE 13, 2023) (kN)	PREVIOUS RECORDED LOAD ⁽¹⁾ (NOV. 24, 2022) (kN)	CHANGE IN LOAD SINCE PREVIOUS READING (kN)
A19	VC2340	1	202/100	219.52 on June 4, 2023	215.38	178.57	36.81
A34	VC2341	1	202/100	229.54 on April 7, 2023	202.51	175.59	26.92
A51	VC2342	1	202/100	206.49 on April 1, 2023	166.02	163.47	2.54
A67	VC2343	2	160/100	134.22 on April 1, 2023	126.39	116.49	9.90
A77	VC2344	2	160/100	198.25 on June 9, 2023	194.34	157.91	36.43

Drawings 32121-PH009-1 through 32121-PH009-3 in Appendix A provide a sketch of the approximate locations of the monitoring instrumentation for this site.

* Previous readings on May 27, 2022



**TABLE PH009-5
 SPRING 2023 – OLD HWY 2:02 SHOP SLIDE
 STANDPIPE PIEZOMETER INSTRUMENTATION READING SUMMARY**

Date Monitored: June 13, 2023

INSTRUMENT #	DATE INITIALIZED	TIP DEPTH (m)	GROUND ELEV. (m)	CURRENT STATUS	MAXIMUM MEASURED WATER LEVEL BGS (m)	MEASURED WATER LEVEL BGS (m)	PREVIOUS READING BGS (m)	CHANGE IN WATER LEVEL SINCE PREVIOUS READING (m)
SP11-06	May 21, 2015	12.98	-	Active	8.31 on June 15, 2018	DRY	DRY	N/A
SP05-1	Jun. 6, 2005	9.91	N/A	Active	1.56 on June 9, 2012	7.65	7.21	-0.44
SP05-4	Jun. 6, 2005	9.91	N/A	Active	4.80 on May 18, 2008	5.80	6.10	0.30
SP05-5	Jun. 6, 2005	12.04	N/A	Active	2.55 on May 18, 2007	2.94	2.62	-0.32
SP09-8	August 20, 2009	23.77	393.778	Active	N/A	DRY	DRY	N/A
SP09-9	August 20, 2009	11.28	361.294	Active	N/A	DRY	DRY	N/A
SP09-10	August 17, 2009	21.03	379.506	Active	7.05 on June 15, 2018	8.34	8.36	0.02
SP19-3	February 7, 2019	9.25	393.650	Active	3.44 on June 13, 2020	4.40	4.35	-0.05

Drawings 32121-PH009-1 through 32121-PH009-3 in Appendix A provide a sketch of the approximate location of the monitoring instrumentation for this site



**TABLE PH009-6 – CONTINUED...
 SPRING 2023 – OLD HWY 2:02 SHOP SLIDE
 VIBRATING WIRE PIEZOMETER INSTRUMENTATION READING SUMMARY**

Date Monitored: June 13, 2023

INSTRUMENT	DATE INITIALIZED	TIP ELEV. (m)	GROUND ELEV. (m)	CURRENT STATUS	HIGHEST MEASURED WATER LEVEL ELEVATION (Depth, mBGS)	CURRENT GROUNDWATER ELEVATION (m) (DEPTH, (mBGS))	PREVIOUS GROUNDWATER ELEVATION (m) (DEPTH, (mBGS))	CHANGE IN WATER LEVEL SINCE PREVIOUS READING (m)
VW09-3 (10022)	August 18, 2009	356.40	361.73	Operational	359.86 m on August 18, 2009 (1.87)	DRY	DRY	N/A
VW09-4 (10021)	August 17, 2009	361.19	379.58	Operational	373.29 m on August 17, 2009 (7.26)	365.65 (13.93)	365.85 (13.73)	-0.20

Drawings 32121-PH009-1 through 32121-PH009-3 in Appendix A provide a sketch of the approximate location of the monitoring instrumentation for this site
 Note: BGS = Below Ground Surface



**TABLE PH009-7
 SPRING 2023 – OLD HWY 2:02 SHOP SLIDE
 PNEUMATIC PIEZOMETER INSTRUMENTATION READING SUMMARY**

Date Monitored: June 13, 2023

INSTRUMENT #	DATE INITIALIZED	TIP DEPTH (m)	GROUND ELEV. (m)	CURRENT STATUS	HIGHEST MEASURED WATER LEVEL BGS (m)	MEASURED PORE PRESSURE (kPa)	CURRENT GROUNDWATER ELEVATION (m) (Depth, mBGS)	PREVIOUS GROUNDWATER ELEVATION (m) (Depth, mBGS)	CHANGE IN WATER LEVEL SINCE PREVIOUS READING (m)
PN19-5A	February 14, 2019	9.30	372.11	Damaged	365.55 on February 14, 2019	N/A	N/A	362.90 (9.21)	N/A
PN19-5B	February 14, 2019	19.25	372.11	Active	367.41 on August 18, 2021	135.1	366.64 (5.48)	366.70 (5.41)	-0.07

Drawings 32121-PH009-1 through 32121-PH009-3 in Appendix A provide a sketch of the approximate location of the monitoring instrumentation for this site
 Note: BGS = Below Ground Surface



3. INTERPRETATION OF MONITORING RESULTS

Slope inclinometer SI05-1 showed no discernible movement over 0.0 m to 3.0 m depth since the fall of 2022 readings. SI09-3 continued to show no discernible movement. SI09-4 showed rates of movement of 0.2 mm/yr and 0.4 mm/yr over 8.6 m to 10.5 m depth and 11.7 m to 13.5 m depth, respectively, since the fall of 2022 readings. These movement zones were first observed in 2021 during construction and displacement has been increasing slightly with each subsequent set of readings. The upper portion of SI09-4 was bent during grading and related shortening of the instrument during construction. SI11-01 showed a rate of movement of 4.1 mm/yr over 13.9 m to 16.3 m depth. SI11-01 showed a maximum rate of movement of 34.3 mm/yr over this zone in June 14, 2022, near the end of construction, however the movement rate has decreased for two consecutive readings cycles. SI19-5 showed no discernible movement over 8.2 m to 11.2 m depth and a rate of movement of 0.2 mm/yr over 17.9 m to 19.7 m depth. The overall movement in SI19-5 has slowed significantly since slope offloading and the completion of construction.

It is anticipated that the concrete pile wall and associated lower slope offloading and flattening will eventually reach a new equilibrium, and there should be a further reduction in the rates of movement in the inclinometers at this site. However, SI11-01 is located just beyond the north limits of the wall and will need to be watched carefully to see if additional slope stabilization measures are warranted.

SAA-P34 has shown an average rate of movement of 4.9 mm/yr in the downslope direction since the fall of 2022 readings, with a current pile head movement of 6.0 mm since datalogger readings began for this instrument on May 27, 2022. SAA-P34 showed an increased rate of movement during the winter months and showed a maximum pile head movement of close to 10 mm in early April 2023 before moving in the upslope direction. This increased movement in the winter months appears to correspond to the increased load cell readings also observed at this pile over the same time period and is considered to be due to expansion of the soil behind the wall upon freezing.

SAA-P77 showed no movement since the fall of 2022 readings. SAA-P77 has shown a total pile head movement of 1.6 mm since datalogger readings began on May 27, 2022. SAA-P77 showed movement in the downslope direction during the winter months before showing an upslope movement trend starting in late March 2023. However, the movement trend in SAA-P77 was much less pronounced than in SAA-P34.

SAA-P113 has shown an average rate of movement of 4.9 mm/yr in the downslope direction since the fall of 2022 readings, with a total pile head movement of 9.3 mm since datalogger readings began on May 27, 2022. The higher observed movement in SAA-P113 can be attributed to the fact that the pile wall at this location is a cantilever arrangement, and not a tied-back wall. The last two months of readings in this SAA show a trend of accelerating movement, and this instrument should be closely monitored to see if this trend continues. The total pile head deflection to date, combining the data before and after resetting the SAA has been at least 13.2 mm.

Overall, the SAA data collected since May 27, 2022, indicates that the current rate of movement in the SAAs is lower than what was observed by the manual readings. This can likely be attributed



to the completion of the pile wall, locking off of the anchors in wall type 1 and wall type 2, and the regrading/offloading work completed downslope of the wall.

The vibrating wire strain gauges are summarized in Table PH009-3. The strain gauges are primarily RST VW5000-15 sister-bar style strain gauges; however, there are also 4 RST VWSG-E embedment style strain gauges installed in P34 in pairs at 2.0 m depth and 4.1 m depth. After completion of construction, it was noted that the datalogger program was programmed to read the VWSG-E gauges at the wrong frequency sweep range, which caused erroneous data to be collected for these instruments before November 24, 2022. As such, the strain gauge plots for P34 are missing readings for these 4 strain gauges prior to this date.

The strain gauges in P34 show their maximum positive (tension) strain (121.4 microstrain) on the upslope pile face at around 9 m depth, with a corresponding trend of negative (compression) strain (-202.1 microstrain) on the downslope pile face at the same depth. This seems to correspond to the observed deflection of the pile in the downslope direction noted in the SAA above 9 m depth. The strain gauges on the downslope side of P77 indicate a maximum negative strain of -135.7 microstrain at a depth of 7.1 m. P77 does not show as clear of a trend of strain in the upslope pile strain gauges compared to P34. The upslope strain gauges for P113 show a noticeable increase in positive strain at 15 m depth on the upslope face of the pile, which may indicate an inflection point where the pile is bending. The strain gauges are plotted on Figures PH009-1 through PH009-9 in Appendix A.

The load cell readings are summarized in Table PH009-4. All of the anchors show an increase in measured load compared to the fall of 2022 readings, ranging from 2.54 kN in VC2342 (anchor A51) to 36.81 kN in VC2340 (anchor A19). All of the anchors also recorded all-time high measured loads during a period between April 1, 2023 and June 9, 2023.

The load cells are generally showing a trend of increasing loads. VC3431 (anchor A34), VC2342 (anchor VC2342) and VC2343 (anchor A67) all showed their maximum loads during the late winter months before relaxing during spring thaw. VC2340 (anchor A19) and VC2344 (anchor A77) are showing an overall trend of increasing load, without the post-winter relaxation seen in the other anchors. Overall, the anchor loads have risen significantly since they were locked off, and VC2340 and VC2341 are currently above their SLS design loads. The load cells will need to be closely monitored to see if the increased movement trend continues. The load cell readings are plotted on Figure PH009-10 in Appendix A.

Standpipe piezometers SP05-1, SP05-5 and SP19-3 showed decrease in groundwater level of 0.44 m, 0.32 m and 0.05 m, respectively, since the fall of 2022 readings. Standpipe piezometers SP05-4 and SP09-10 showed increases in groundwater level of 0.30 m and 0.02 m, respectively, since the fall of 2022 readings. SP11-06, SP09-8 and SP09-9 continued to be dry (SP09-8 and SP09-9 have been dry since installation).

The results of the standpipe piezometers are summarized in Table PH009-5, and are plotted in Figure PH009-11 in Appendix A.

VW09-4 showed a decrease in groundwater level of 0.20 m since the fall of 2022 readings following a general trend for the last decade. VW09-3 has been dry since August 2009. Vibrating



wire piezometer results are summarized in Table PH009-6, and are plotted in Figure PH009-12 in Appendix A.

Pneumatic piezometer PN19-5B showed a slight increase in groundwater level of 0.07 m since the spring of 2022 readings. Pneumatic piezometer results are summarized in Table PH009-7, and are plotted in Figure PH009-13 in Appendix A.

4. RECOMMENDATIONS

4.1 Future Work

The instruments should be read again in the fall of 2023. The movement rates in the slope inclinometers should be closely monitored to see if movements begin to decelerate following the completion of the pile wall. The movement rate in SI11-01 should be monitored carefully as it is beyond the north extent of the wall.

The instruments at the pile wall, particularly for the load cells, will need to be frequently monitored to see if the movement rates increase. At the moment, the loads, strain, and deflections are within acceptable limits based on the modeling done during detailed design of the wall.

4.2 Instrumentation Repairs

Pneumatic piezometer PN19-5A was found to be malfunctioning during the current readings. This instrument has been found to be malfunctioning for two consecutive readings cycles and should be removed from the readings program.



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.
Don Proudfoot, M.Eng., P. Eng.
Partner | Senior Geotechnical Engineer

Bruce Nestor, P.Eng.
Geotechnical Engineer
/ak

Attachments:

- Statement of Limitations and Conditions
- Appendix A
 - Field Inspector's report
 - Site Plan Showing Approximate Instrument Locations (Drawings No. 32121-PH009-1, 32121-PH009-2, and 32121-PH009-3)
 - SI Reading Plots
 - SAA Reading Plots
 - Figures PH009-1 through PH009-9 (Vibrating Wire Strain Gauge Readings)
 - Figure PH009-10 (Vibrating Wire Load Cell Readings)
 - Figure PH009-11 (Standpipe Piezometer Readings)
 - Figure PH009-12 (Vibrating Wire Piezometer Readings)
 - Figure PH009-13 (Pneumatic Piezometer Readings)



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.

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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.

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- 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.

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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.



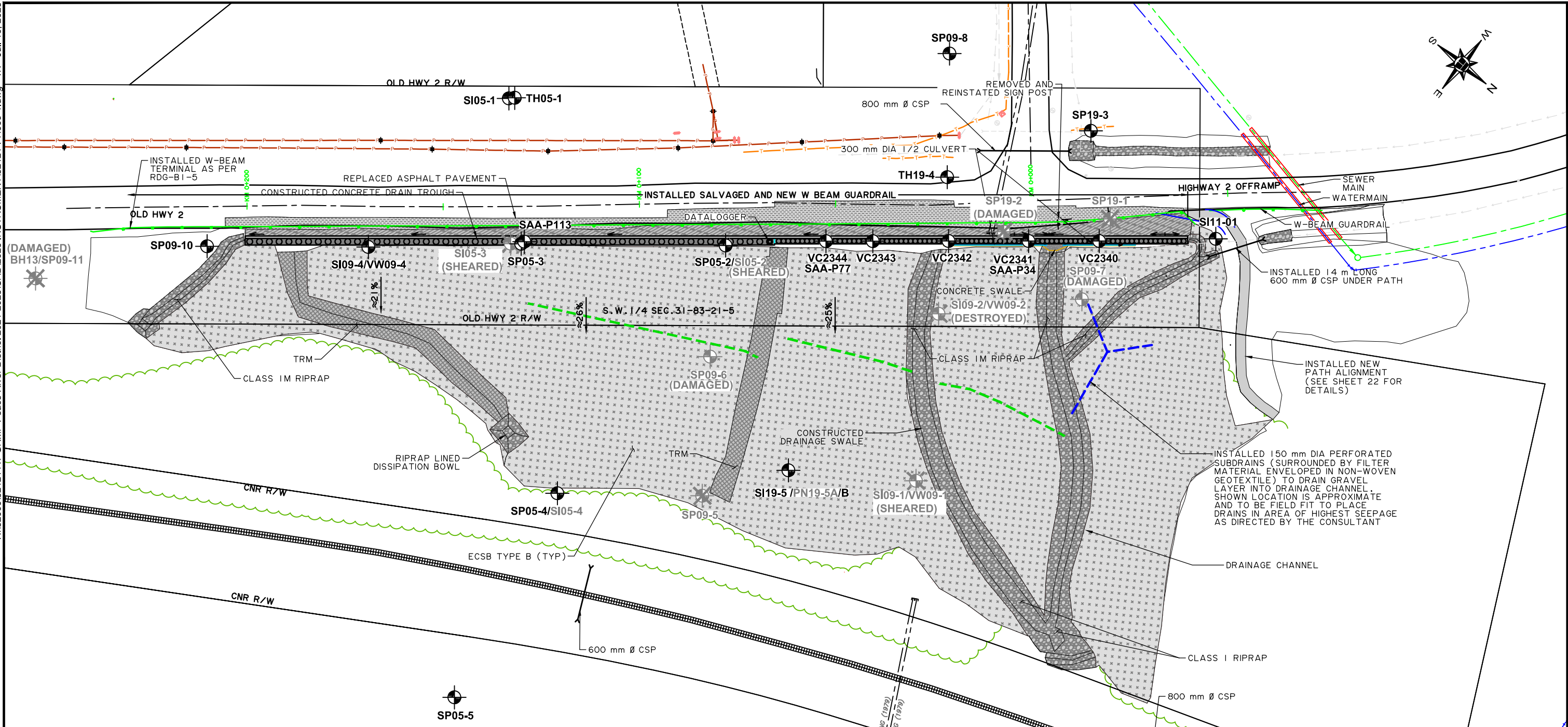
**ALBERTA TRANSPORTATION AND ECONOMIC CORRIDORS GRMP (CON0022164)
PEACE REGION (PEACE RIVER DISTRICT)
INSTRUMENTATION MONITORING RESULTS**

SPRING 2023

**APPENDIX A
DATA PRESENTATION**

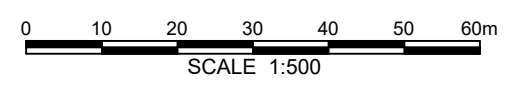
SITE PH009: OLD HWY 2:02 SHOP SLIDE

H:\32000\32121 AT GRMP Peace River District 2021-2025\CAD\2023 INSTRUMENT\32121-PH009-1.dwg - 1N - Jul. 10. 2023



LEGEND

- | | | | | | |
|--|---|--|---------------------------|--|---------------------------|
| | ASPHALT CEMENT PAVEMENT | | GUARDRAIL | | TELUS UNDERGROUND VAULT |
| | ASPHALT CEMENT SLOPE PROTECTION (40 mm THICK) | | TELUS LINE (BURIED) | | DATALOGGER ENCLOSURE |
| | EROSION CONTROL SOIL COVERING (TYPE B) | | GAS LINE | | INSTRUMENT LOCATION |
| | PERMANENT RECP (TRM TYPE B, COMPLETE WITH SYNTHETIC PERMEABLE DITCH BARRIERS AT 15 m INTERVALS ALONG SWALE) | | POWER LINE AND POWER POLE | | NON-OPERATIONAL |
| | CLASS 1M RIPRAP (0.4 m THICK) | | GUY WIRE | | SLOPE INCLINOMETER |
| | CLASS 1 RIPRAP (0.8 m THICK) | | RAIL LINE | | VIBRATING WIRE PIEZOMETER |
| | FIBRE ROLL | | ROW BOUNDARY | | STANDPIPE PIEZOMETER |
| | | | SIGN POST | | PNEUMATIC PIEZOMETER |



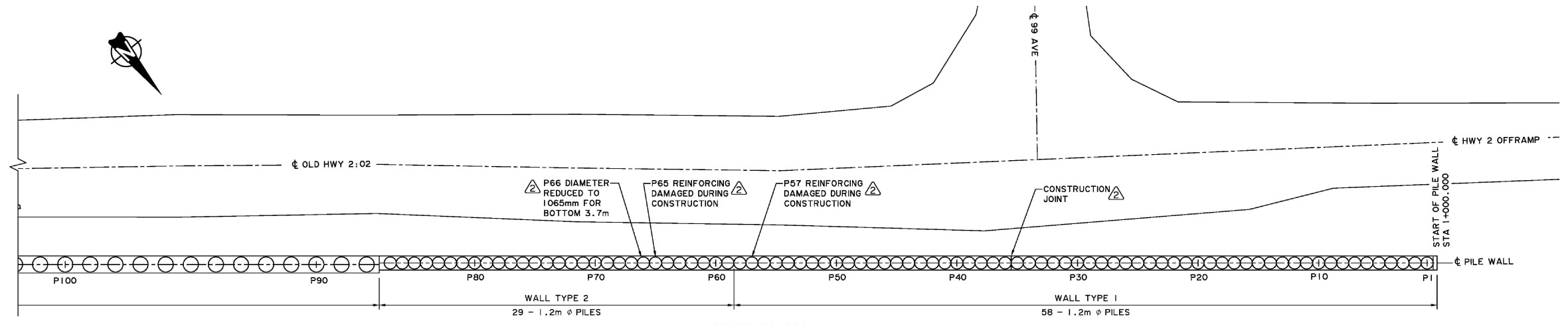
PEACE REGION (PEACE RIVER DISTRICT)

**PH009: OLD HWY 2:02 SHOP SLIDE
SITE PLAN SHOWING INSTRUMENT LOCATIONS**

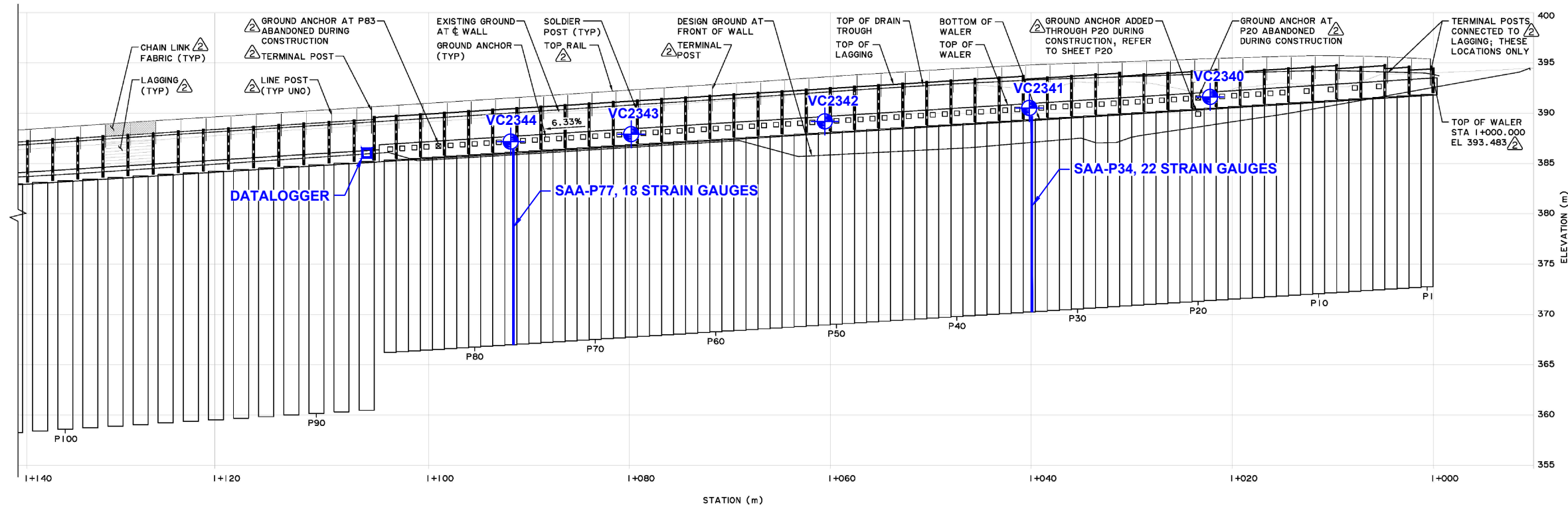
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DRAWN BY	ML
DESIGNED BY	BWN
APPROVED BY	DWP
SCALE	1:1500
DATE	JUNE 2023
FILE No.	32121

THURBER ENGINEERING LTD.





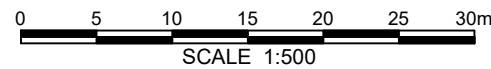
SITE PLAN
1:200



ELEVATION - PILE WALL

LEGEND

-  INSTRUMENT LOCATION
-  DATALOGGER ENCLOSURE



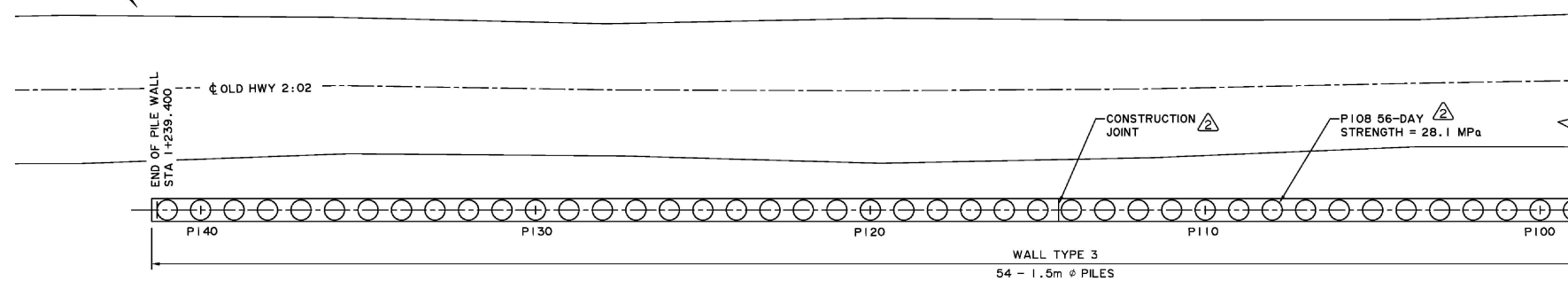
PEACE REGION (PEACE RIVER DISTRICT)

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PILE WALL GENERAL LAYOUT 2**

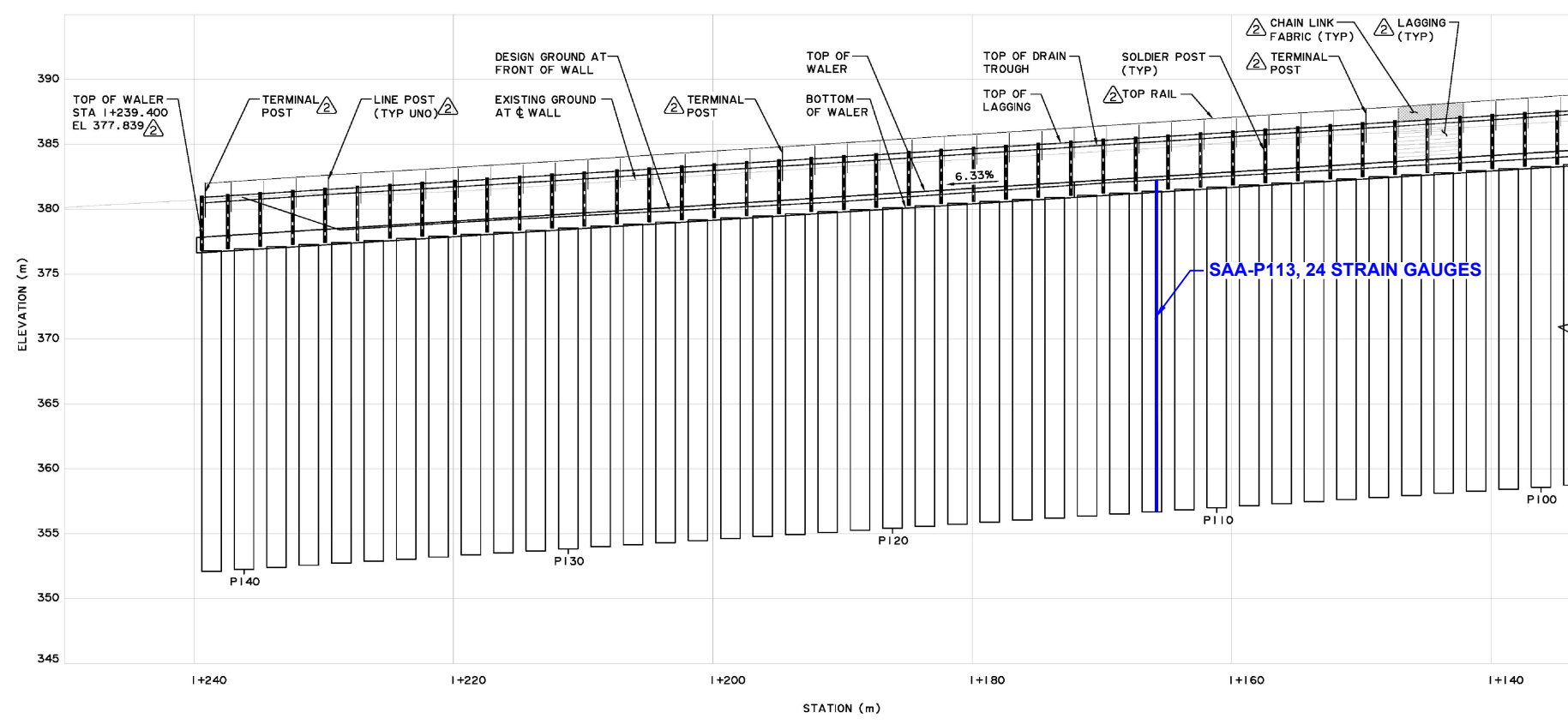
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DESIGNED BY	BWN
APPROVED BY	DWP
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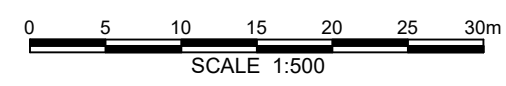




SITE PLAN
1:200



ELEVATION - PILE WALL



PEACE REGION (PEACE RIVER DISTRICT)

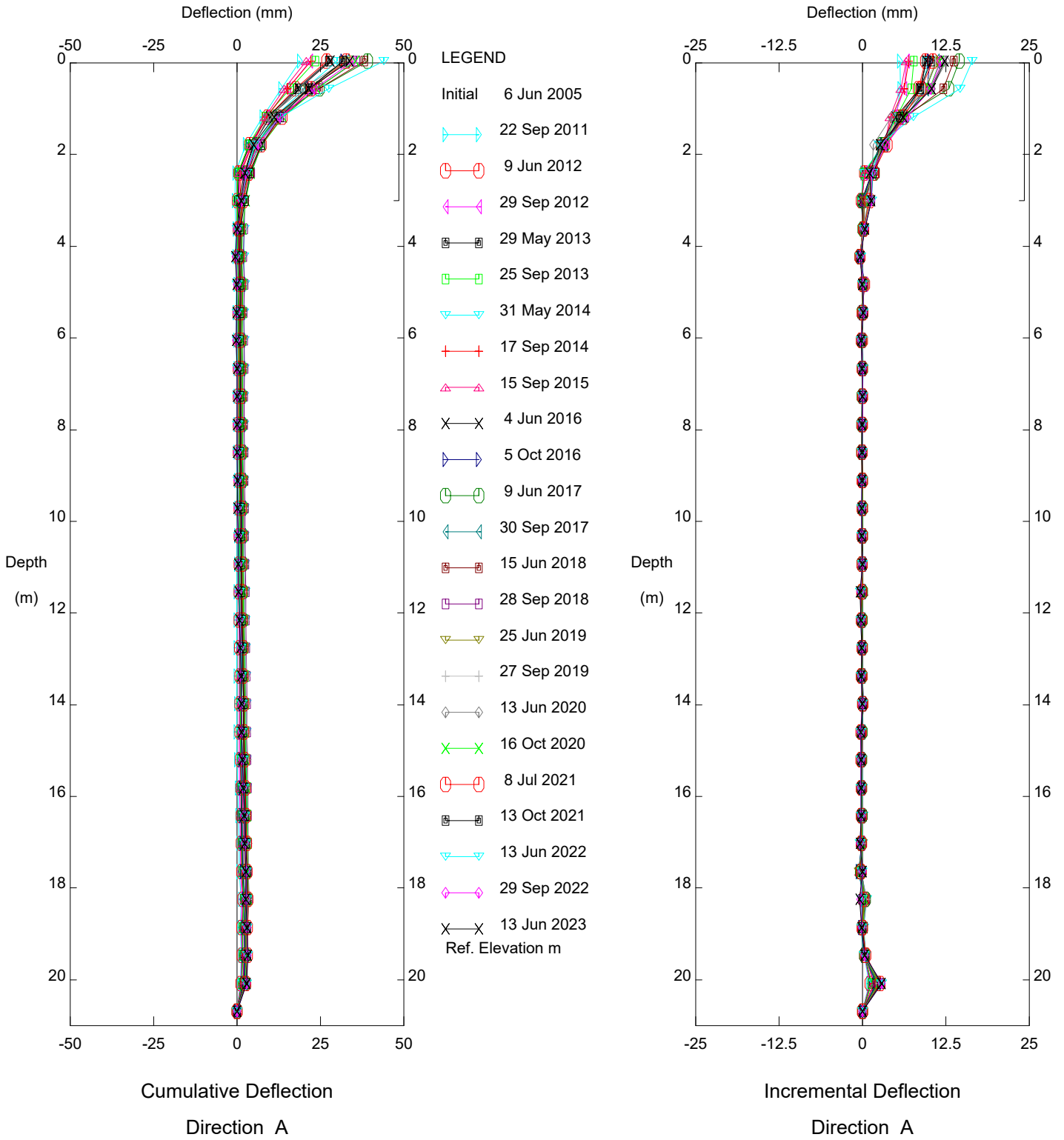
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PILE WALL GENERAL LAYOUT 1

DWG No. 32121-PH009-3

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DESIGNED BY	BWN
APPROVED BY	DWP
SCALE	1:500
DATE	JUNE 2023
FILE No.	32121



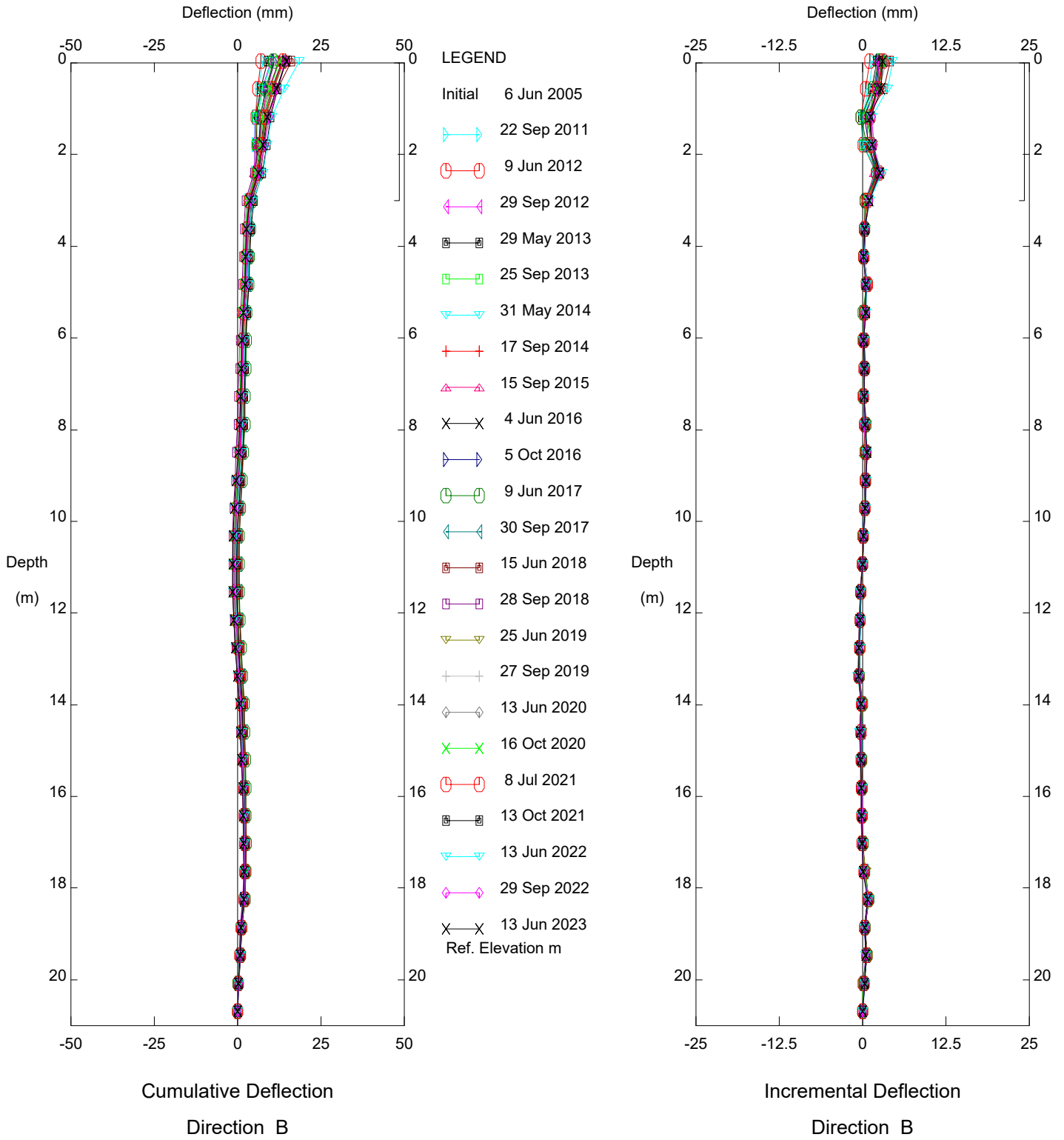
Thurber Engineering Ltd



PH009 Old Hwy 2:02 Shop Slide, Inclinometer SI05-1

Alberta Transportation

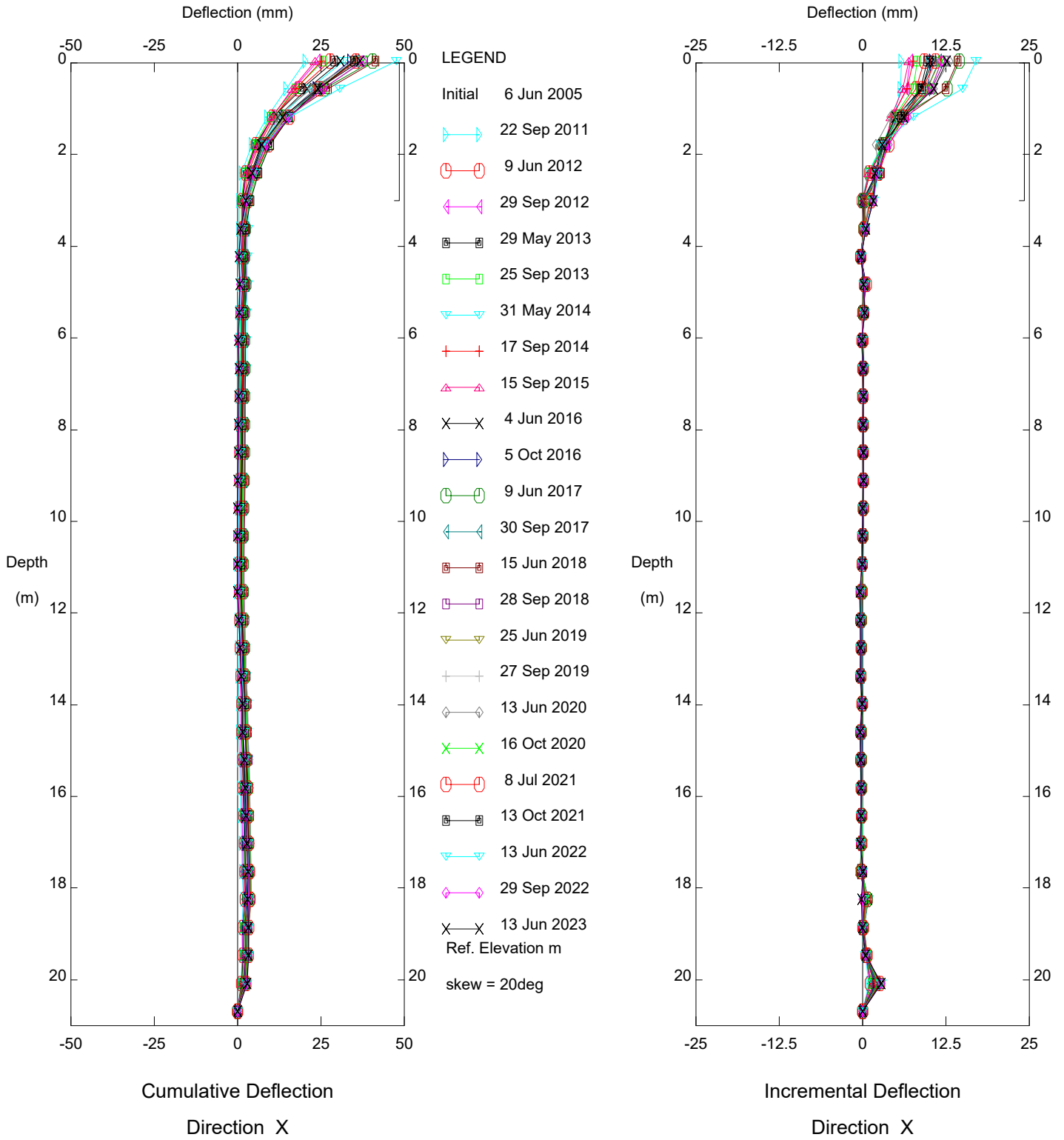
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PH009 Old Hwy 2:02 Shop Slide, Inclinometer SI05-1

Alberta Transportation

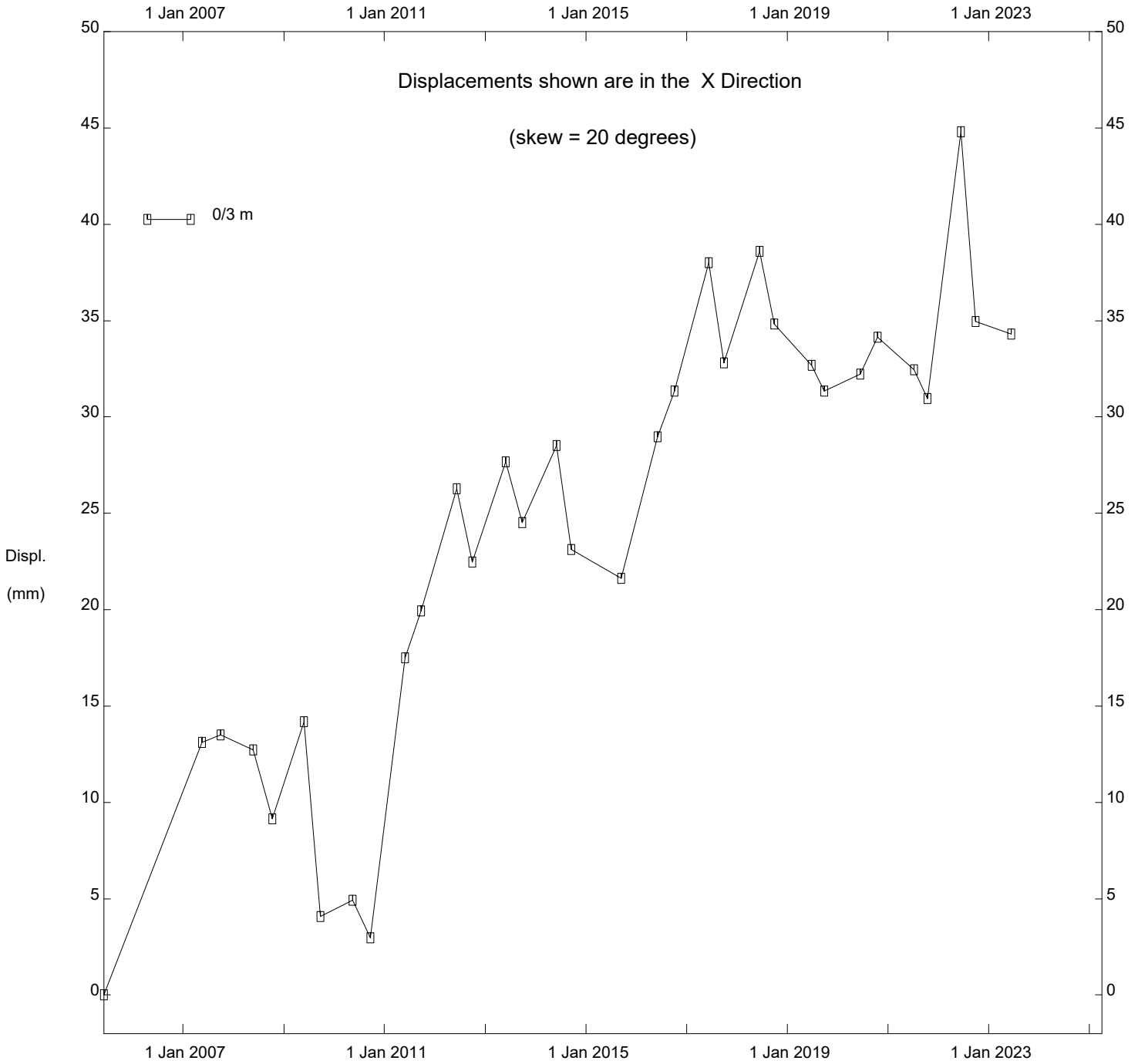
Thurber Engineering Ltd



PH009 Old Hwy 2:02 Shop Slide, Inclinometer SI05-1

Alberta Transportation

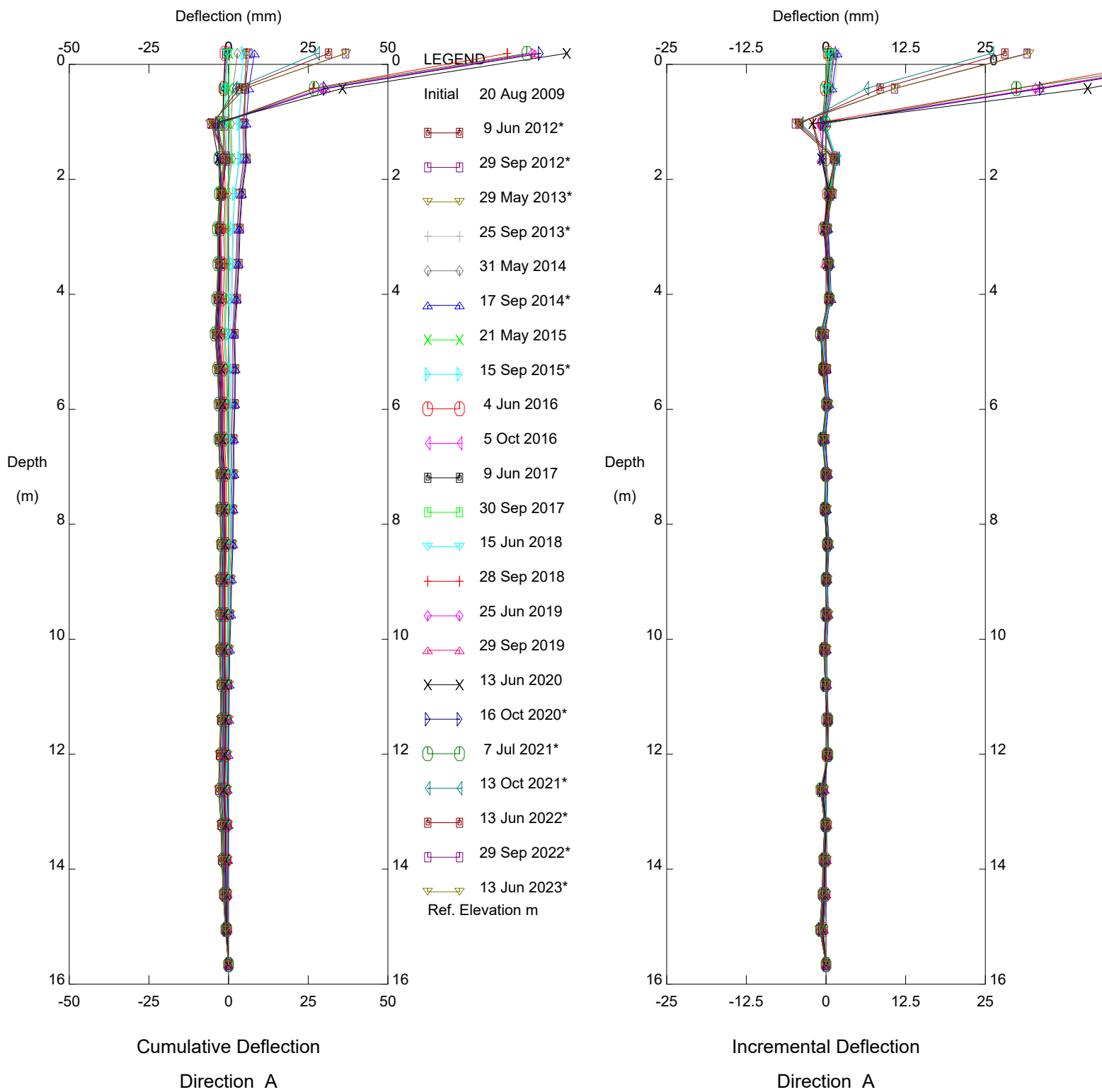
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Alberta Transportation

Thurber Engineering Ltd

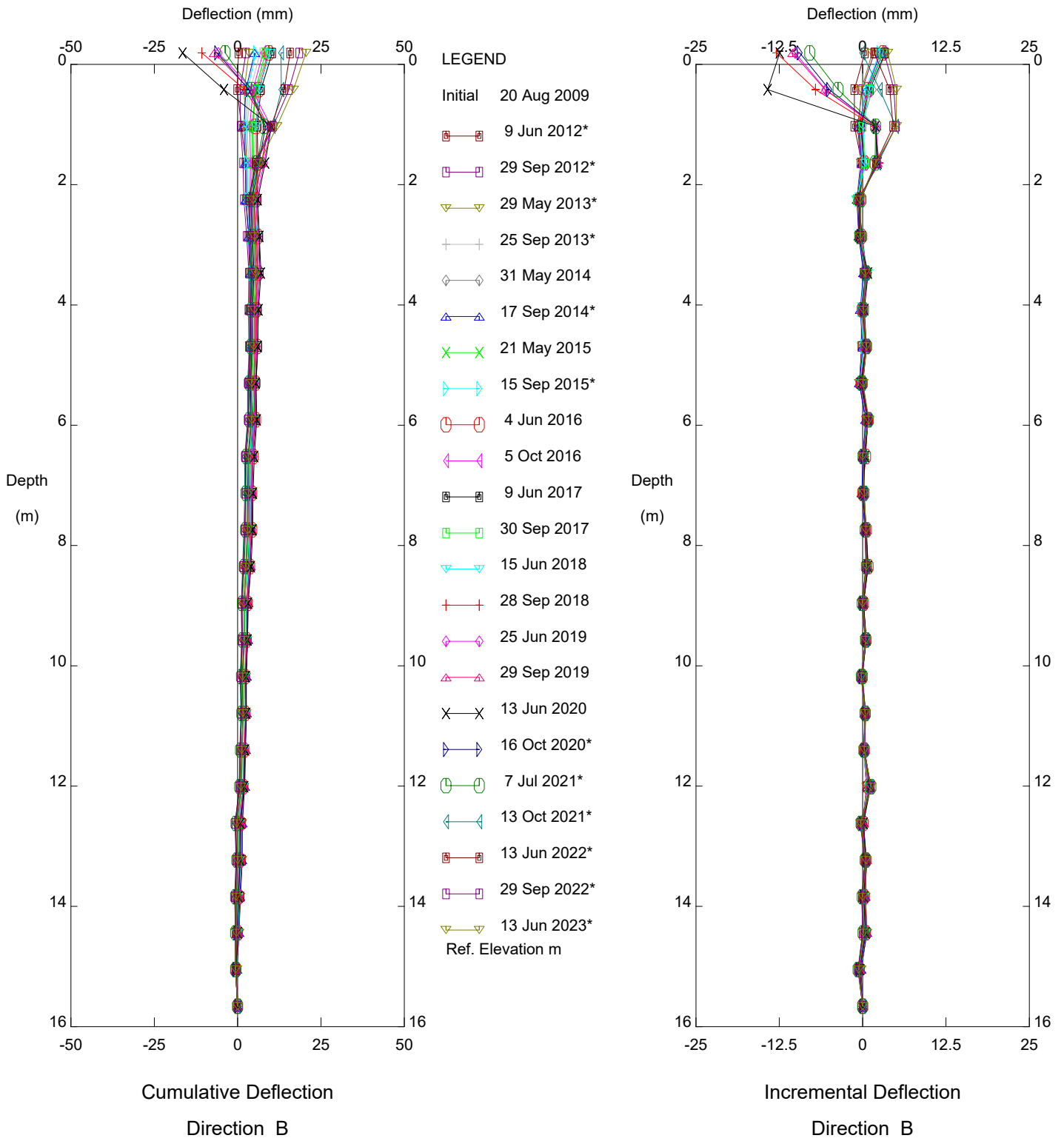


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Alberta Transportation

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

Thurber Engineering Ltd

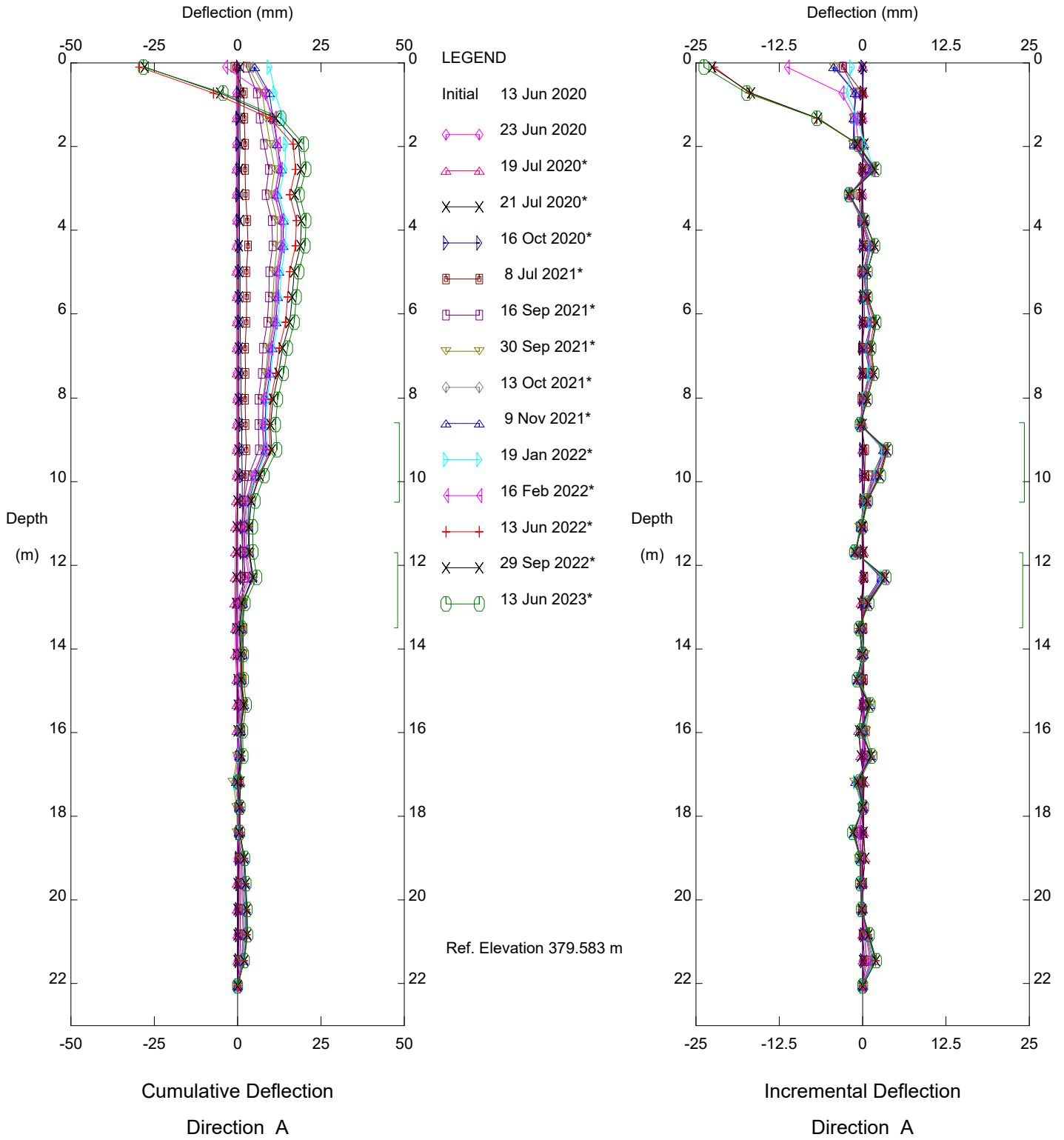


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Alberta Transportation

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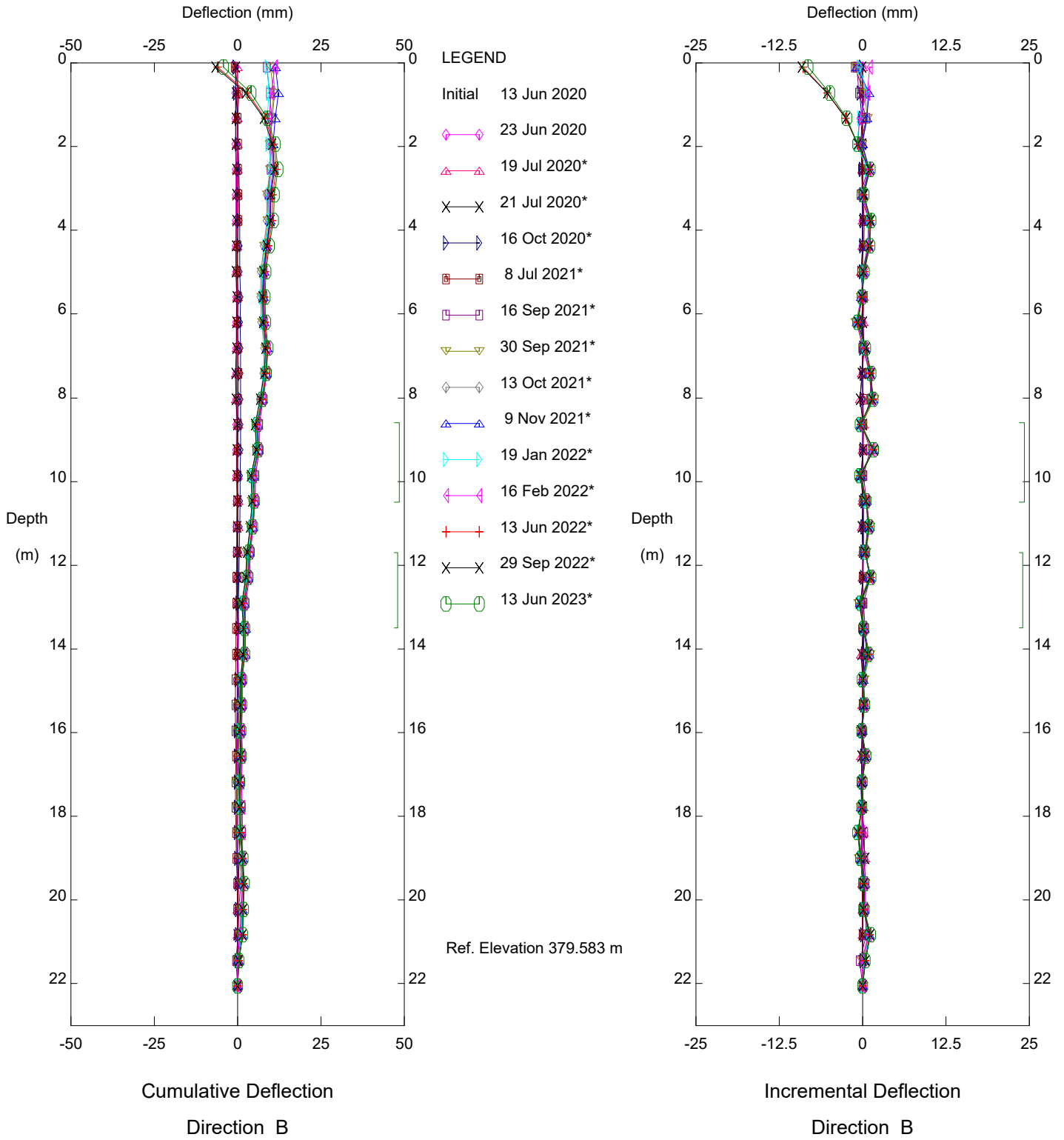


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Alberta Transportation

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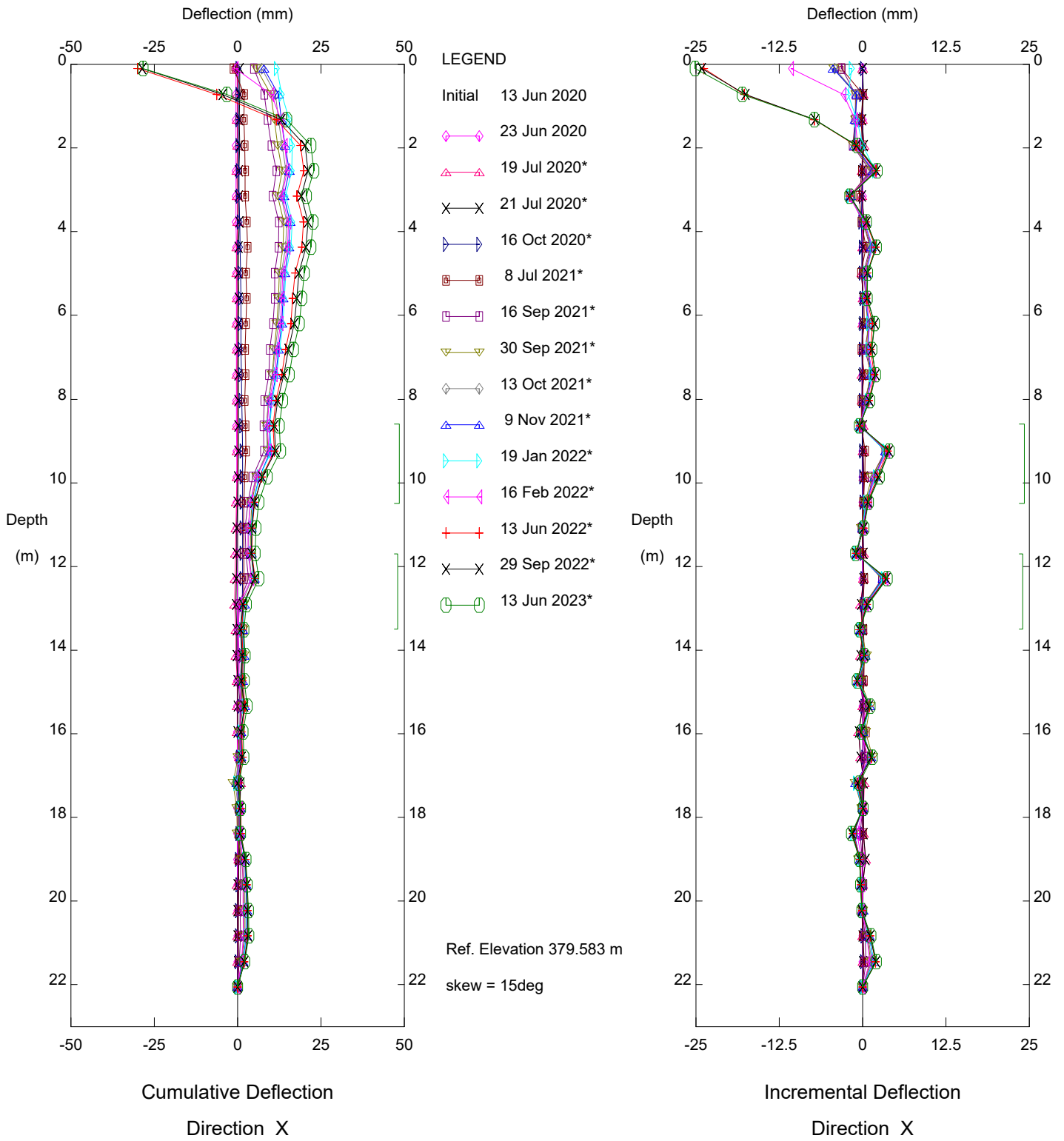


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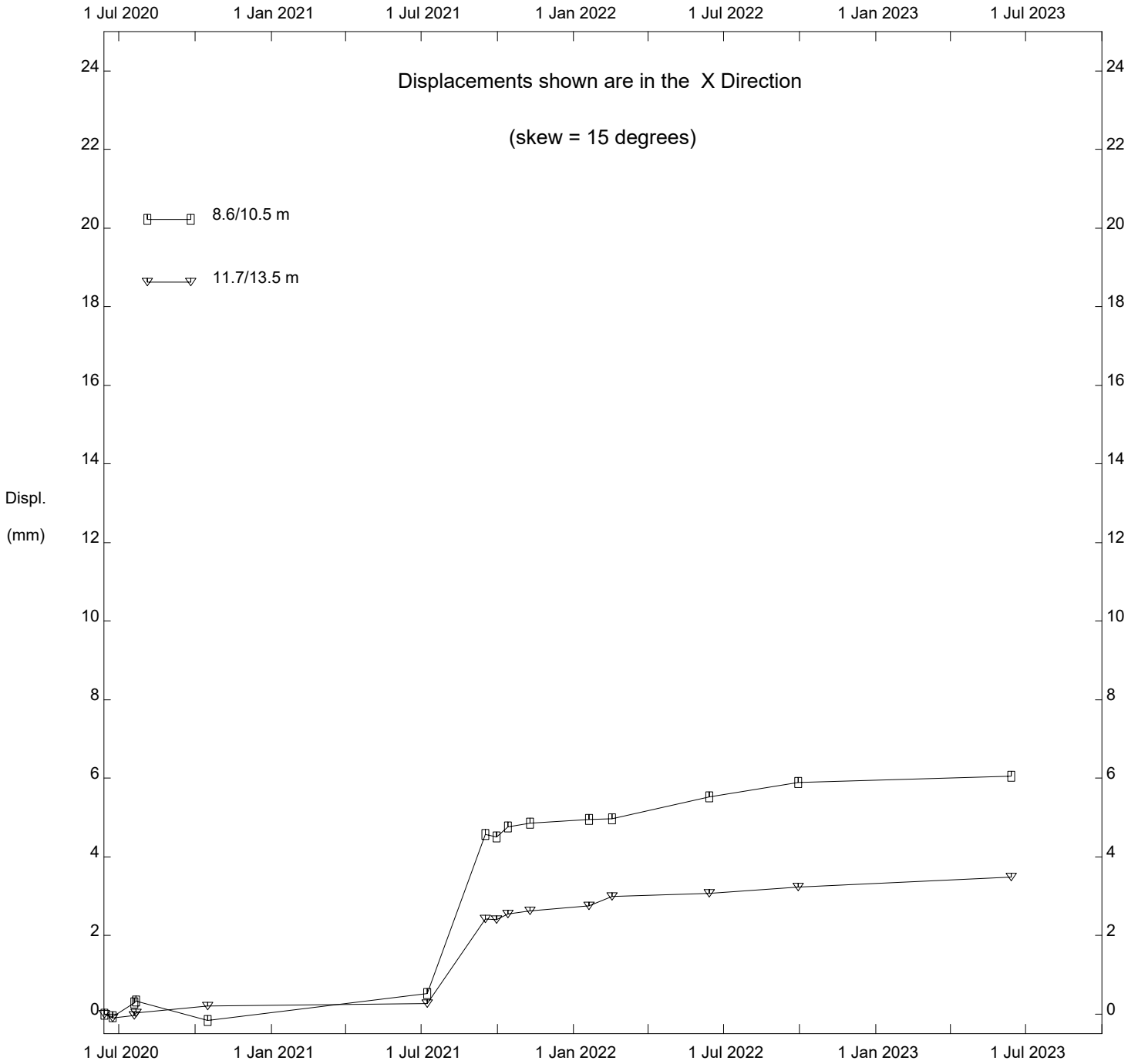


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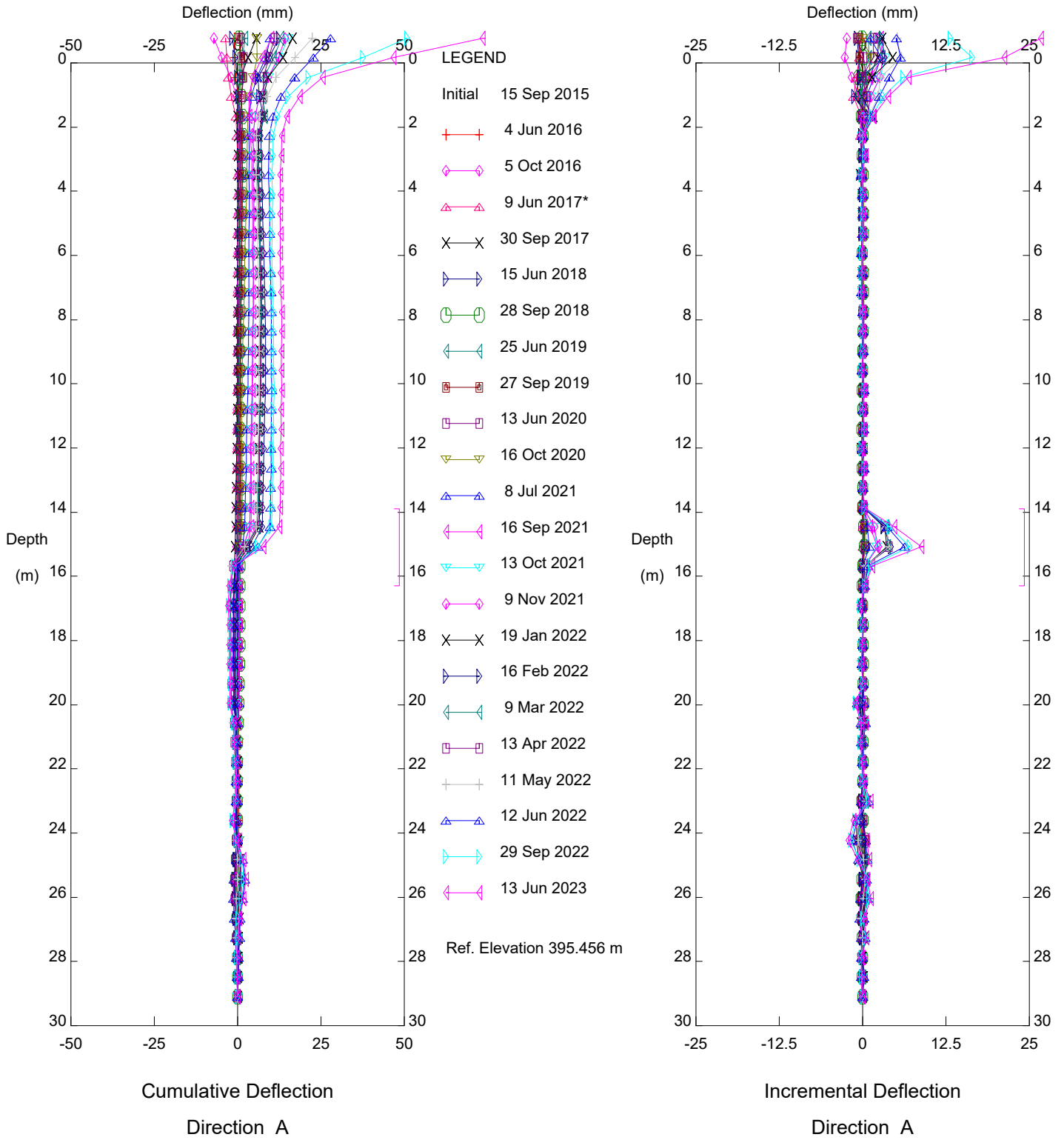
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Alberta Transportation

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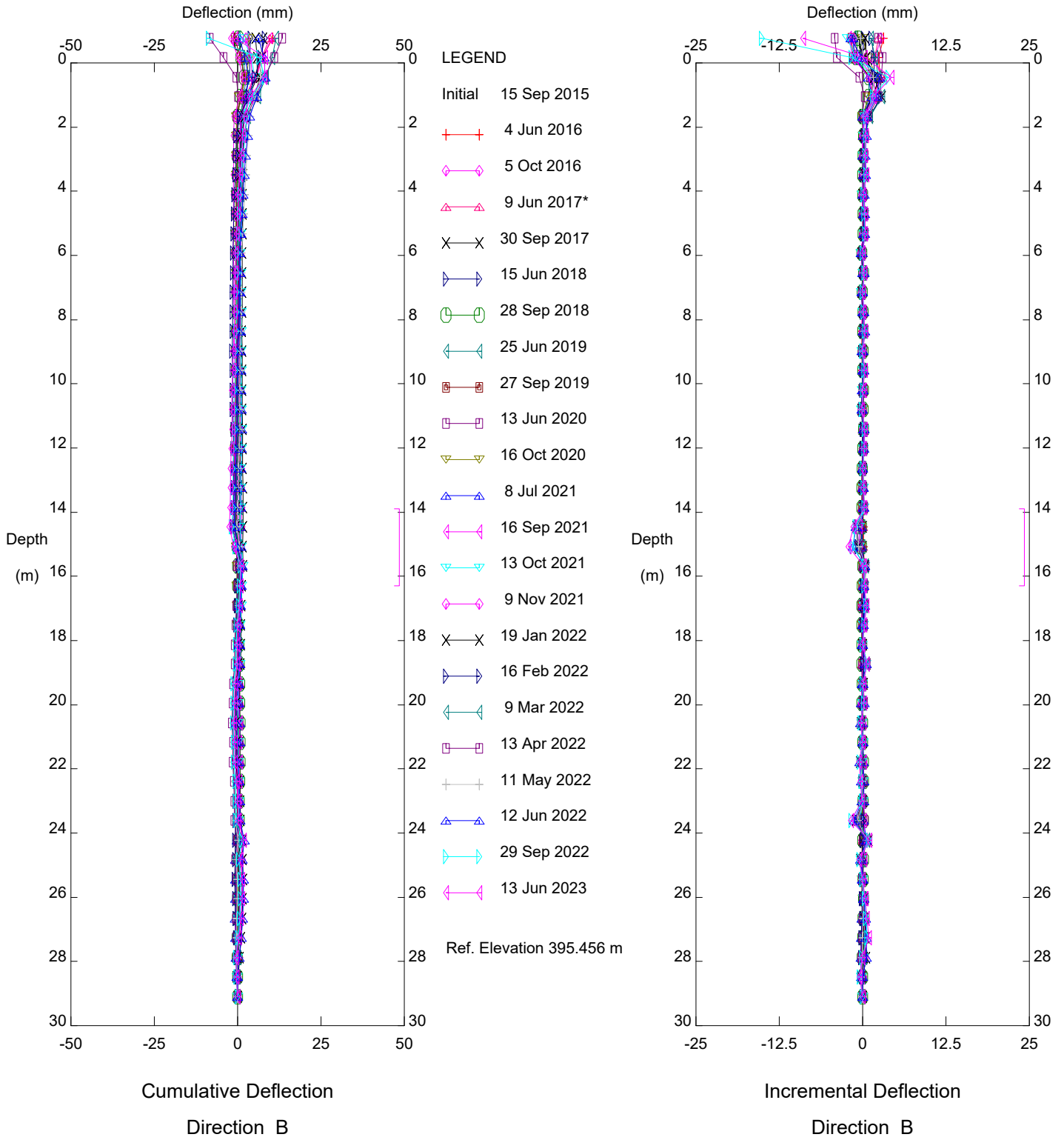


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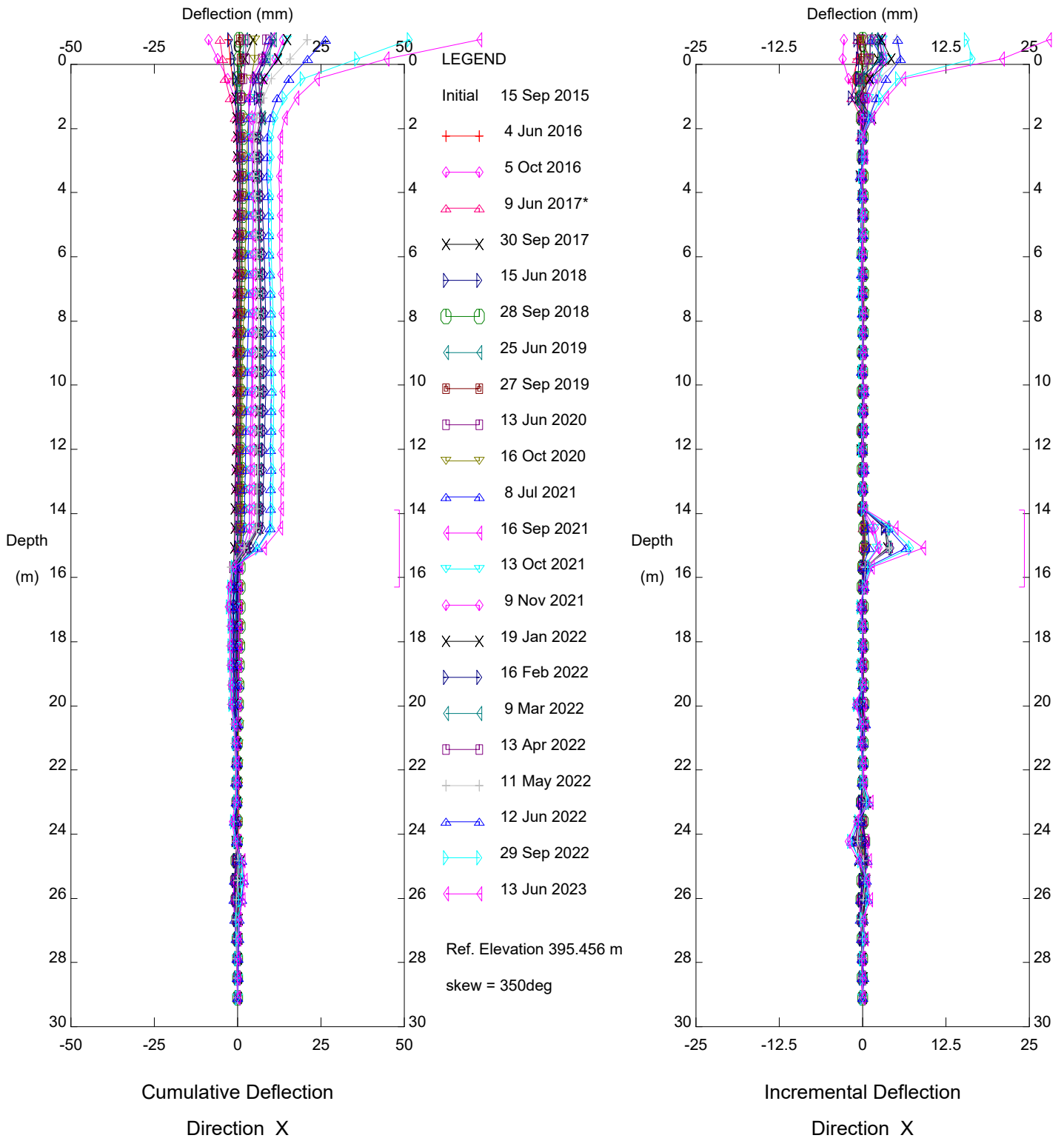


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Alberta Transportation

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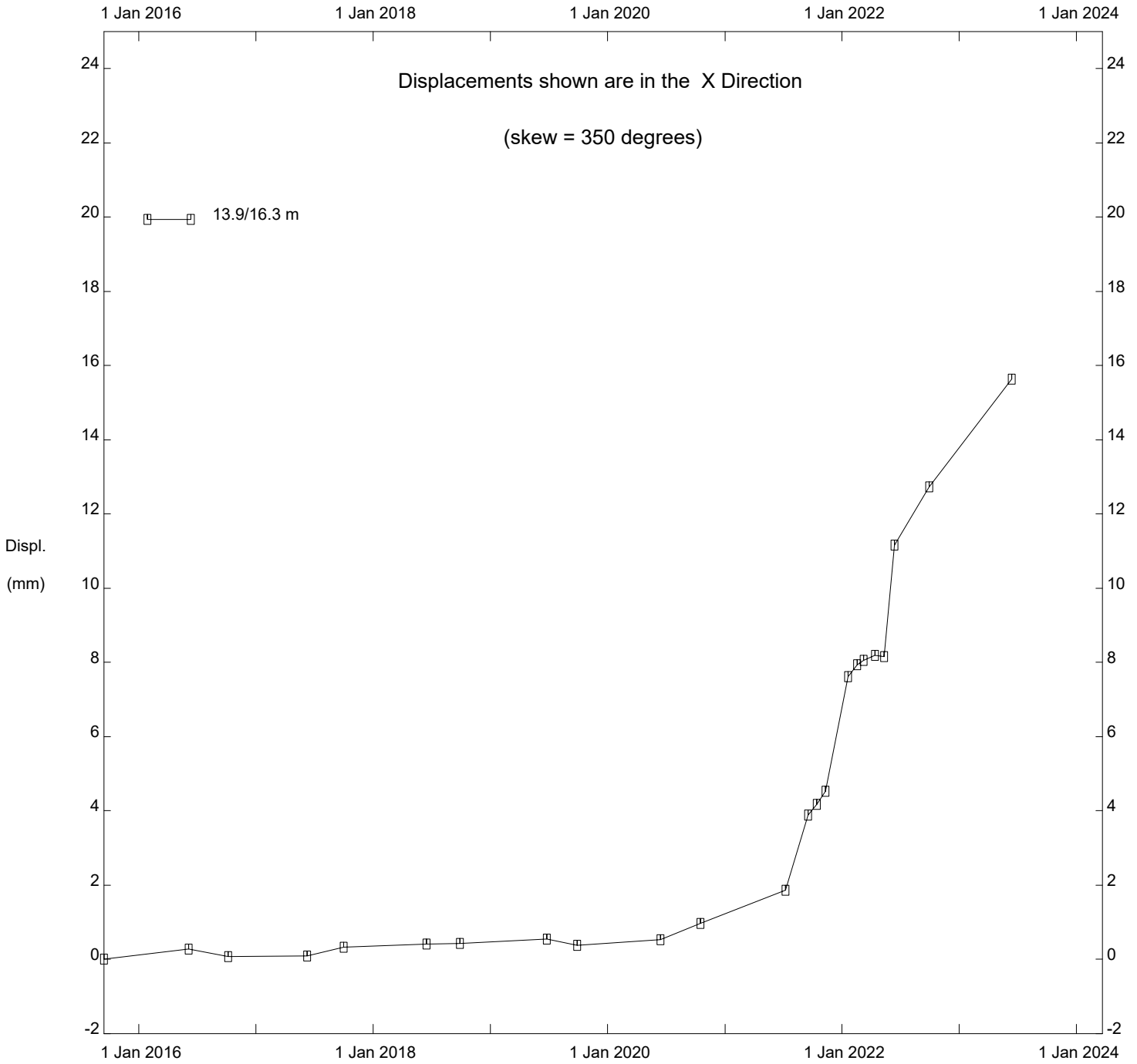


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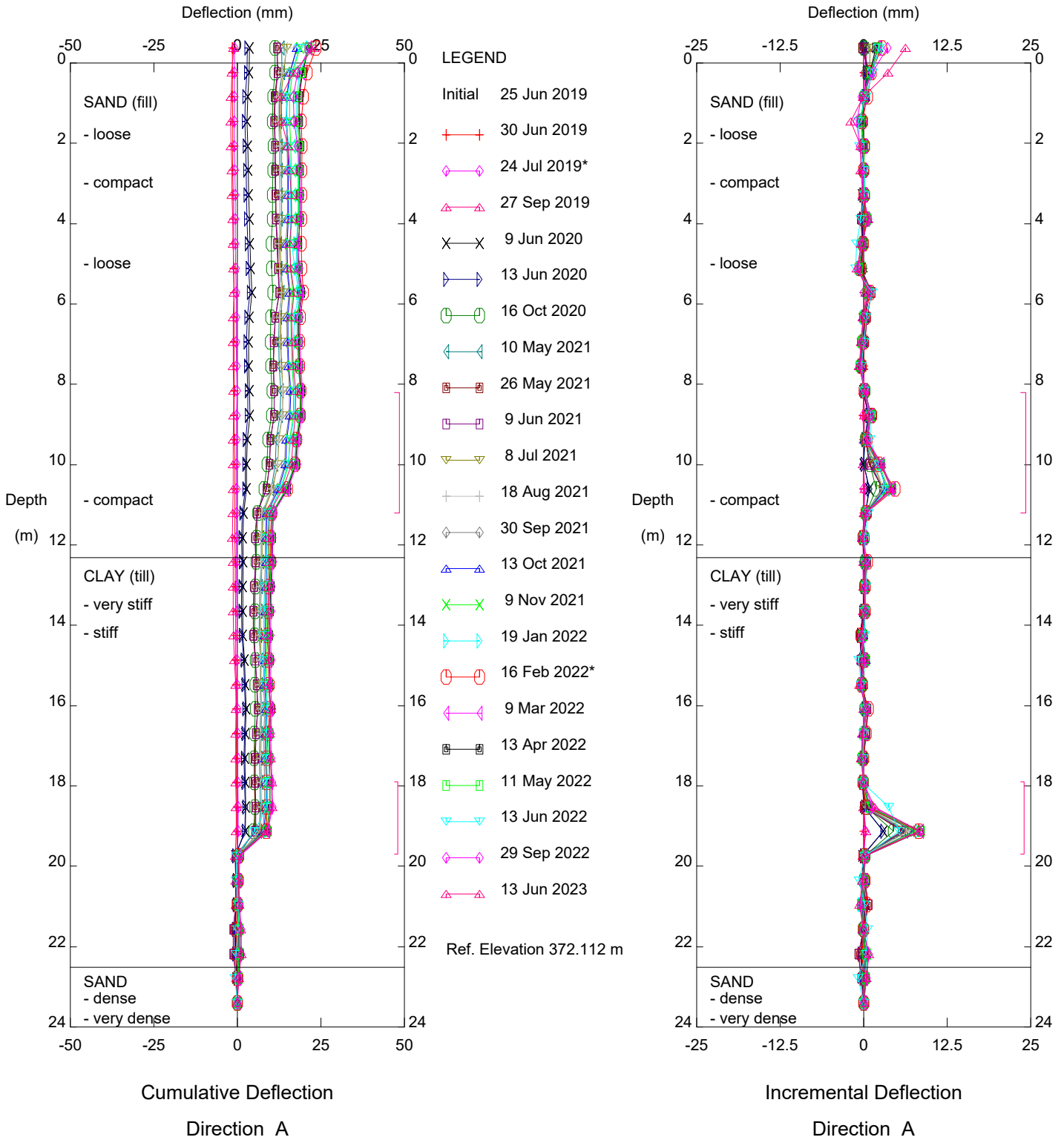
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Alberta Transportation

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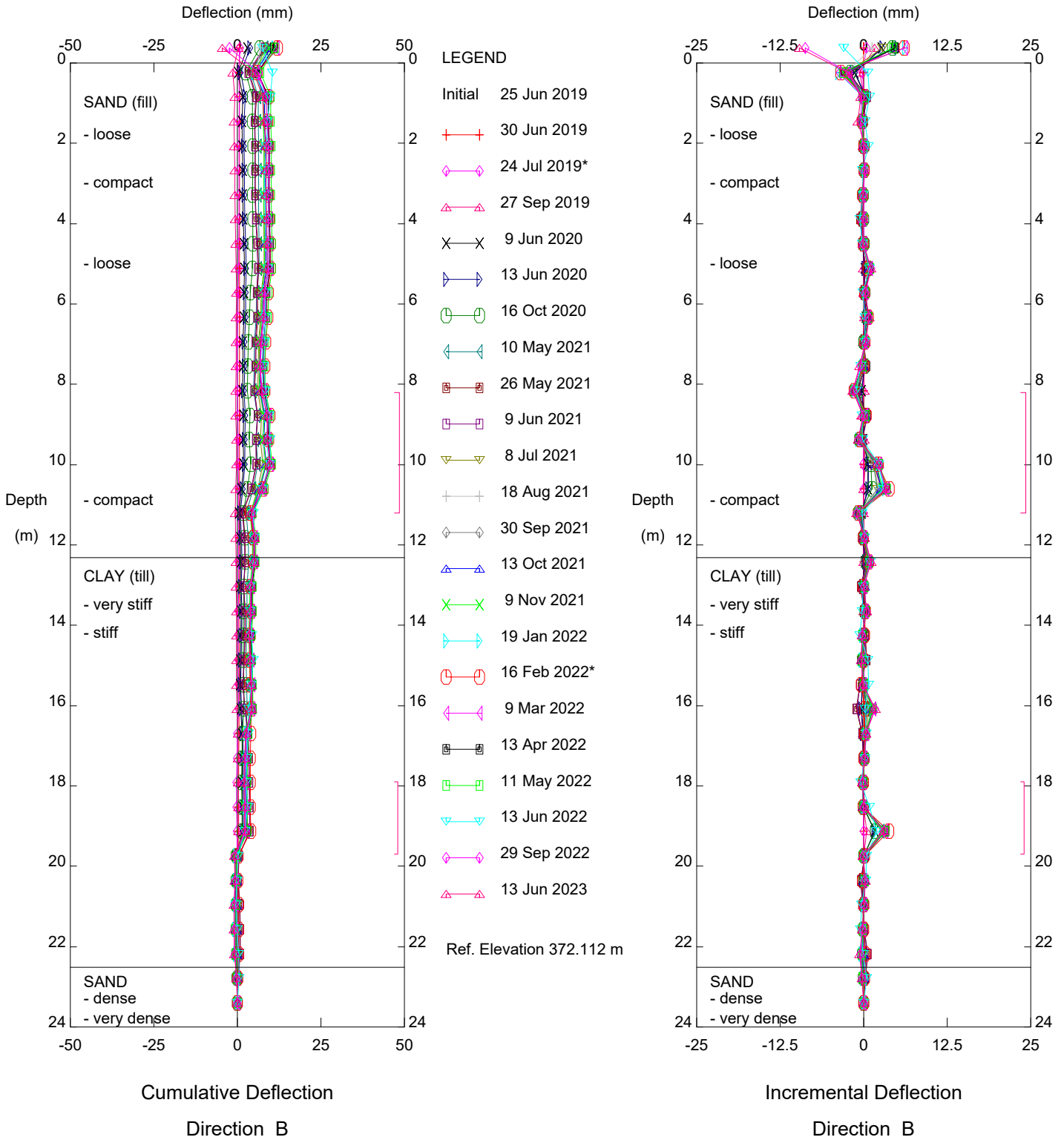


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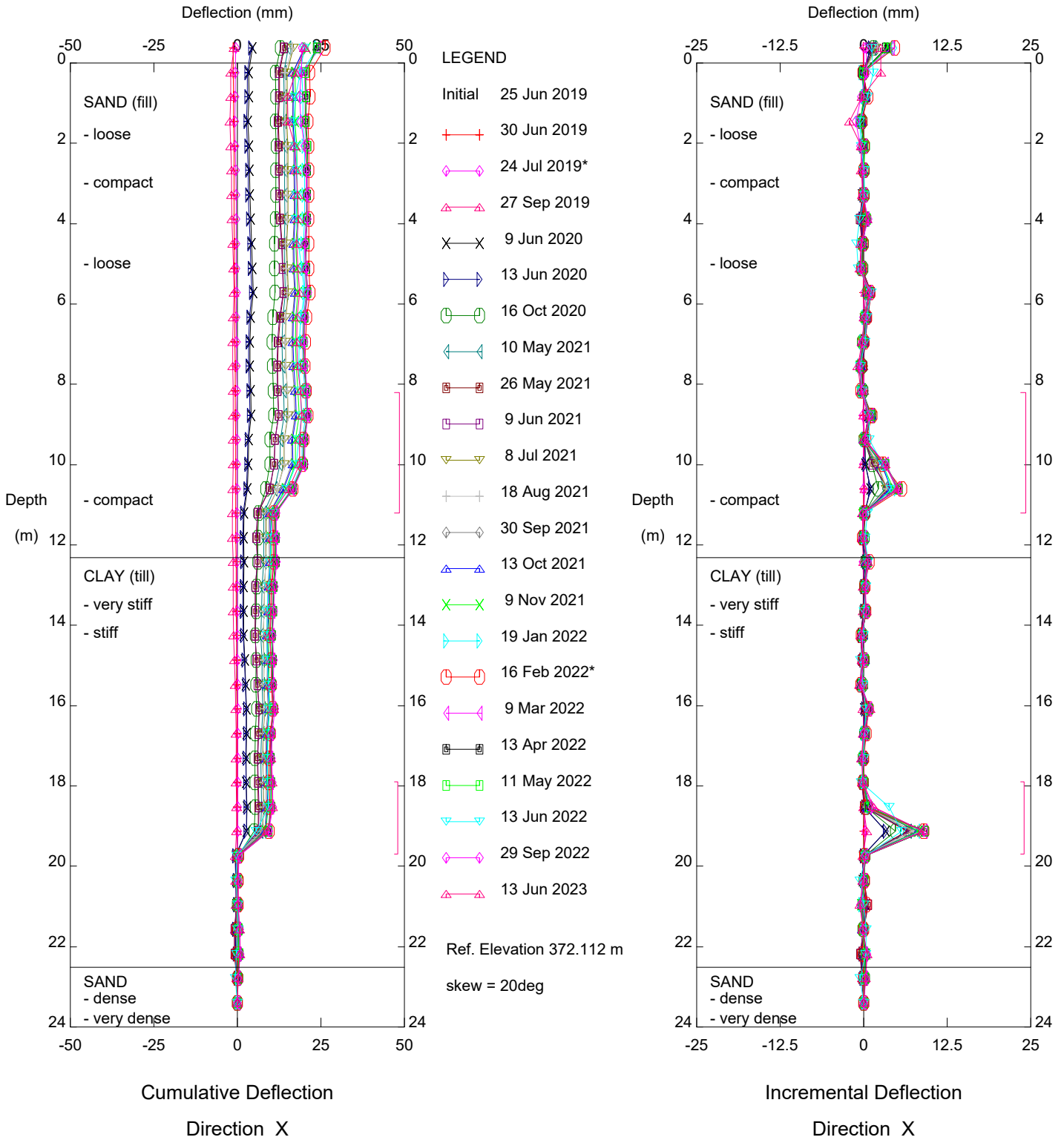


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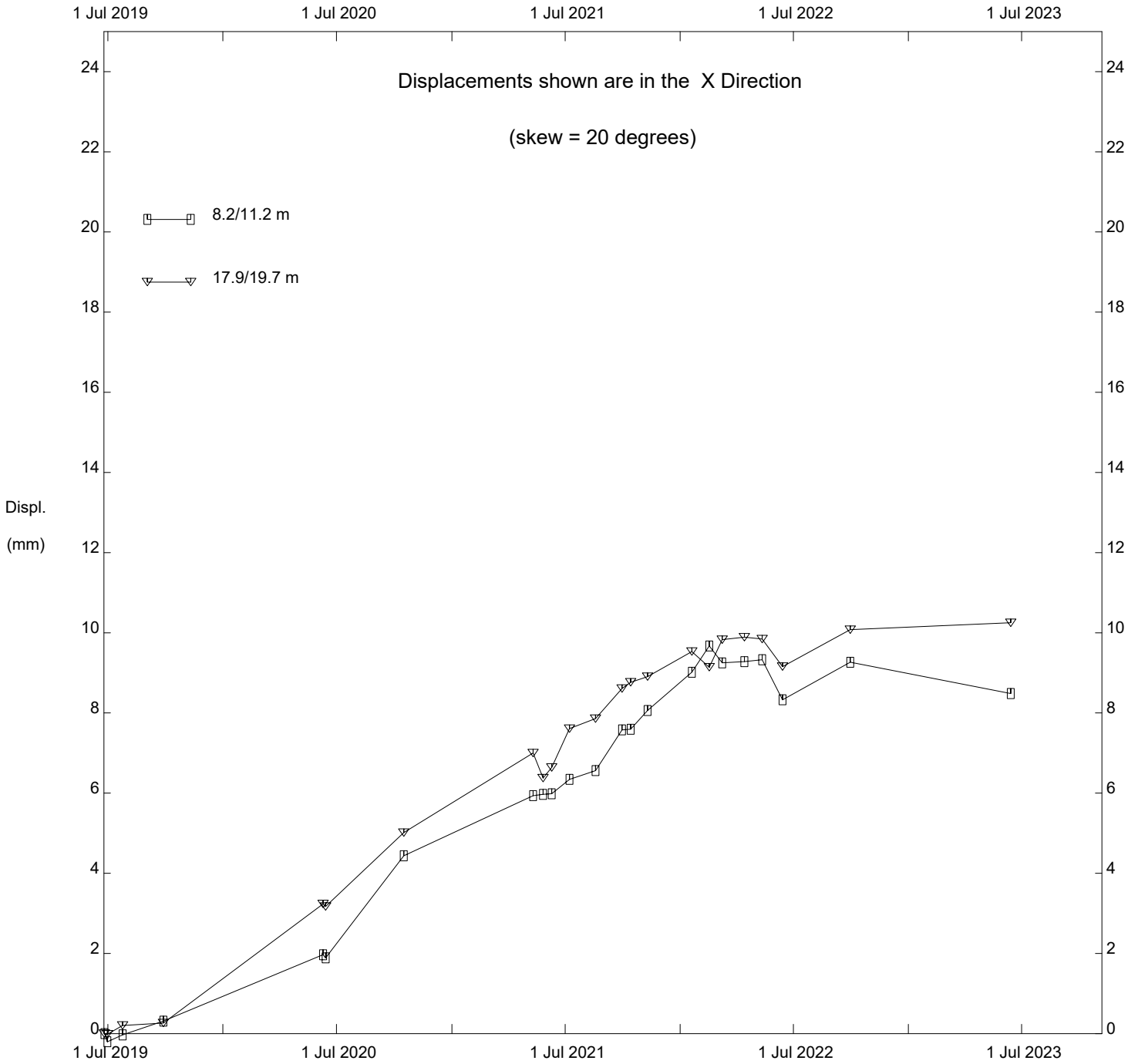


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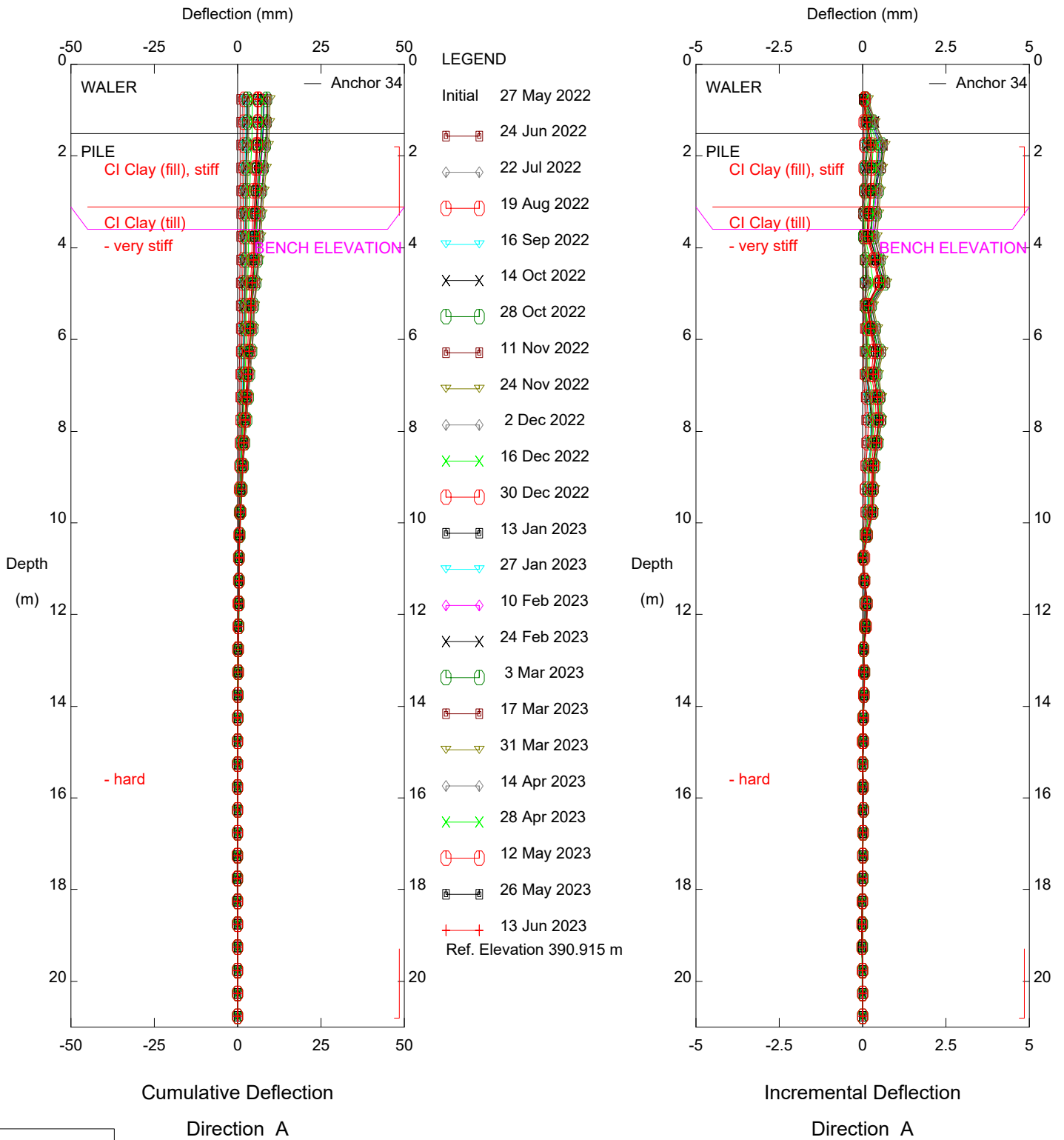
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Alberta Transportation

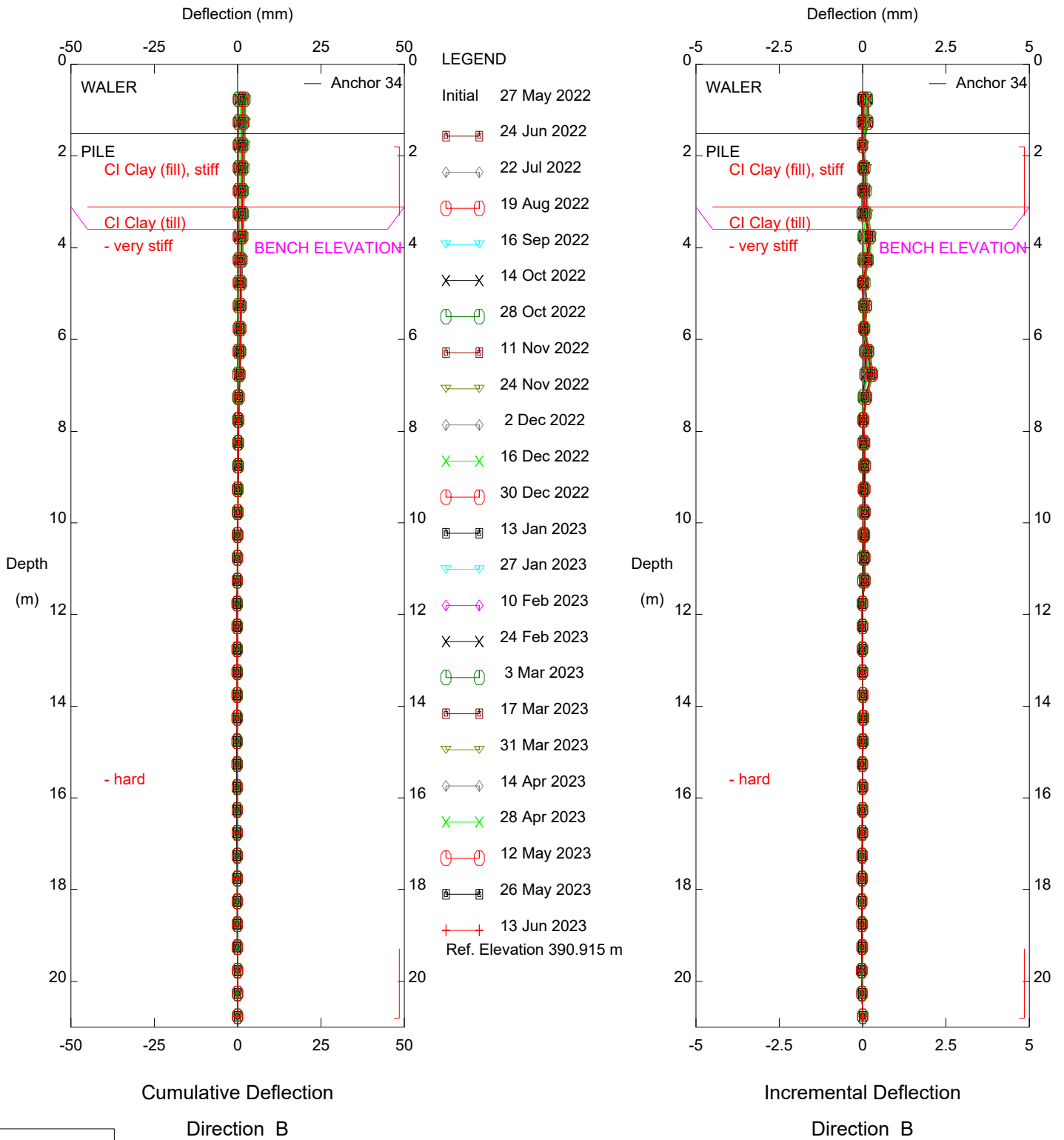
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Dates of Note:
 July 31, 2021 - P34 poured, SAA installed
 February 8-April 20, 2022 - wall backfilled to top of water
 April 20, 2022 - Anchor A34 locked off
 April 20-May 31, 2022 - wall backfilled to top of lagging and road level
 May 3-June 27, 2022 - Grading downslope of pile wall

Shop Slide Type 1 Wall Section, Inclinometer SAA-P34
 Alberta Transportation

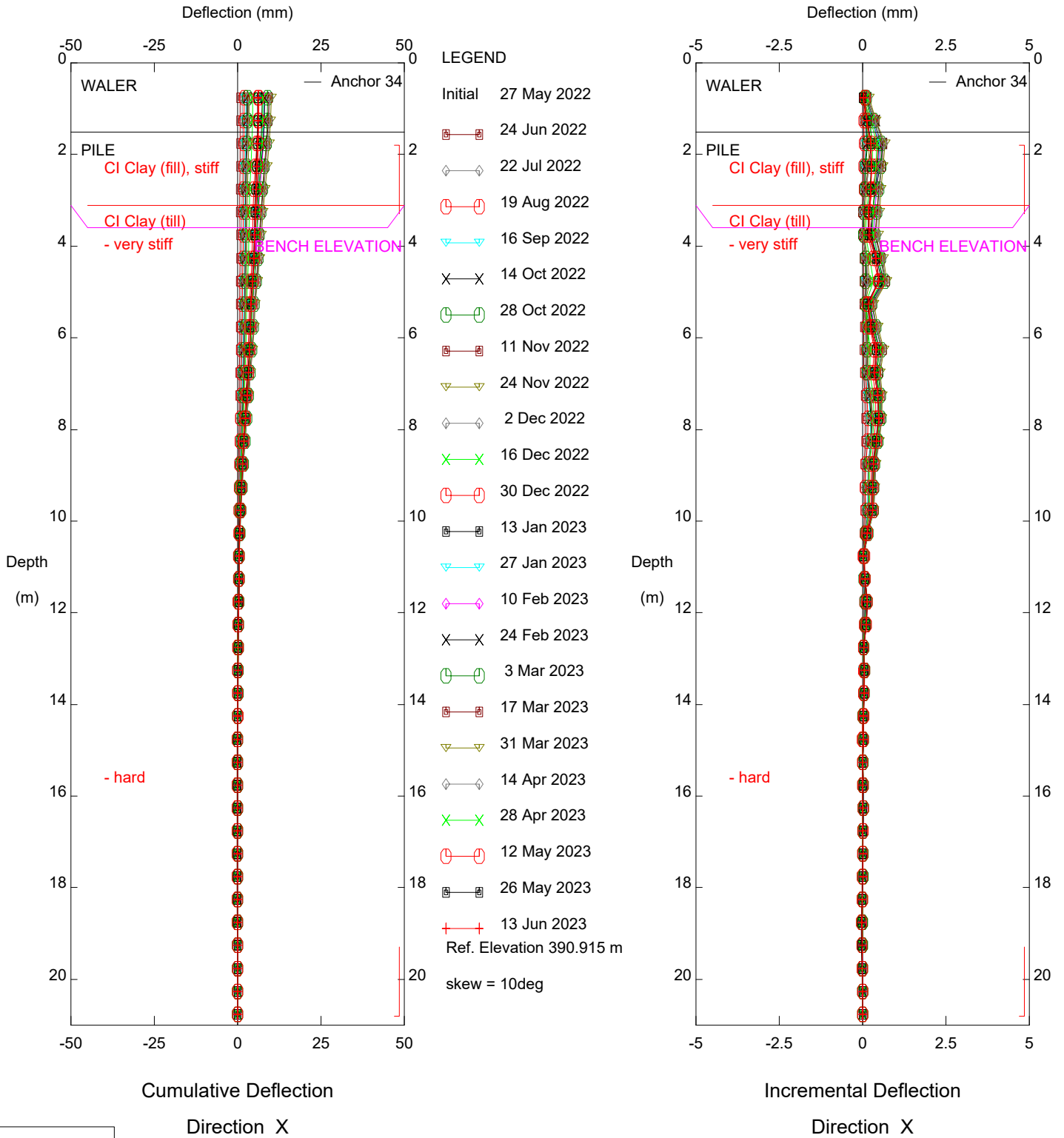
Thurber Engineering Ltd



Dates of Note:
 July 31, 2021 - P34 poured, SAA installed
 February 8-April 20, 2022 - wall backfilled to top of water
 April 20, 2022 - Anchor A34 locked off
 April 20-May 31, 2022 - wall backfilled to top of lagging and road level
 May 3-June 27, 2022 - Grading downslope of pile wall

Shop Slide Type 1 Wall Section, Inclinometer SAA-P34
 Alberta Transportation

Thurber Engineering Ltd



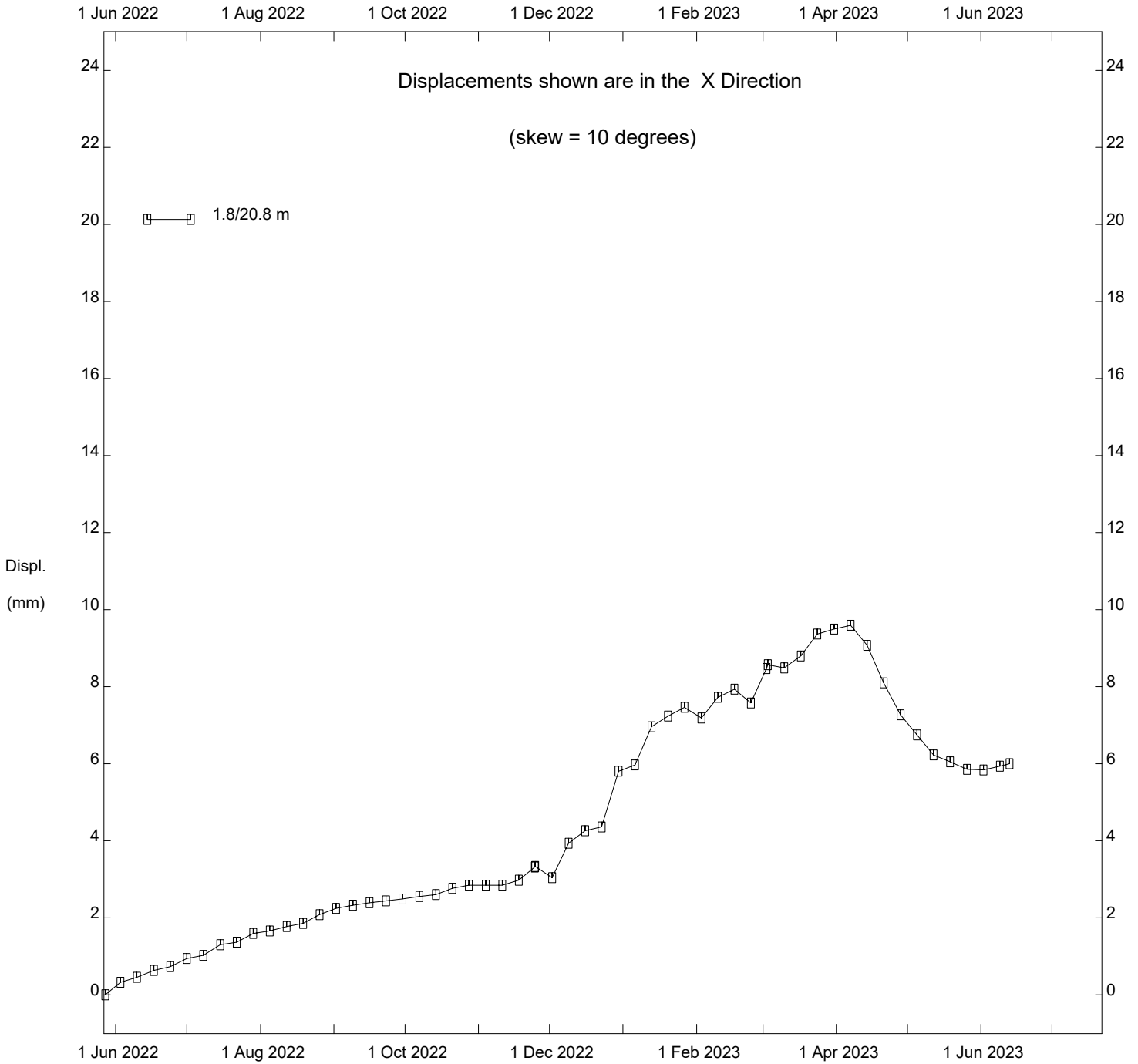
Dates of Note:

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- February 8-April 20, 2022 - wall backfilled to top of water
- April 20, 2022 - Anchor A34 locked off
- April 20-May 31, 2022 - wall backfilled to top of lagging and road level
- May 3-June 27, 2022 - Grading downslope of pile wall

Shop Slide Type 1 Wall Section, Inclinator SAA-P34

Alberta Transportation

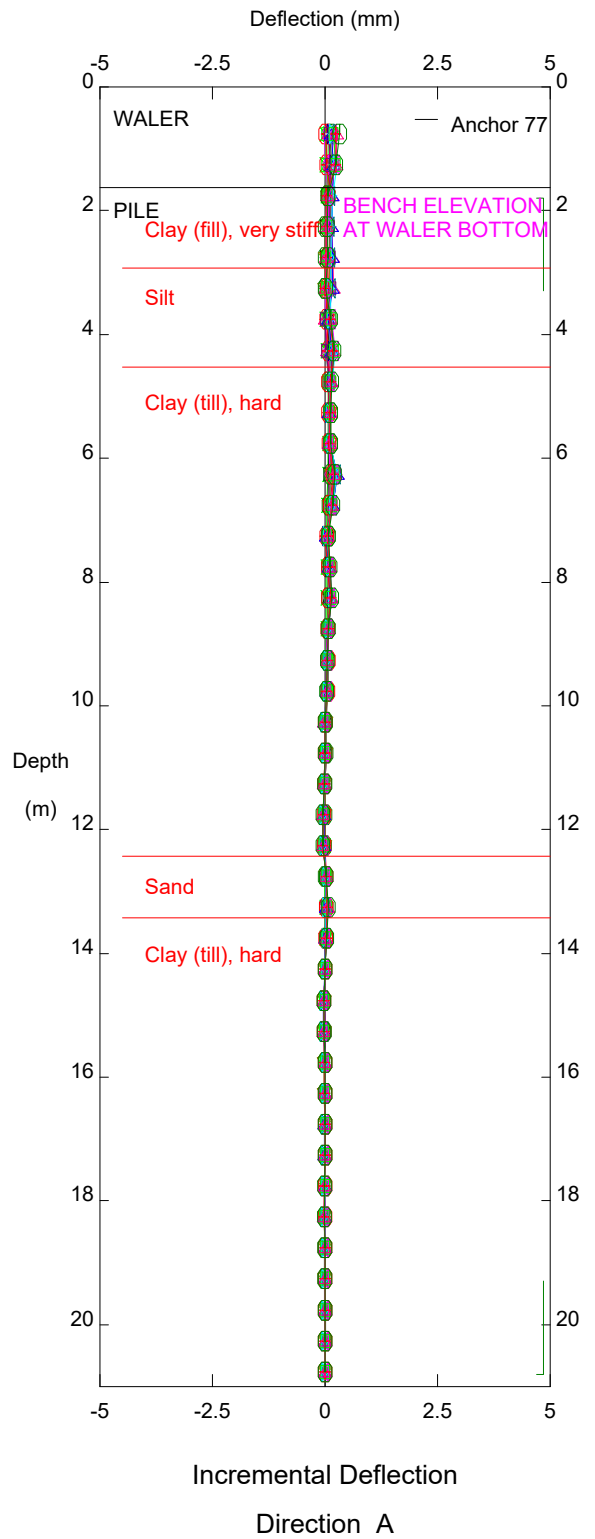
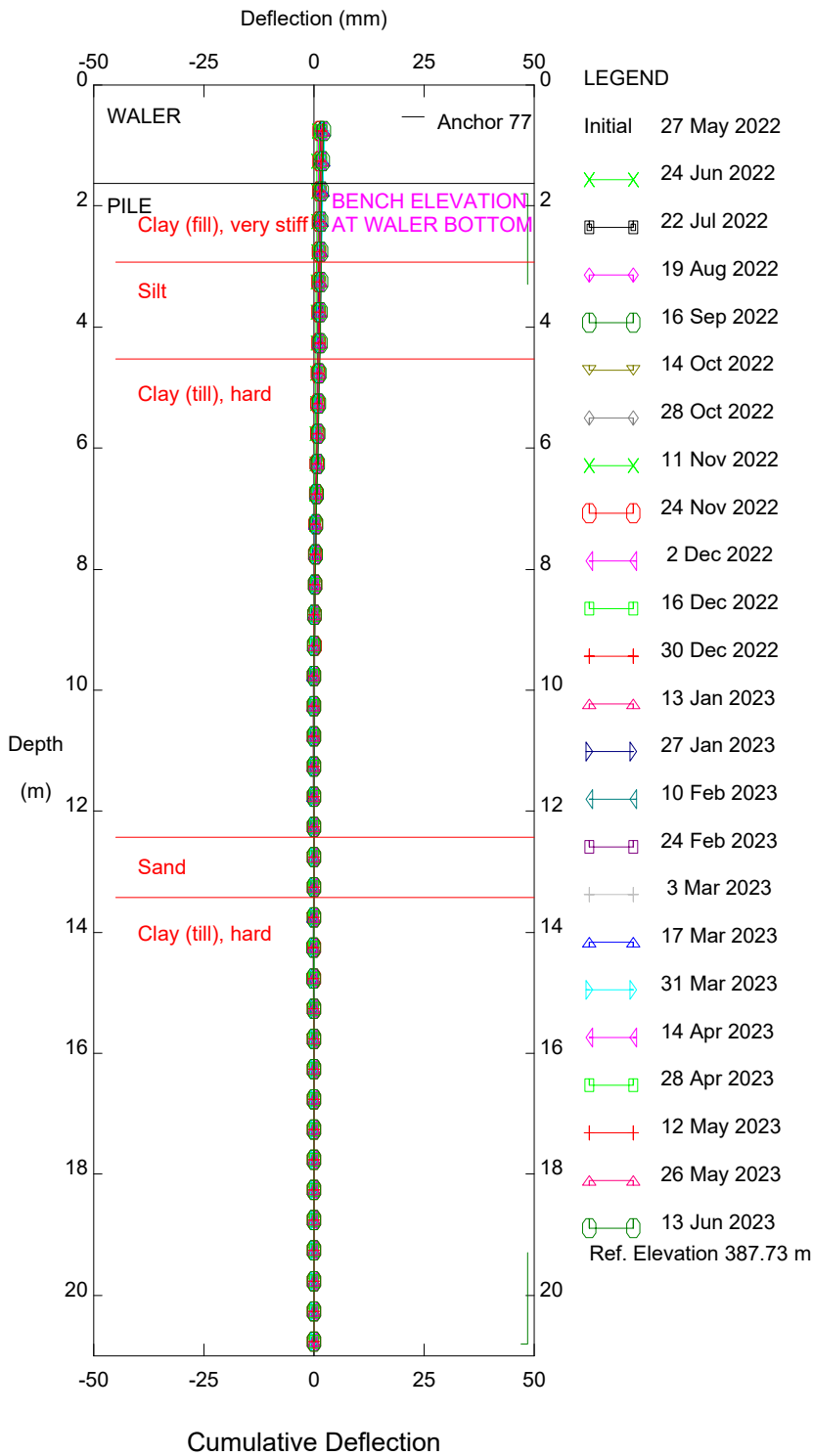
Thurber Engineering Ltd



Shop Slide Type 1 Wall Section, Inclinometer SAA-P34

Alberta Transportation

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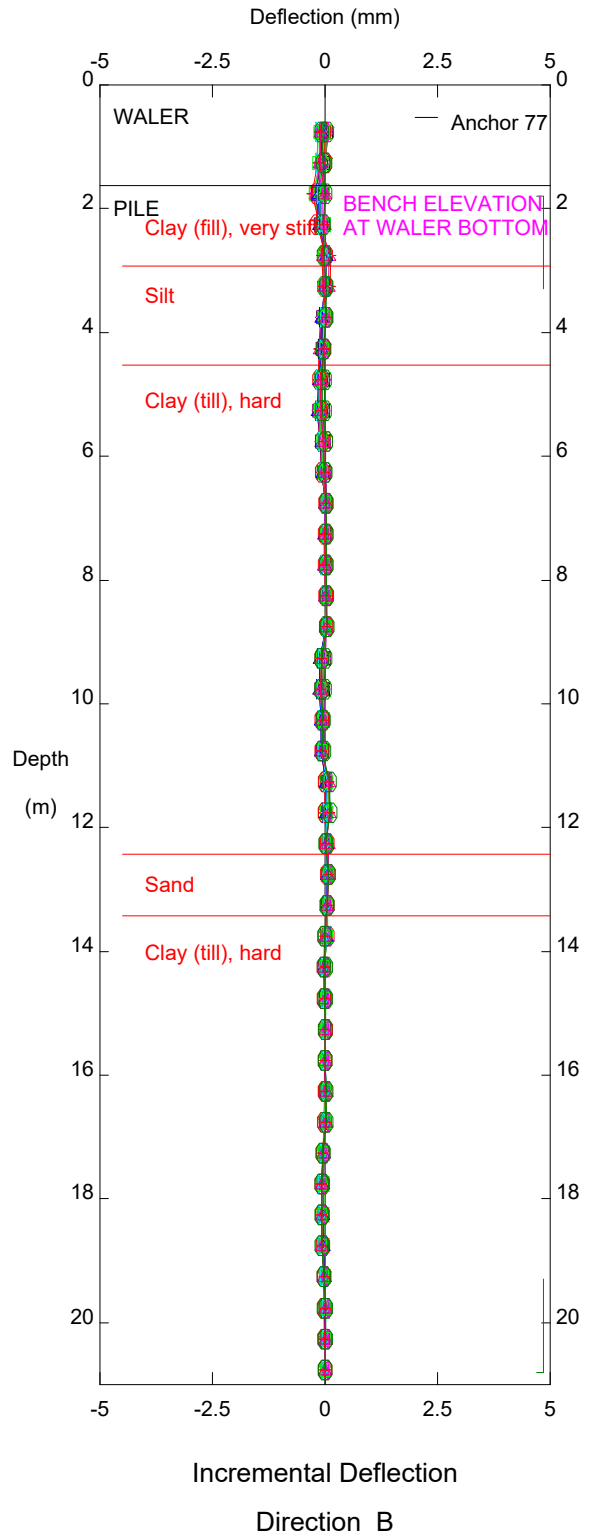
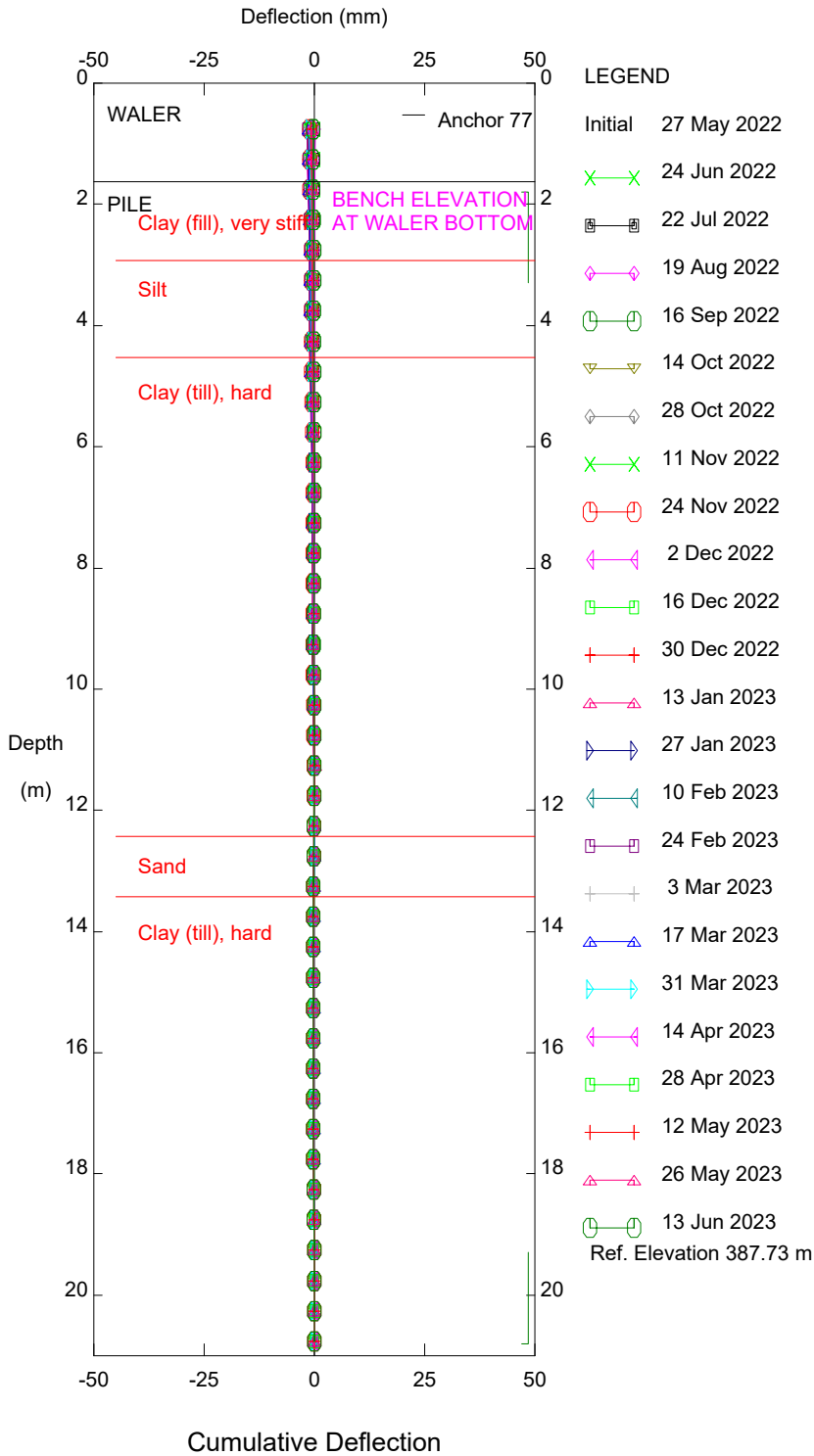
Dates of Note:

- July 15, 2021 - P77 poured, SAA installed
- February 8-April 1, 2022 - wall backfilled to top of waler
- April 1, 2022 - Anchor A77 locked off
- April 1-May 31, 2022 - wall backfilled to top of lagging and road level
- May 3-June 27, 2022 - Grading downslope of pile wall

Shop Slide Wall Type 2 Section, Inclinator SAA-P77

Alberta Transportation

Thurber Engineering Ltd



Dates of Note:

July 15, 2021 - P77 poured, SAA installed

February 8-April 1, 2022 - wall backfilled to top of waler

April 1, 2022 - Anchor A77 locked off

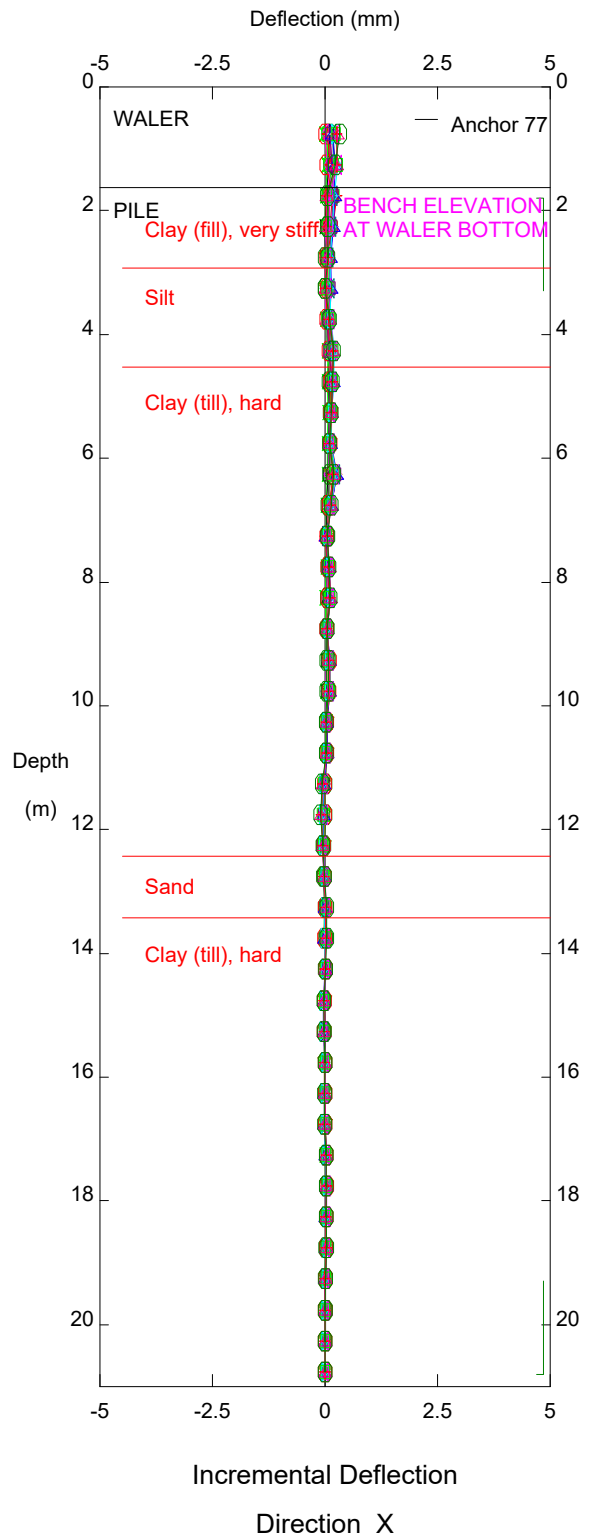
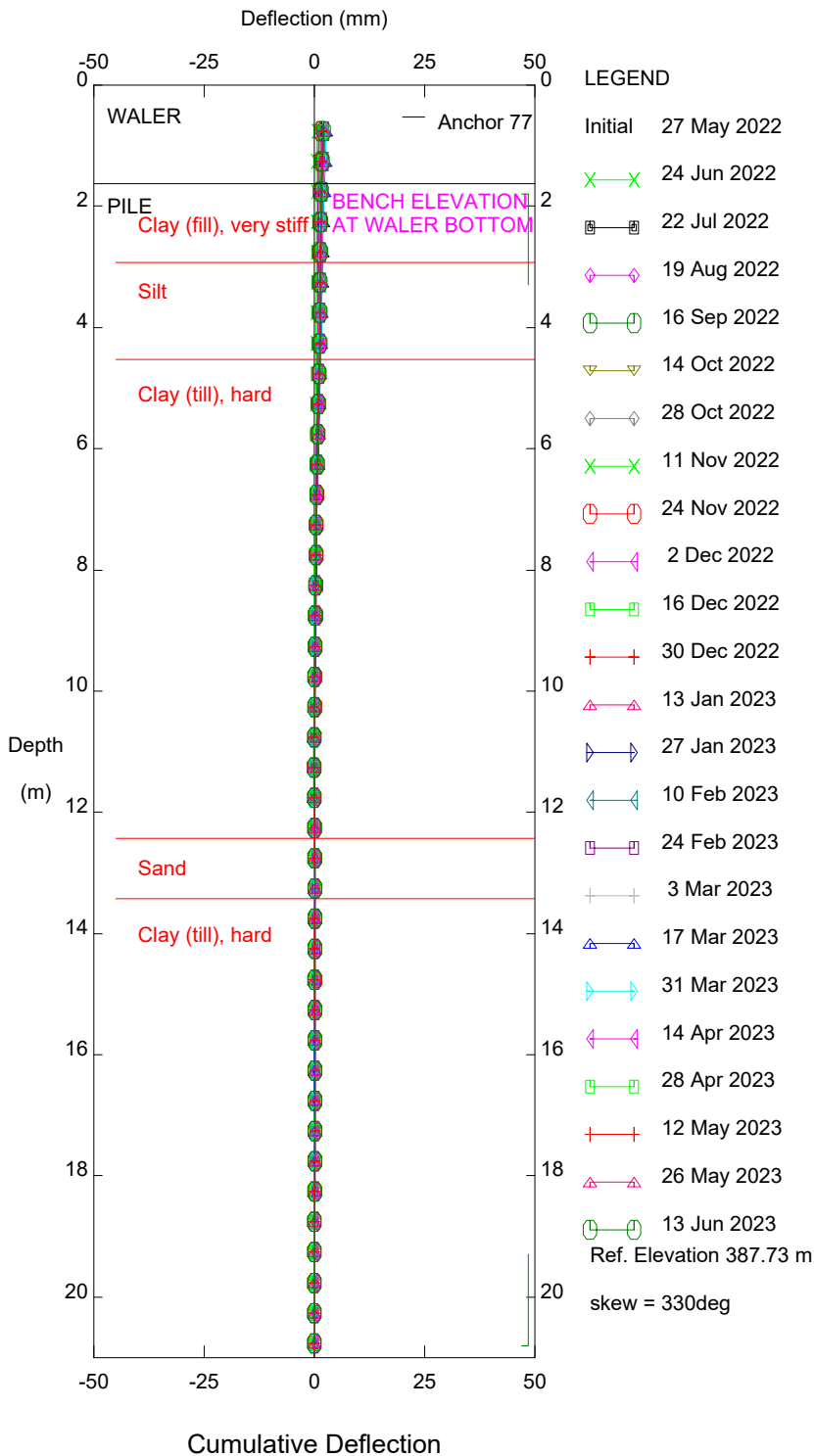
April 1-May 31, 2022 - wall backfilled to top of lagging and road level

May 3-June 27, 2022 - Grading downslope of pile wall

Shop Slide Wall Type 2 Section, Inclinator SAA-P77

Alberta Transportation

Thurber Engineering Ltd



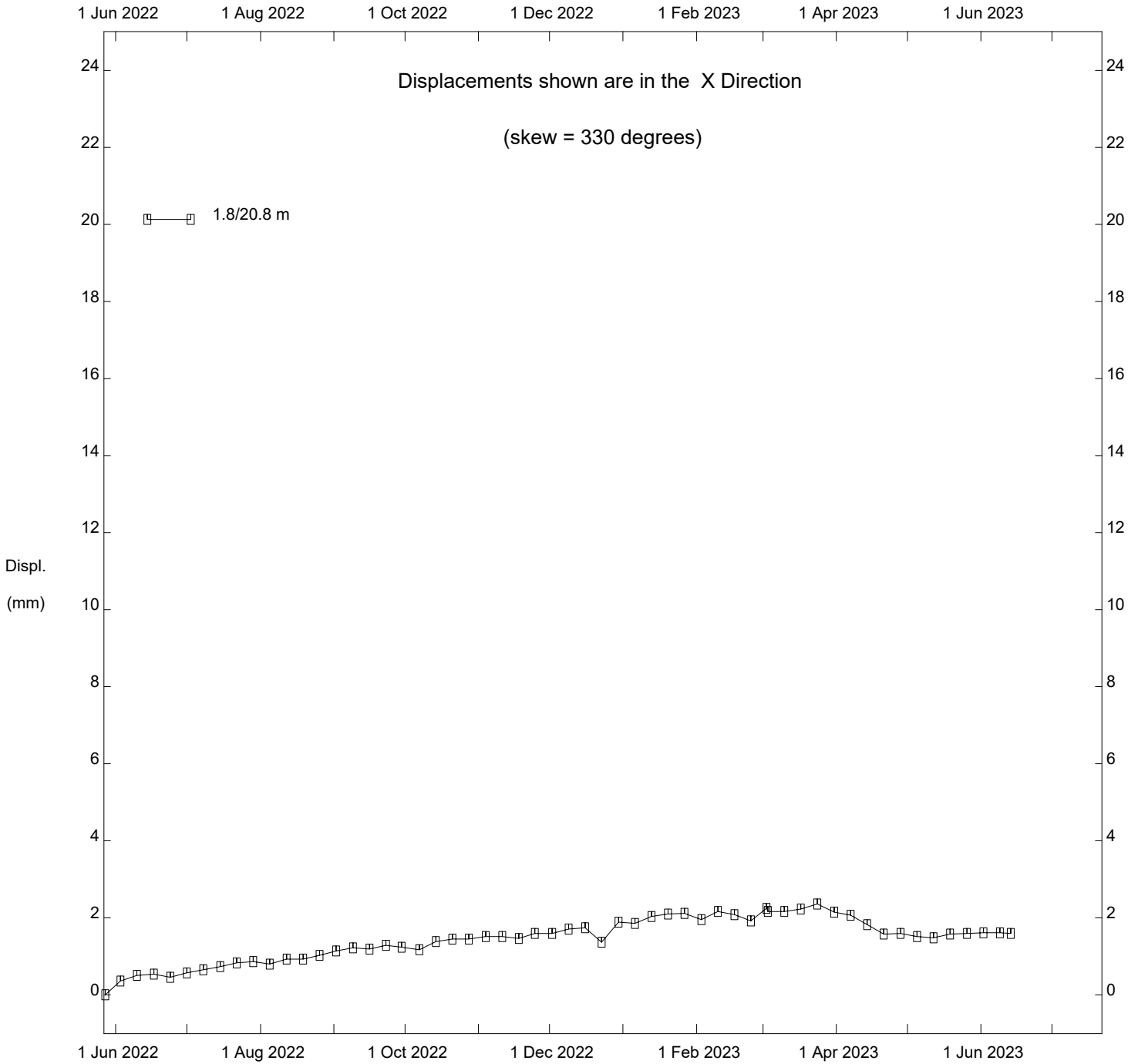
Dates of Note:

- July 15, 2021 - P77 poured, SAA installed
- February 8-April 1, 2022 - wall backfilled to top of waler
- April 1, 2022 - Anchor A77 locked off
- April 1-May 31, 2022 - wall backfilled to top of lagging and road level
- May 3-June 27, 2022 - Grading downslope of pile wall

Shop Slide Wall Type 2 Section, Inclinator SAA-P77

Alberta Transportation

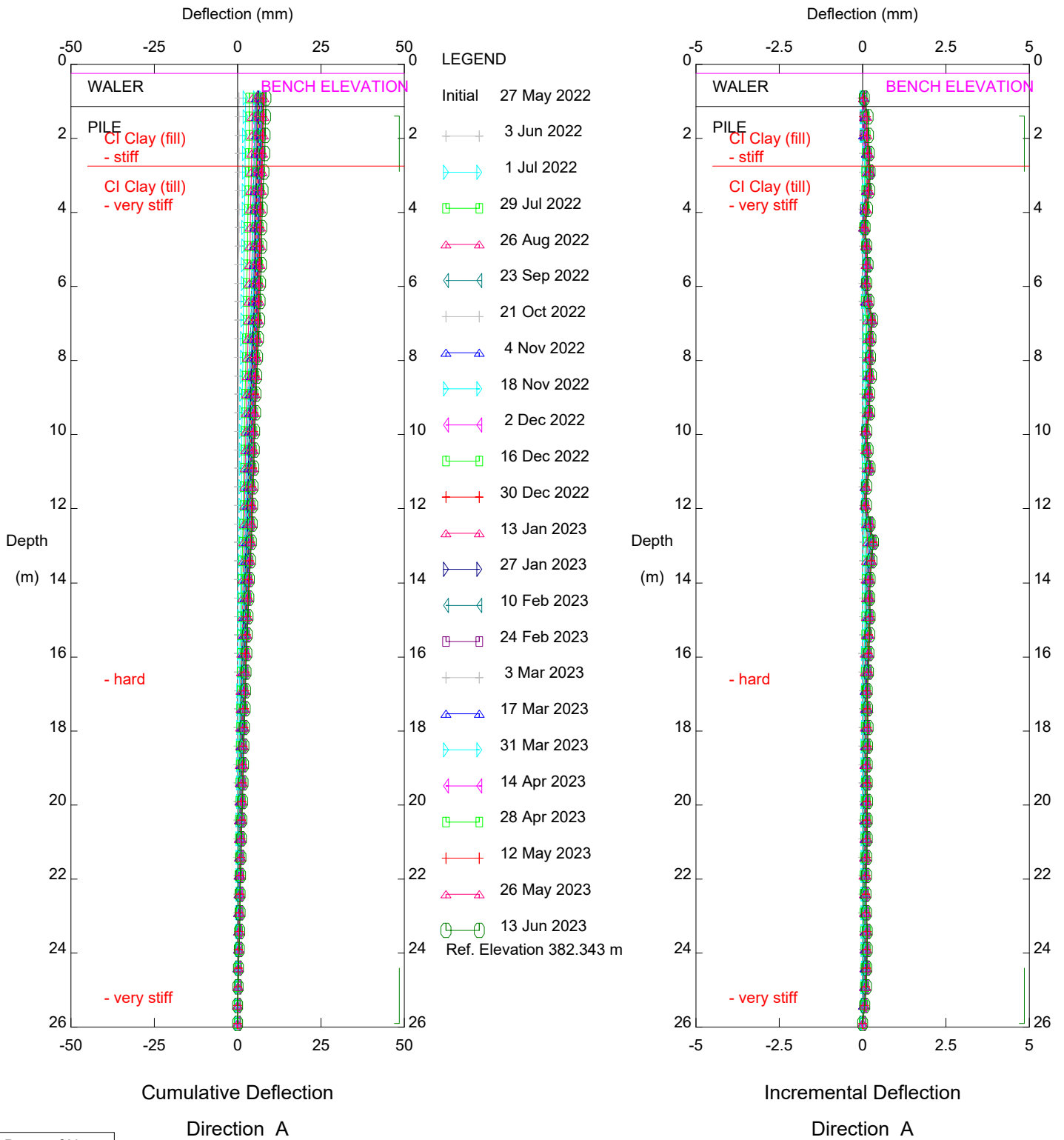
Thurber Engineering Ltd



Shop Slide Wall Type 2 Section, Inclinometer SAA-P77

Alberta Transportation

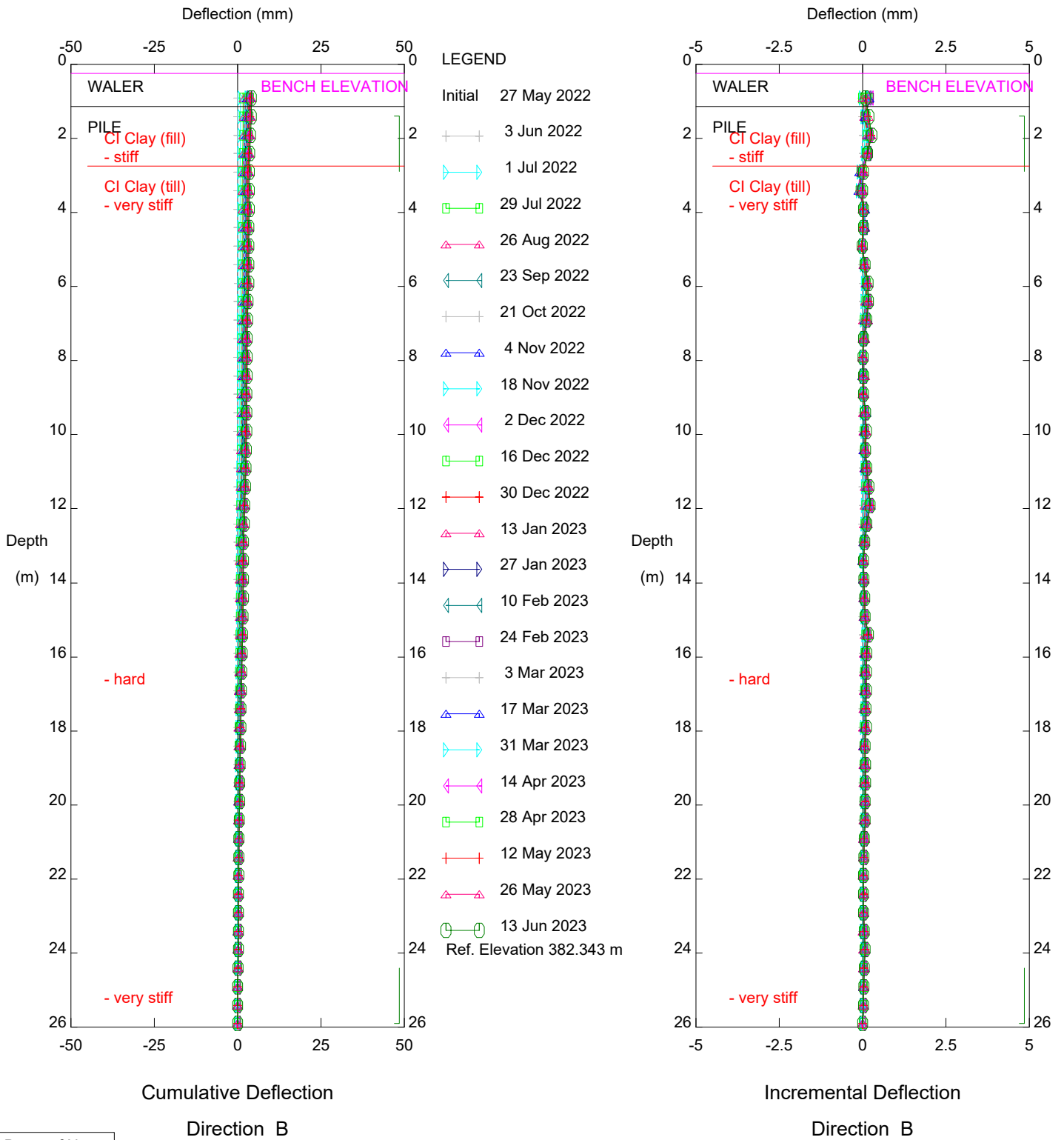
Thurber Engineering Ltd



Dates of Note:
 Sep. 23, 2022 - P113 poured, SAA installed
 February 8-May 31, 2022 - backfill completed above waler
 May 3-June 27, 2022 - grading downslope of pile wall

Shop Slide Wall Type 3, Inclinometer SAA-P113
 Alberta Transportation

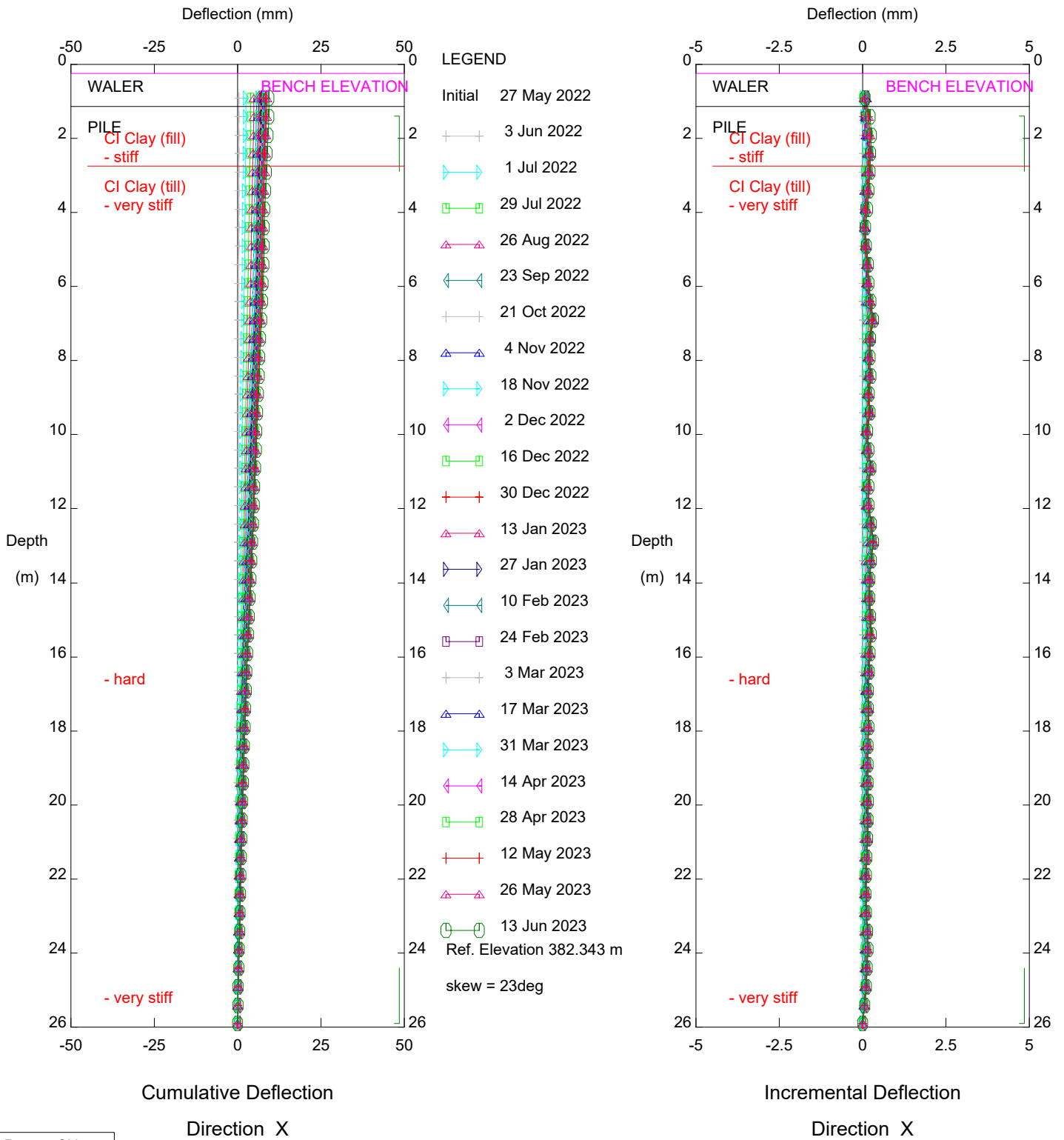
Thurber Engineering Ltd



Dates of Note:
 Sep. 23, 2022 - P113 poured, SAA installed
 February 8-May 31, 2022 - backfill completed above waler
 May 3-June 27, 2022 - grading downslope of pile wall

Shop Slide Wall Type 3, Inclinometer SAA-P113
 Alberta Transportation

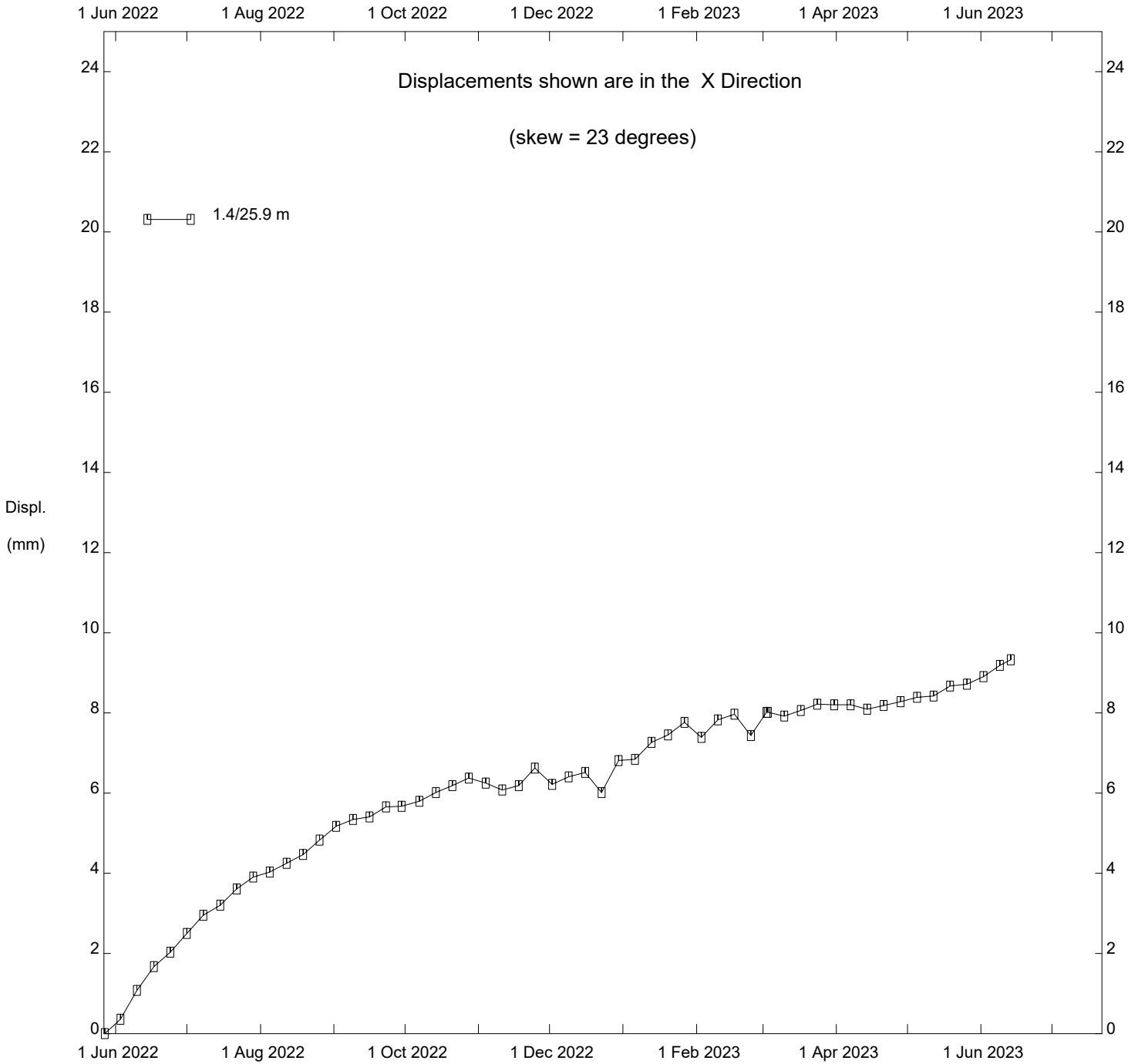
Thurber Engineering Ltd



Dates of Note:
 Sep. 23, 2022 - P113 poured, SAA installed
 February 8-May 31, 2022 - backfill completed above waler
 May 3-June 27, 2022 - grading downslope of pile wall

Shop Slide Wall Type 3, Inclinometer SAA-P113
 Alberta Transportation

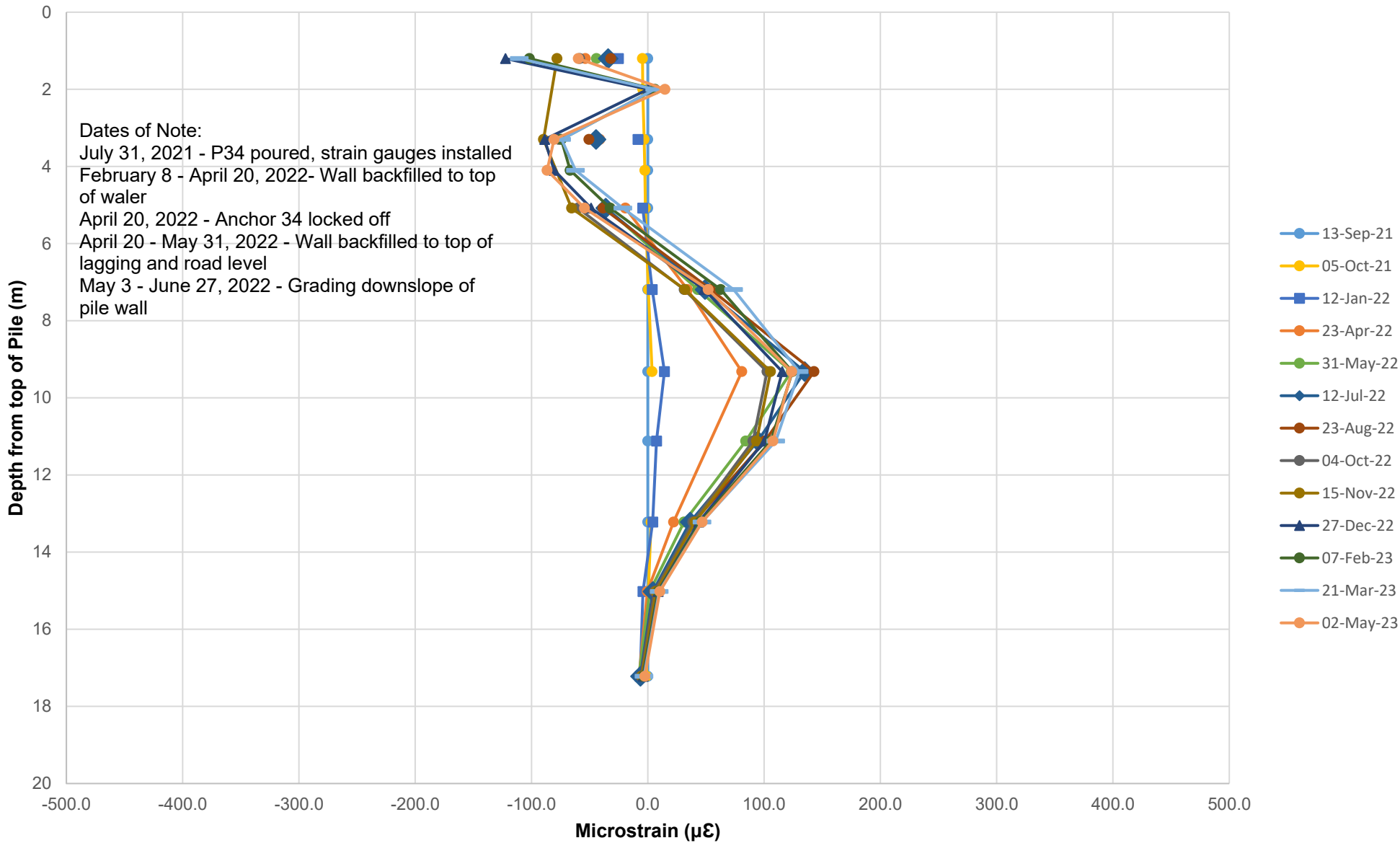
Thurber Engineering Ltd



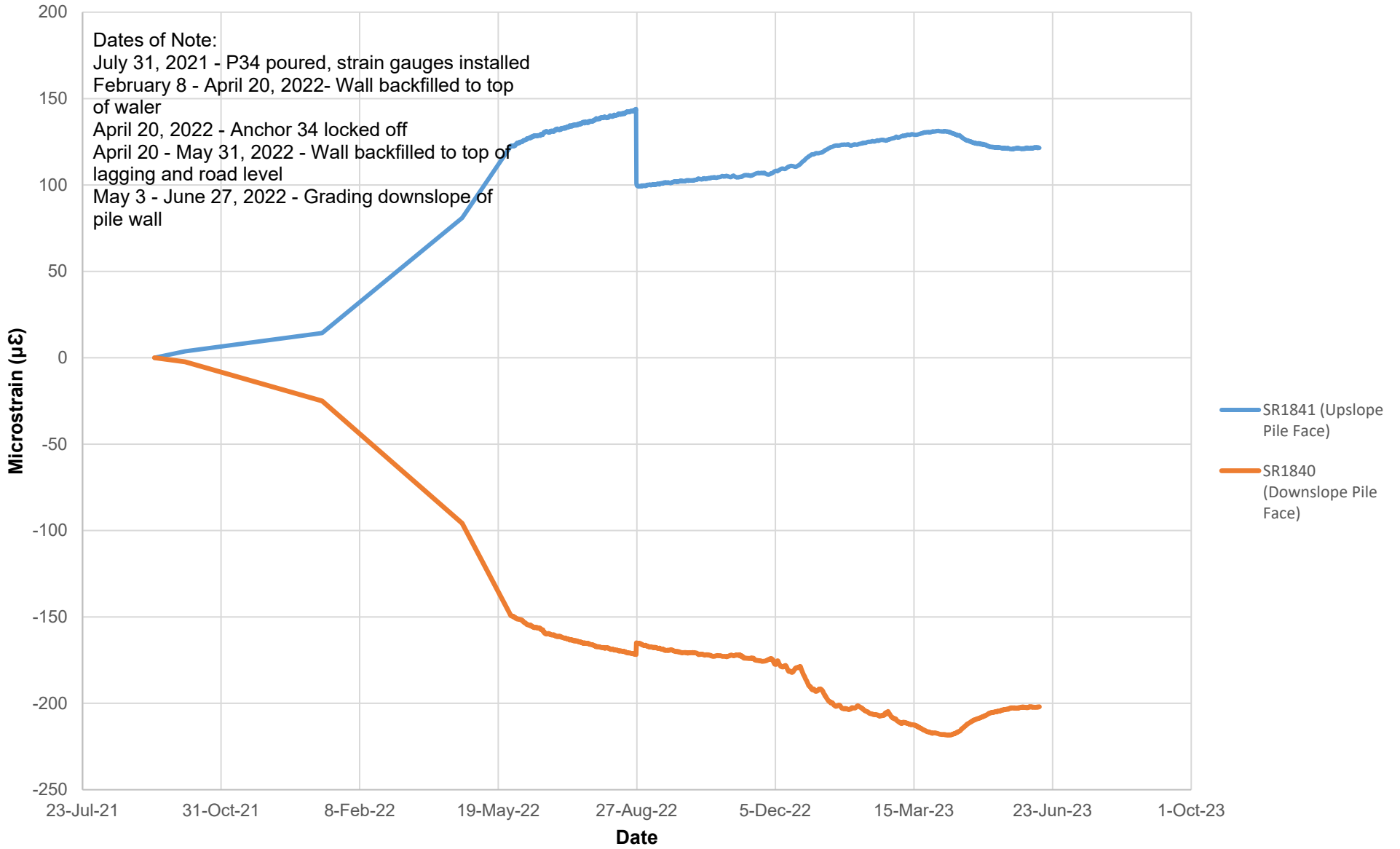
Shop Slide Wall Type 3, Inclinator SAA-P113

Alberta Transportation

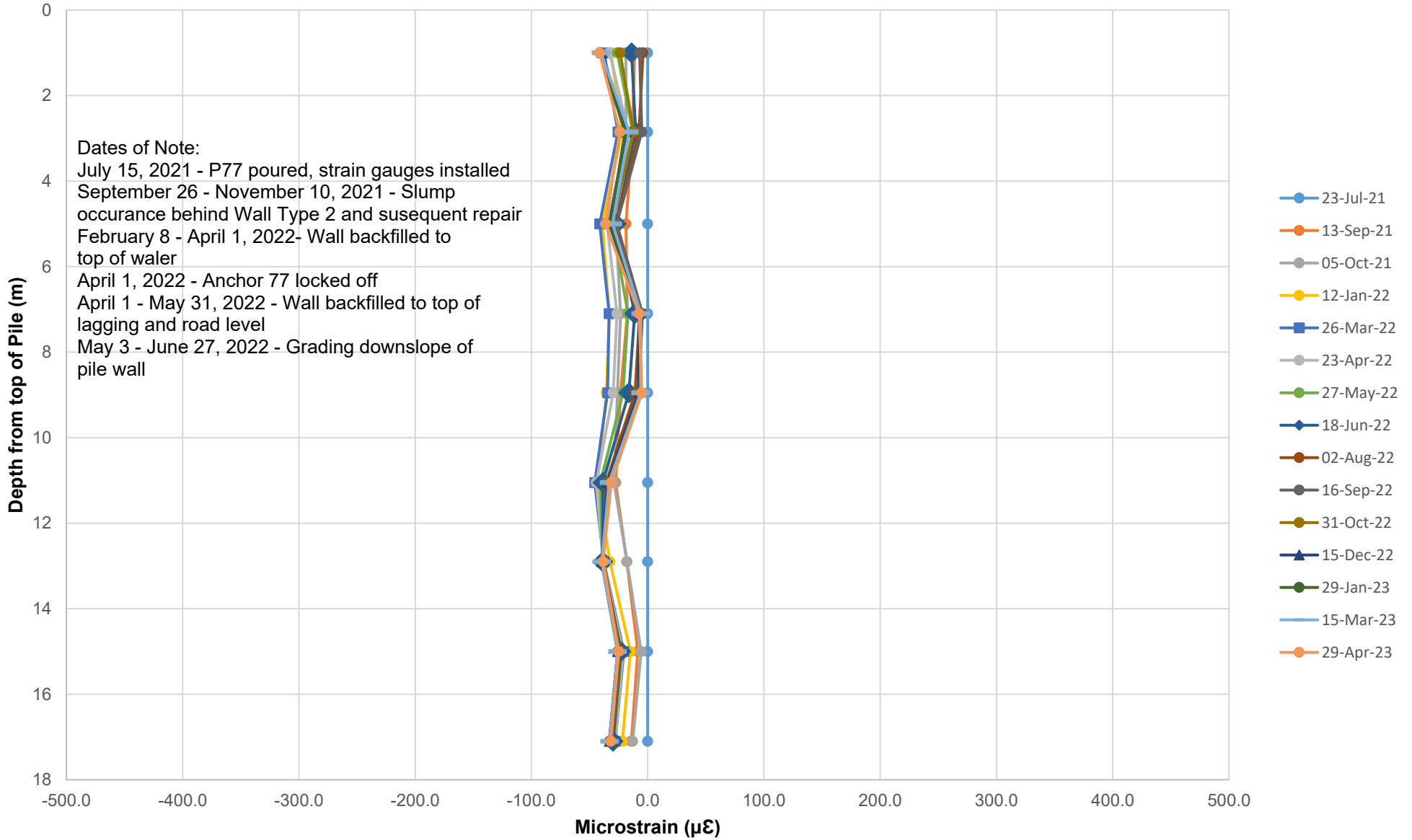
**FIGURE PH009-1: PEACE RIVER SHOP SLIDE
P34 UPSLOPE SIDE STRAIN GAUGE VALUES VS DEPTH**



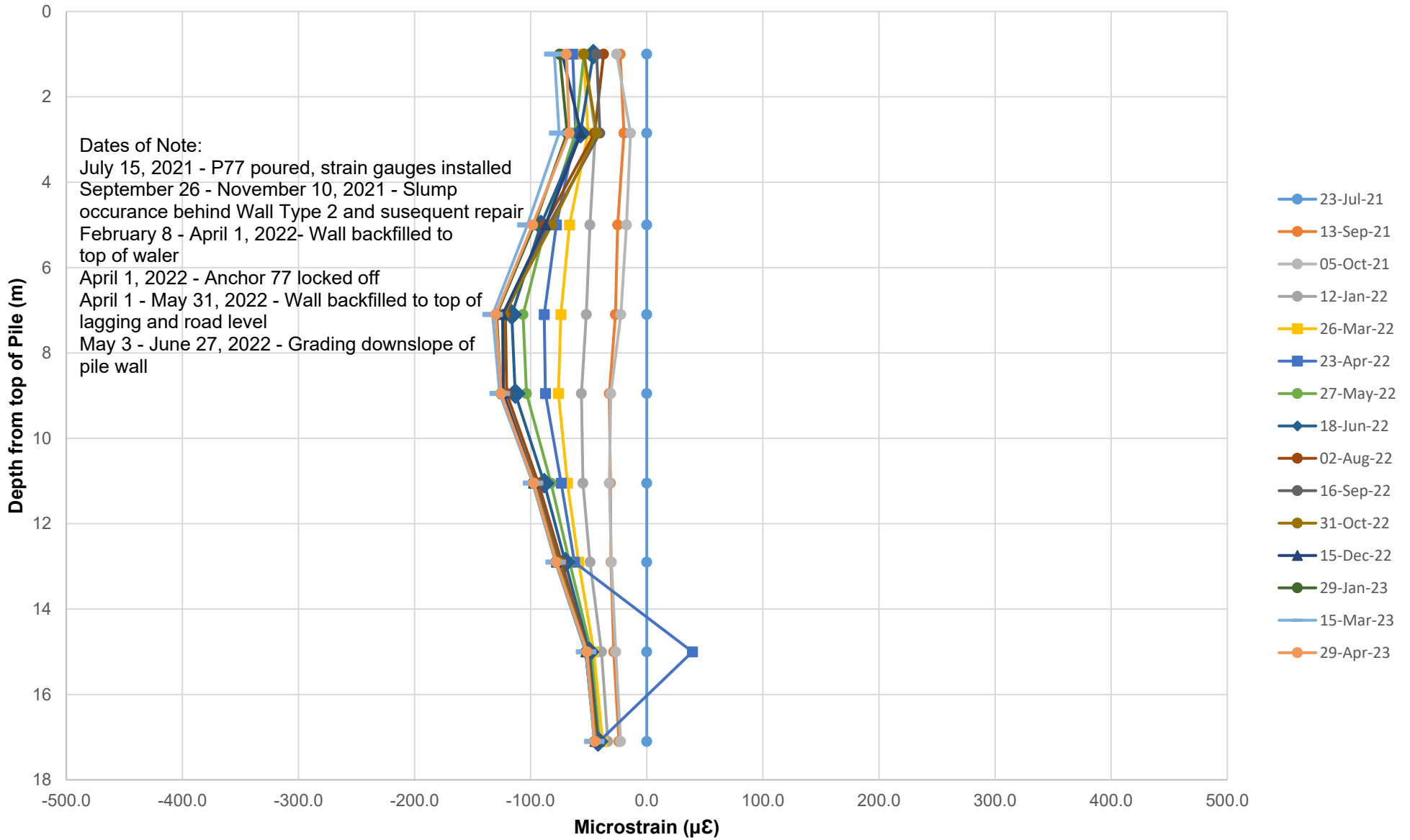
**FIGURE PH009-3: PEACE RIVER SHOP SLIDE
P34 MAXIMUM STRAIN VS TIME (9.3 m DEPTH)**



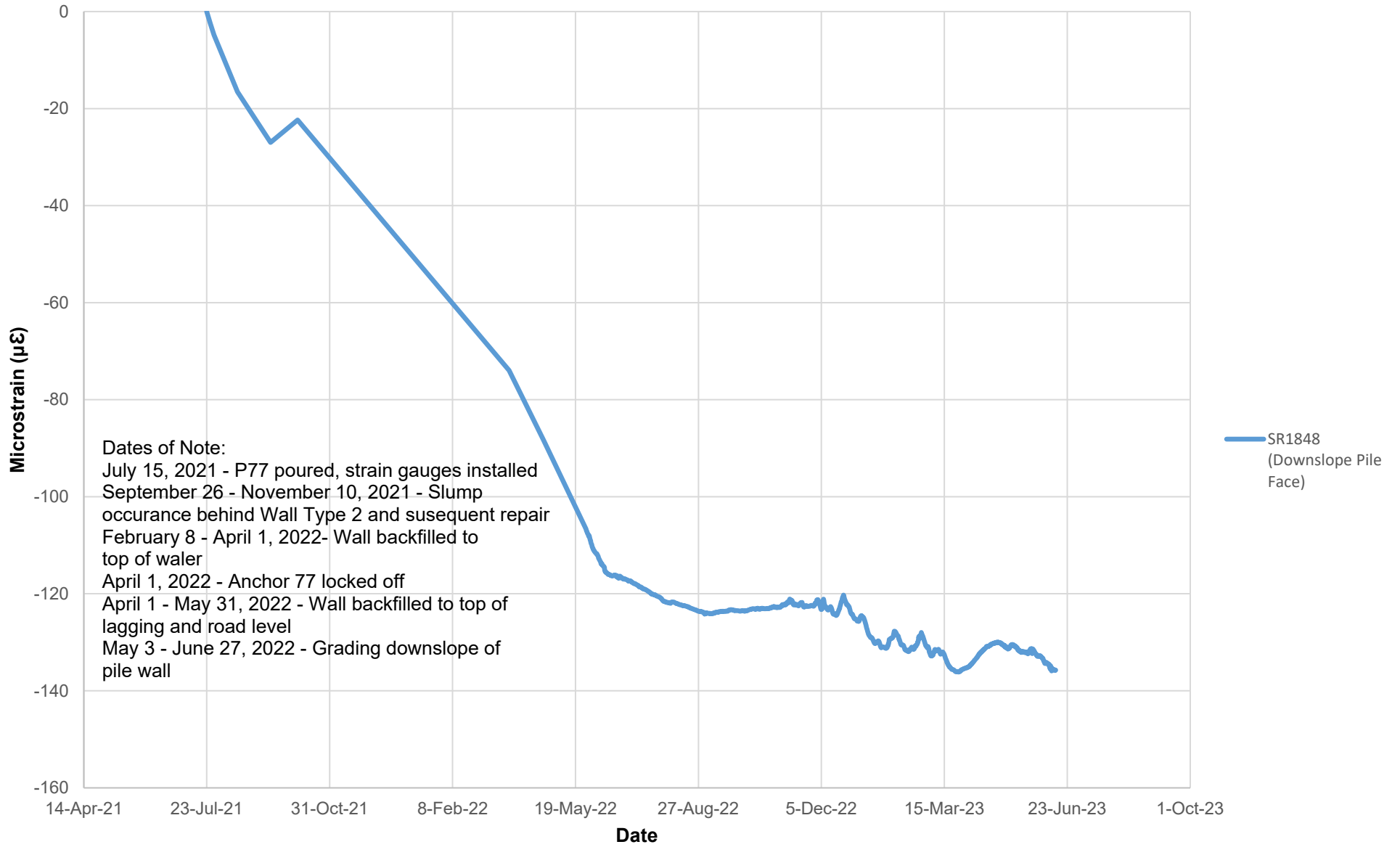
**FIGURE PH009-4: PEACE RIVER SHOP SLIDE
P77 UPSLOPE SIDE STRAIN GAUGE VALUES VS DEPTH**



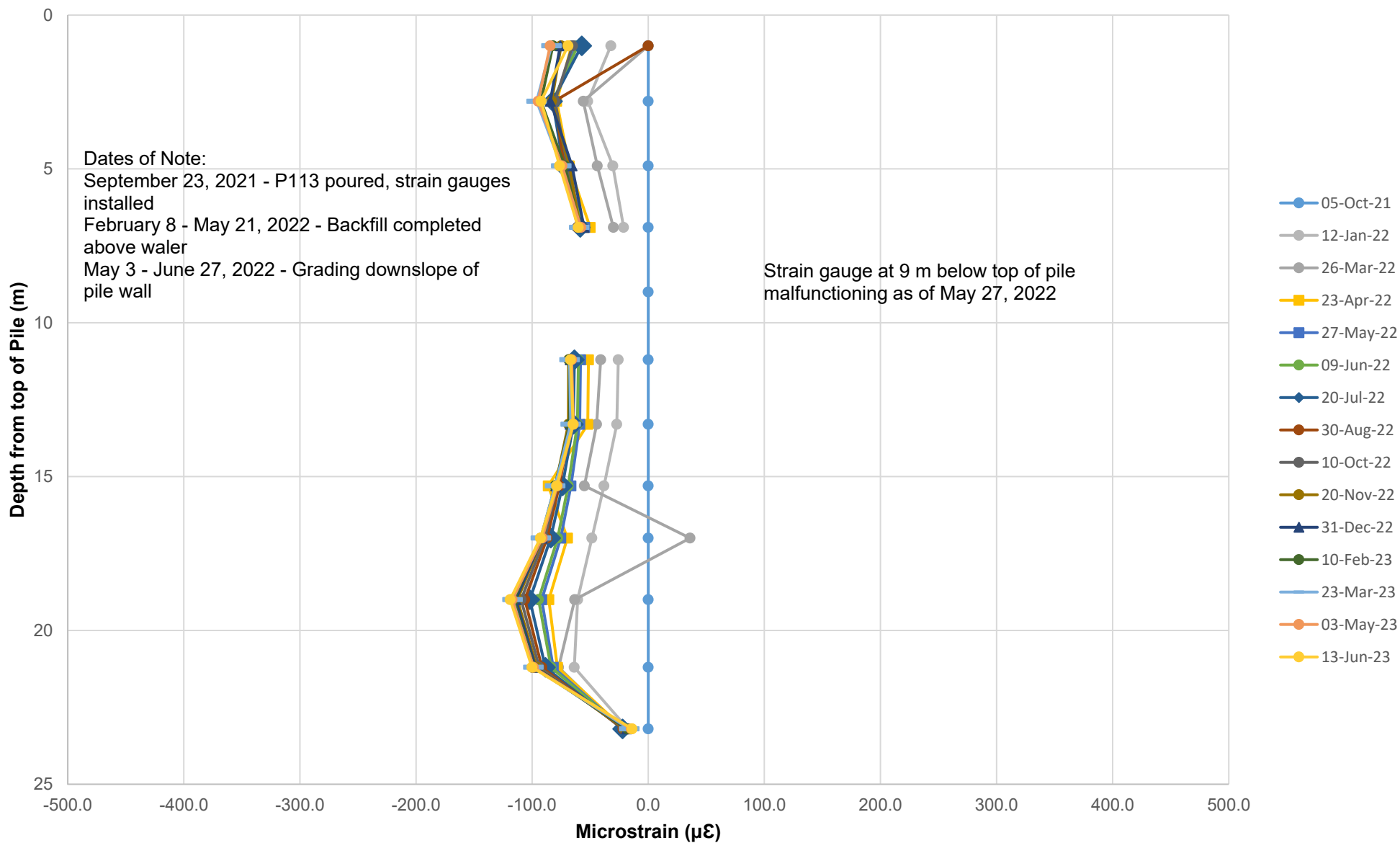
**FIGURE PH009-5: PEACE RIVER SHOP SLIDE
P77 DOWNSLOPE SIDE STRAIN GAUGE VALUES VS DEPTH**



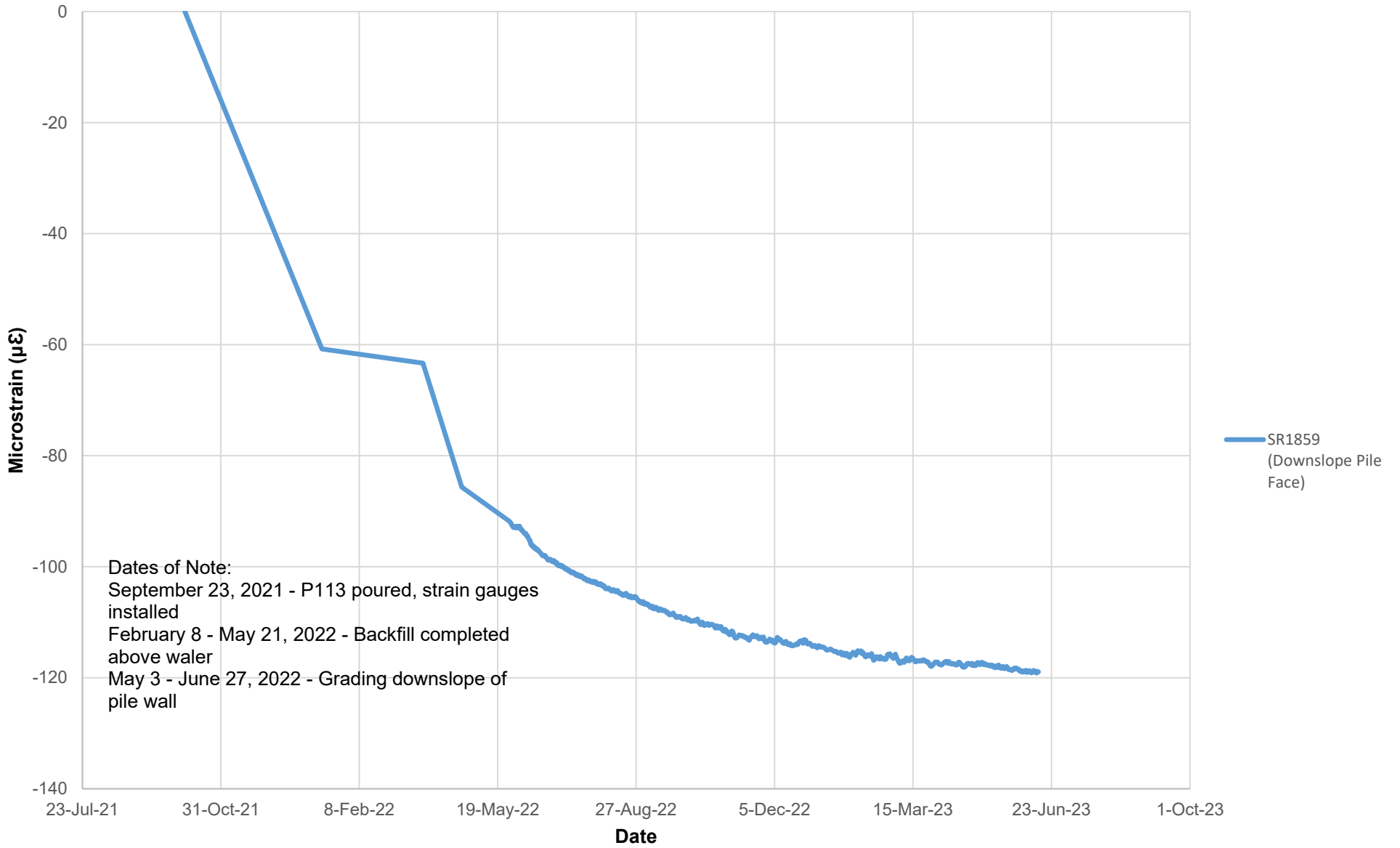
**FIGURE PH009-6: PEACE RIVER SHOP SLIDE
P77 MAXIMUM STRAIN VS TIME (7.1 m DEPTH)**



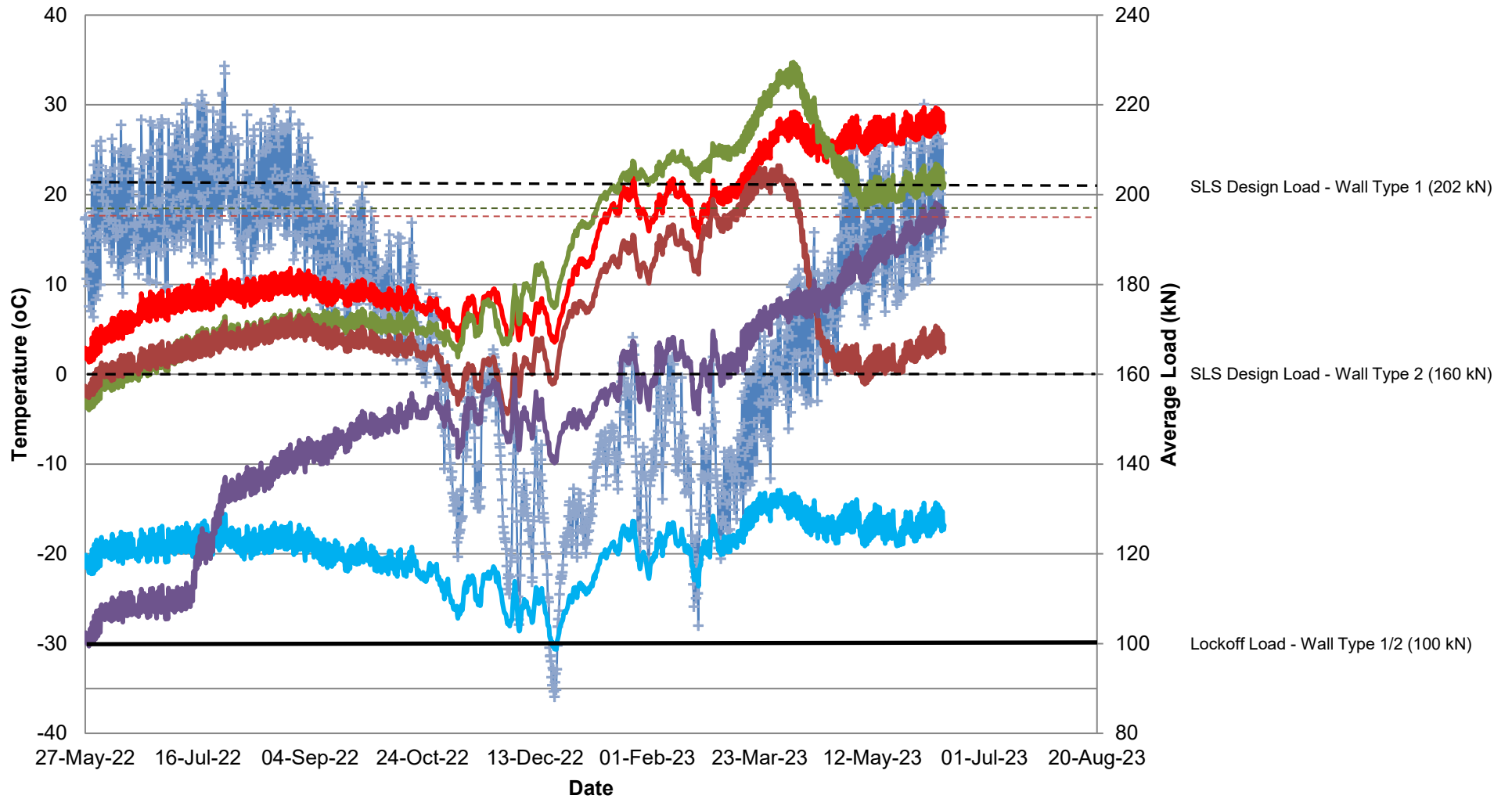
**FIGURE PH009-8: PEACE RIVER SHOP SLIDE
P113 DOWNSLOPE SIDE STRAIN GAUGE VALUES VS DEPTH**



**FIGURE PH009-9: PEACE RIVER SHOP SLIDE
P113 MAXIMUM STRAIN VS TIME (19.0 m DEPTH)**

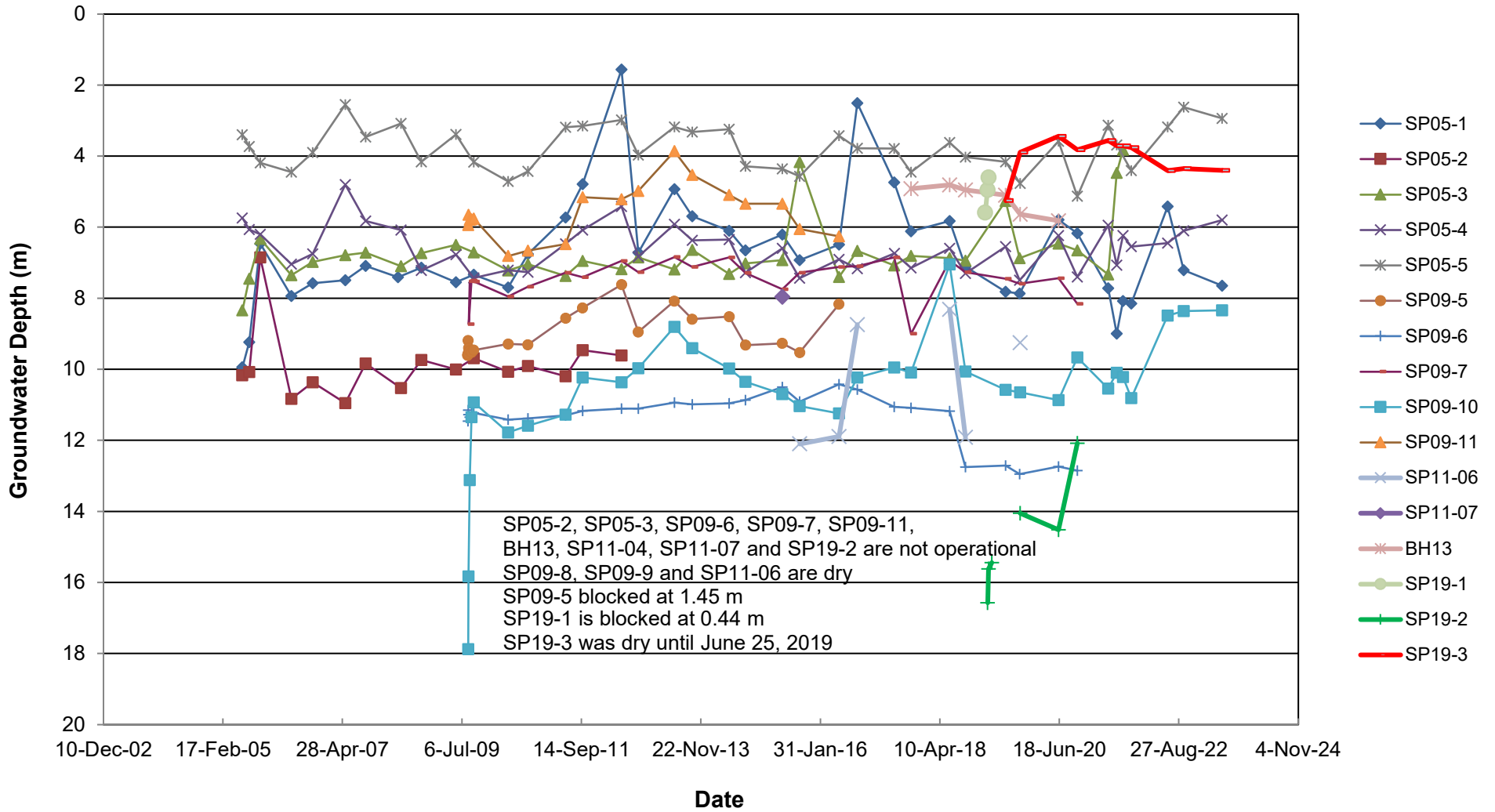


**FIGURE PH009-10
OLD HWY 2:02 SHOP SLIDE LOAD CELL READINGS**



- | | | |
|------------------------------|------------------------------|------------------------------|
| —+— Temperature oC | — A19 (VC2340) - Wall Type 1 | — A34 (VC2341) - Wall Type 1 |
| — A51 (VC2342) - Wall Type 1 | — A67 (VC2343) - Wall Type 2 | — A77 (VC2344) - Wall Type 2 |

**FIGURE PH009-11
STANDPIPE PIEZOMETER READINGS:
OLD HWY 2:02 SHOP SLIDE**



**FIGURE PH009-12
VIBRATING WIRE PIEZOMETER DATA
OLD HWY 2:02 SHOP SLIDE**

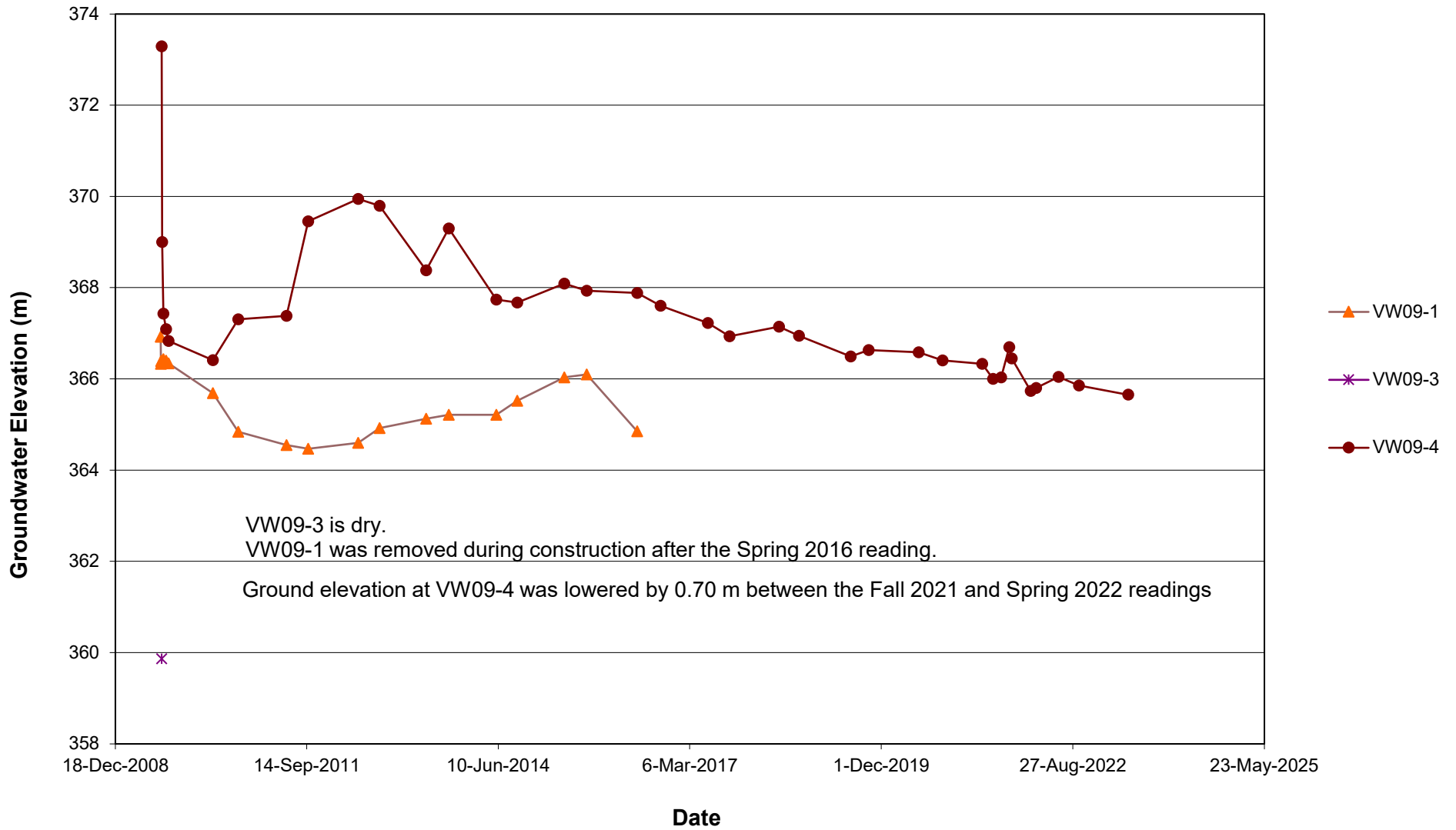


FIGURE PH009-13
PNEUMATIC PIEZOMETER READINGS: OLD HWY 2:02 (SHOP SLIDE)

