

July 15, 2024

Alberta Transportation and Economic Corridors
4th Floor, Provincial Building
4920 – 51st Street
Red Deer, Alberta
T4N 6K8

Tony Penney, P.Eng.
Construction Engineer

Dear Mr. Penney:

**CON0022160 Central Region GRMP Instrumentation Monitoring
Site C062; H41:02, km 2.889 Vermillion Backslope
Section C – 2024 Spring Readings**

1 GENERAL

One slope inclinometer (SI) (SI18-C62-03), six vibrating wire piezometers (VWPs) (VW48782 through VW48785, VW48787, and VW48788), and one standpipe piezometer (SP) (SP18-01) were read at the C062 site in the Central Region on May 14, 2024 by Aden Shipton, E.I.T. of Klohn Crippen Berger Ltd. (KCB). These instruments were read as part of the Central Region Geohazard Risk Management Program (GRMP). The site is located on Hwy 41:02, km 2.889, approximately 2.9 km north of Vermillion, Alberta. The approximate site coordinates are 5912662 N, 509163 E (UTM Zone 12, NAD 83). A site plan is presented in Figure 1.

The geohazard at the C062 site consists of a large, deep-seated-translational earth slide on the east (northbound) backslope of Hwy 41:02.

In April 2018, KCB conducted a geotechnical site investigation at the C062 site. Drilling was completed by Mobile Augers and Research Ltd. The encountered stratigraphy was as follows: medium to high plastic silty clay till, overlying bedrock (mudstone).

1.1 Instrumentation

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

In April 2018, KCB installed three SIs (SI18-C62-01 through SI18-C62-03), six VWPs (VW48782 through VW48785, VW48787, and VW48788), and one SP (SP18-01) to monitor depth of movement and ground water conditions, respectively. SI18-C62-01, VW48783, VW48784, and VW48788 were installed in borehole BH18-C62-01, located in the graben area at the crest of the slope. SI18-C62-02, VW48785, VW48787, and SP18-01 were installed in boreholes BH18-C62-02 and BH18-C62-03,

located approximately midslope, and SI18-C62-03 and VW48782 were installed in borehole BH18-C62-04, located at the toe of the slope in the east (northbound) ditch. By September 2019, SI18-C62-01 (crest) and SI18-C62-02 (midslope) were both sheared.

The instruments are protected by above-ground casing protectors.

The operable SI was read using the same metric RST Digital MEMS Inclinometer System that has been used to read the SI since it was installed.

The VWPs were read using an RST VW2106 vibrating wire readout and the SP was read using an RST Water Level Meter.

Table 1.1 Instrumentation Installation Details

| Instrument ID | Instrument Type | Date Installed | UTM Coordinates ¹ (m) | | Ground Surface Elevation ¹ (m) | Stick Up (m) | Depth (mbgs ²) | Condition |
|---------------|-----------------|----------------|----------------------------------|---------|---|--------------|----------------------------|-------------------------|
| | | | Northing | Easting | | | | |
| SI18-C62-01 | SI | Apr. 07, 2018 | 5912695 | 509210 | 608 | 0.9 | 22.2 | Inoperable ³ |
| SI18-C62-02 | SI | Apr. 06, 2018 | 5912669 | 509199 | 600 | 0.9 | 24.4 | Inoperable ³ |
| SI18-C62-03 | SI | Apr. 08, 2018 | 5912647 | 509186 | 593 | 0.8 | 10.5 | Operable |
| VW48782 | VWP | Apr. 08, 2018 | 5912647 | 509186 | 593 | N/A | 9.6 | Operable |
| VW48783 | VWP | Apr. 07, 2018 | 5912695 | 509210 | 608 | N/A | 6.1 | Operable |
| VW48784 | VWP | Apr. 07, 2018 | 5912695 | 509210 | 608 | N/A | 14.3 | Operable |
| VW48785 | VWP | Apr. 06, 2018 | 5912669 | 509199 | 600 | N/A | 12.8 | Operable, but dry |
| VW48787 | VWP | Apr. 06, 2018 | 5912669 | 509199 | 600 | N/A | 23.8 | Operable |
| VW48788 | VWP | Apr. 07, 2018 | 5912695 | 509210 | 608 | N/A | 21.3 | Operable |
| SP18-01 | SP | Apr. 06, 2018 | 5912667 | 509201 | 600 | 0.8 | 13.6 | Operable, but dry |

Notes:

¹ Coordinates and ground surface elevations were estimated from July 2018 survey data.

² Meters below ground surface (mbgs).

³ SI18-C62-01 and SI18-C62-02 have sheared at an approximate depth of 12.0 m and 4.5 m below ground surface, respectively.

2 INTERPRETATION

2.1 General

For the operable SI, the cumulative displacement, incremental displacement, and displacement-time data was plotted in the A-direction (i.e., the direction of the A0-groove). The A0-groove in the SI is aligned approximately with the direction of anticipated maximum movement (i.e., perpendicular to the highway), in the downslope direction.

For the operable VWPs, 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. No data plot is provided for SP18-01 because it has been dry since installation.

The SI and piezometer data plots are included in Appendix I, and a summary of the SI and piezometer data is provided in Table 2.1 through Table 2.3, respectively.

Table 2.1 Slope inclinometer Reading Summary

| Instrument ID | Date | | | | Ground Surface Elevation (m) | Depth of Movement (mbgs ¹) | Direction of Movement | Movement (mm) | | Rate of Movement (mm/year) | | |
|--------------------------|---------------|---|------------------|-------------------------------|------------------------------|--|-----------------------|--------------------|---|----------------------------|-------------------------------|------------------------------|
| | Initialized | Previous Maximum Cumulative Movement Recorded | Previous Reading | Most Recent Reading | | | | Maximum Cumulative | Incremental Since Previous Maximum Cumulative | Previous Maximum | Most Recent Reading | Change from Previous Reading |
| SI18-C62-01 ² | Apr. 16, 2018 | Jul. 13, 2018 | May 16, 2019 | N/A – inoperable ² | 608 | 11.4 – 12.0 | A-Direction | 36.5 | N/A – inoperable ² | 40.2 | N/A – inoperable ² | |
| SI18-C62-02 ² | Apr. 16, 2018 | Jul. 13, 2018 | May 16, 2019 | N/A – inoperable ² | 600 | 3.4 – 4.4 | A-Direction | 50.5 | N/A – inoperable ² | 54.2 | N/A – inoperable ² | |
| SI18-C62-03 | Apr. 16, 2018 | N/A – no discernible movement has been recorded | Sep. 19, 2023 | May 14, 2024 | 593 | N/A – no discernible movement recorded | | | | | | |

Notes:

¹ Meters below ground surface (mbgs).

² SI18-C62-01 and SI18-C62-02 have sheared at an approximate depth of 12.0 m and 4.5 m below ground surface, respectively.

Table 2.2 Vibrating Wire 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) |
| VW48782 | Apr. 08, 2018 | Sep. 19, 2023 | May 14, 2024 | 593 | 9.6 | 3.3 | 1.6 | 1.7 |
| VW48783 | Apr. 07, 2018 | Sep. 19, 2023 | May 14, 2024 | 608 | 6.1 | 4.0 | 4.1 | -0.1 |
| VW48784 | Apr. 07, 2018 | Sep. 19, 2023 | May 14, 2024 | 608 | 14.3 | 13.2 | 13.4 | -0.2 |
| VW48785 | Apr. 06, 2018 | Sep. 19, 2023 | May 14, 2024 | 600 | 12.8 | N/A - instrument is dry | | |
| VW48787 | Apr. 06, 2018 | Sep. 19, 2023 | May 14, 2024 | 600 | 23.8 | 14.9 | 14.5 | 0.4 |
| VW48788 | Apr. 07, 2018 | Sep. 19, 2023 | May 14, 2024 | 608 | 21.3 | 20.1 | 20.1 | 0.0 |

Notes:

¹ Meters below ground surface (mbgs).

Table 2.3 Standpipe Piezometer Reading Summary

| Instrument ID | Date | | | Ground Surface Elevation (m) | Screen 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) |
| SP18-01 | Apr. 06, 2018 | Sep. 19, 2023 | May 14, 2024 | 600 | 10.6 – 13.6 | N/A – instrument dry | | |

Notes:

¹ Meters below ground surface (mbgs).

2.2 Zones of Movement

Prior to being sheared, movement was recorded in SI18-C62-01 (crest) and SI18-C62-02 (midslope) at an approximate depth of 12.0 m and 4.5 m below ground surface, respectively, in clay till. The movement recorded in these instruments was discrete (i.e., occurring on a defined failure plane) at an approximate elevation of 596 m.

Since installation, no discernible movement has been recorded in SI18-C62-03 (toe of slope).

2.3 Interpretation of Monitoring Results

The previous geotechnical site investigations and current instrumentation data suggest the mode of failure is likely a deep-seated translational earth block slide. Discrete movement was recorded in SI18-C62-01 (crest) and SI18-C62-02 (midslope) at an approximate elevation of 596 m. Since installation, no discernible movement has been recorded in SI18-C62-03 (toe of slope). Recorded movement in the midslope and crest of the backslope was at a similar elevation, and the absence of movement at the toe suggests that the depth of the basal failure planes varies from 12.0 m in the graben area (SI18-C62-01) to 4.5 m at the midslope (SI18-C62-02). During the 2018 geotechnical site investigation, a zone of clay till with elevated moisture contents and sand/silty layers was encountered near the basal failure plane location.

The rate of movement previously recorded at the midslope in SI18-C62-02 was higher than the rate of movement recorded in SI18-C62-01 at the crest of the slope. As the lower portion of the slide beneath the midslope continues to move, the upper portion of the slide beneath the crest of the slope will experience an increased rate of movement due to the loss of support associated with the lower portion of the slide moving away from the upper portion of the slide.

The piezometers have been either relatively steady (± 1.5 m) or dry since installation. The May 2024 readings were consistent with historical trends observed in these instruments, except for VW48782 at the toe of the slope which has recorded a 2.7 m increase since spring 2023. Precipitation data from the Alberta Climate Information Service (ACIS) Vermillion AGDM weather station, located approximately 2.5 km southwest of C062, recorded approximately 80 mm more precipitation in May 2024 than May 2023. As VW48782 is installed below the east (northbound) ditch below the slide, the increase in water level is likely in response to greater volumes of surface water runoff through the ditch and the resultant increased infiltration (likely exacerbated by the toe roll partially blocking the ditch).

In the nested piezometers installed in BH18-C62-01 (VW48783, VW48784, and VW48788) at the crest of the slope, two independent water levels were detected in the clay till, which could indicate the presence of two perched groundwater tables. This is likely due to the presence of sand and silt lenses found interbedded within the clay till layer.

The current porewater pressure data and previously recorded movements are consistent with the initial monitoring results presented in our 2018 geotechnical site investigation report dated October 5, 2018. The current instrumentation data also supports the analysis and recommendations

presented in our 2018 report (i.e., that lowering the groundwater table or flattening the backslope could improve overall stability by approximately 50% to 60%).

3 RECOMMENDATIONS

3.1 Future Work

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

Remedial options are currently being discussed between KCB and Alberta Transportation and Economic Corridors (TEC) and may include installing horizontal drains and/or flattening the slope. At this time, the highway below the slide has not been impacted by slope movements, but the toe roll is starting to block the ditch. If the rate of movement is observed to be increasing, as assessed by visual observations at the toe and crest of the slide, or the ditch becomes blocked, TEC will need to take action to ensure that the highway is not impacted (e.g., excavating material that is blocking the ditch to improve drainage).

3.2 Instrument Repairs or 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 Central Region Geohazard Risk Management Program (Contract No. CON0022160), and it may not be relied upon by any other party without KCB's written consent.

KCB has prepared this report in a manner consistent with the level of care, skill and diligence ordinarily provided by members of the same profession for projects of a similar nature at the time and place the services were rendered. KCB makes no warranty, express or implied.

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1. The report is to be read in full, with sections or parts of the report relied upon in the context of the whole report.
2. The observations, findings and conclusions in this report are based on observed factual data and conditions that existed at the time of the work and should not be relied upon to precisely represent conditions at any other time.
3. The report is based on information provided to KCB by the Client or by other parties on behalf of the client (Client-supplied information). KCB has not verified the correctness or accuracy of such information and makes no representations regarding its correctness or accuracy.

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4. KCB should be consulted regarding the interpretation or application of the findings and recommendations in the report.
5. This report is electronically signed and sealed and its electronic form is considered the original. A printed version of the original can be relied upon as a true copy when supplied by the author or when printed from its original electronic file.

Please contact the undersigned if you have any questions or comments regarding this report.
Yours truly,

KLOHN CRIPPEN BERGER LTD.



James Lyons, P.Eng.
Civil Engineer

Aden Shipton, E.I.T.
Civil Engineer in Training

JL:bb

ATTACHMENTS

Figure
Appendix I Instrumentation Plots

FIGURE



Legend

- Instrument Location
- Power Pole
- Toe Roll
- Main Scarp
- Minor Scarp
- Crack



NOTES:
 1. HORIZONTAL DATUM: NAD83
 2. GRID ZONE: UTM Zone 12N
 3. IMAGE SOURCE: World Imagery, ESRI ArcGIS Online
 Acquired for use October 18, 2021.
 4. Instrument locations are approximate (not surveyed).
 5. Strikethrough indicates the instrument is inoperable.

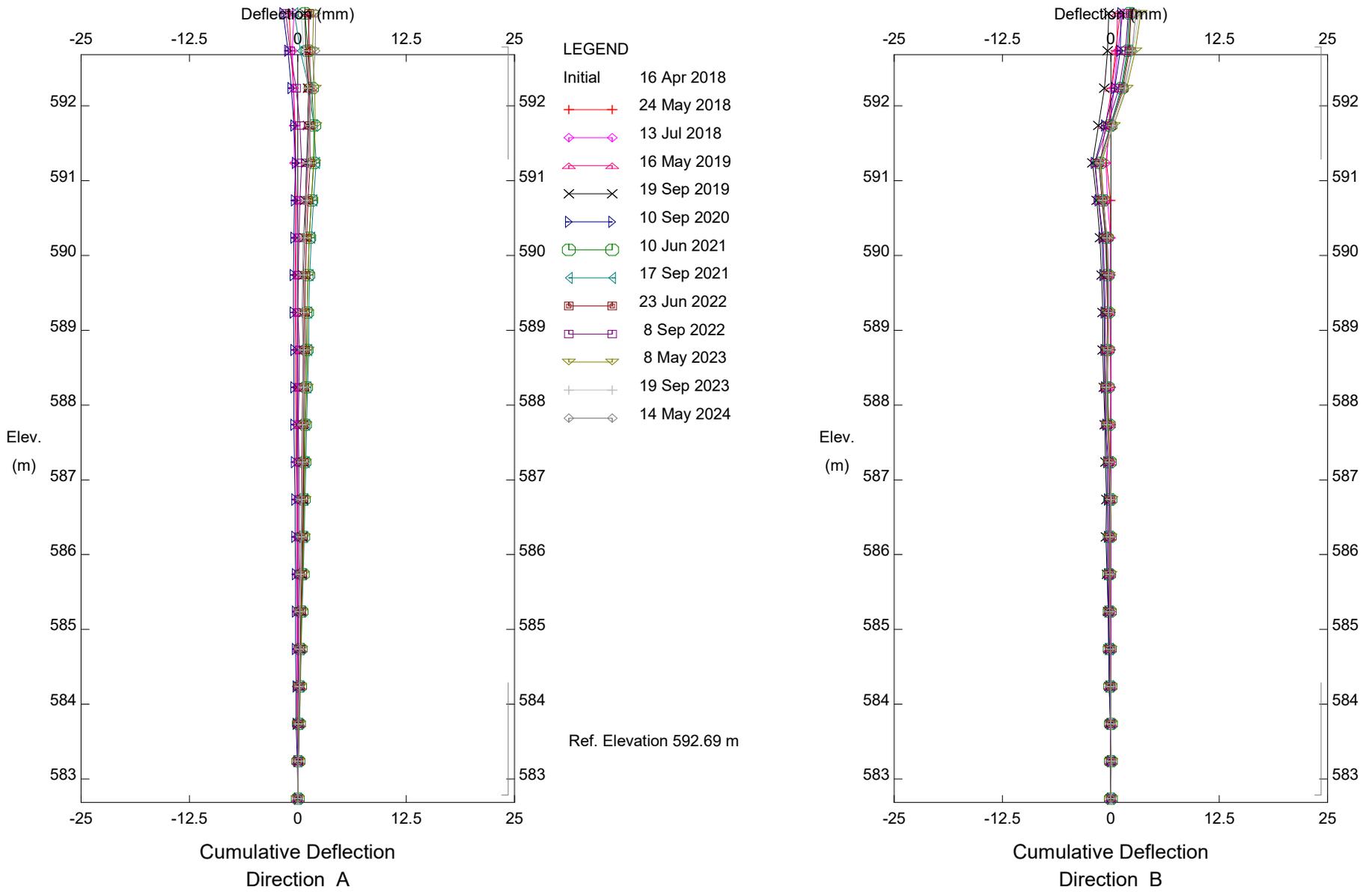
CLIENT

| | | |
|--|--------------------------|--------------|
| PROJECT CENTRAL REGION GEOHAZARD RISK MANAGEMENT PROGRAM | | |
| TITLE Site Plan C062 - Vermillion Backslope Hwy 41:02, km 2.889 | | |
| SCALE 1:1,500 | PROJECT No. A05116A02 | FIG No. 1 |

APPENDIX I

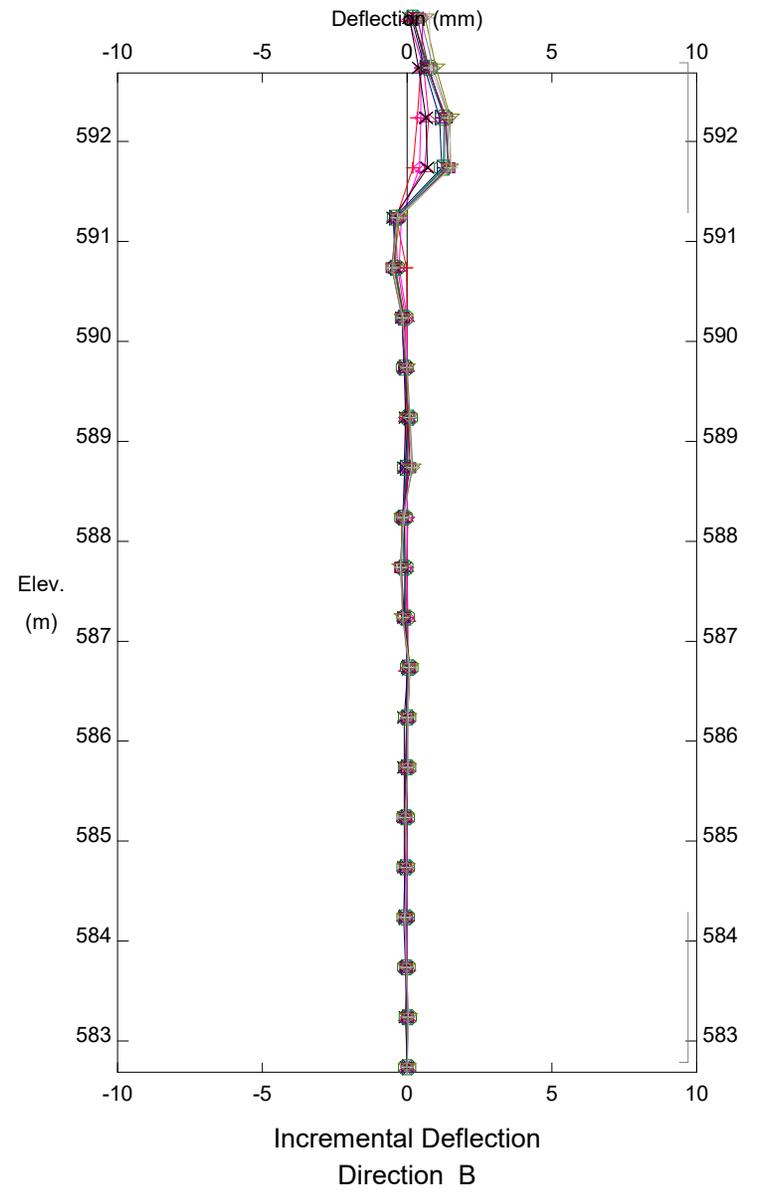
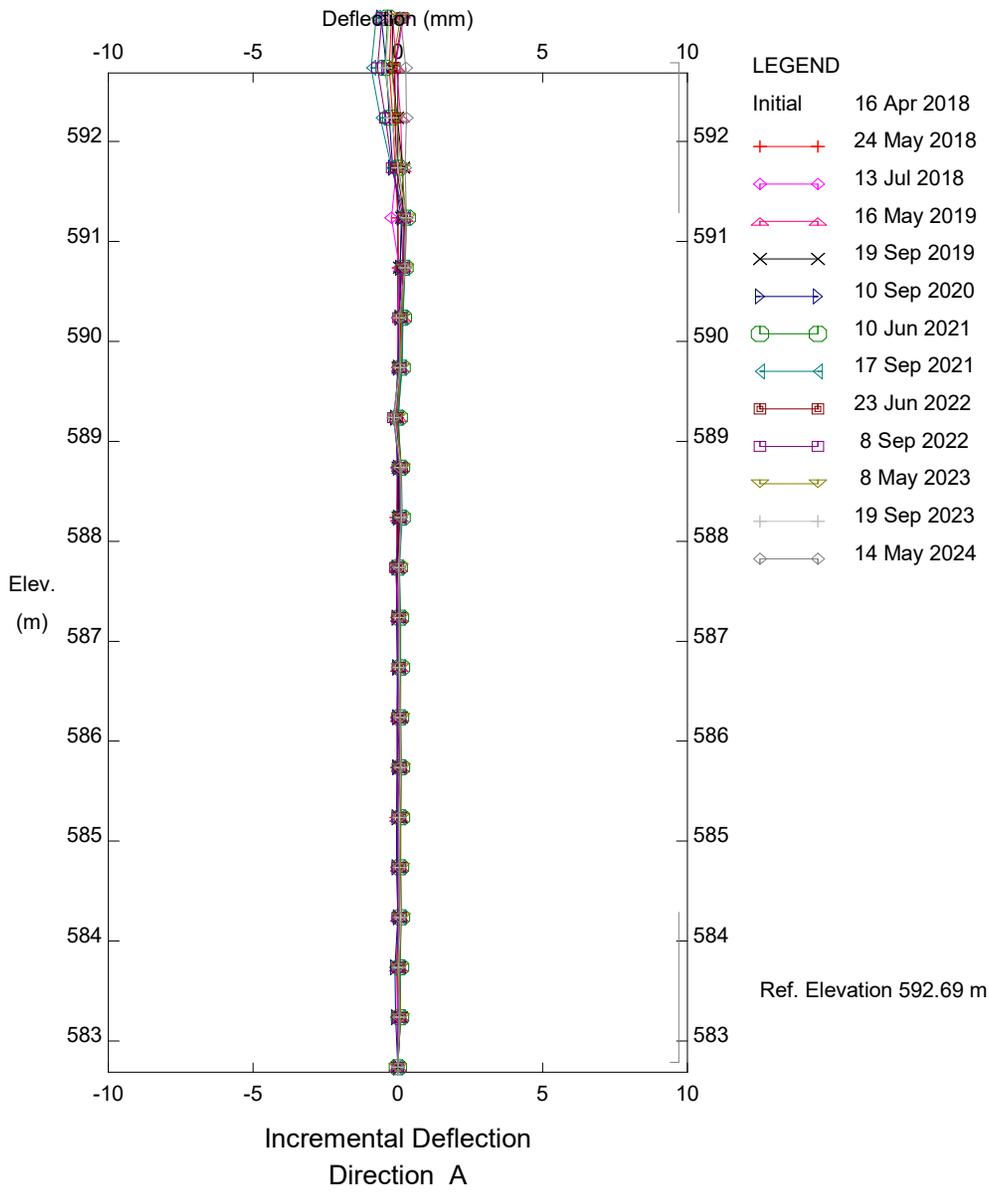
Instrumentation Plots

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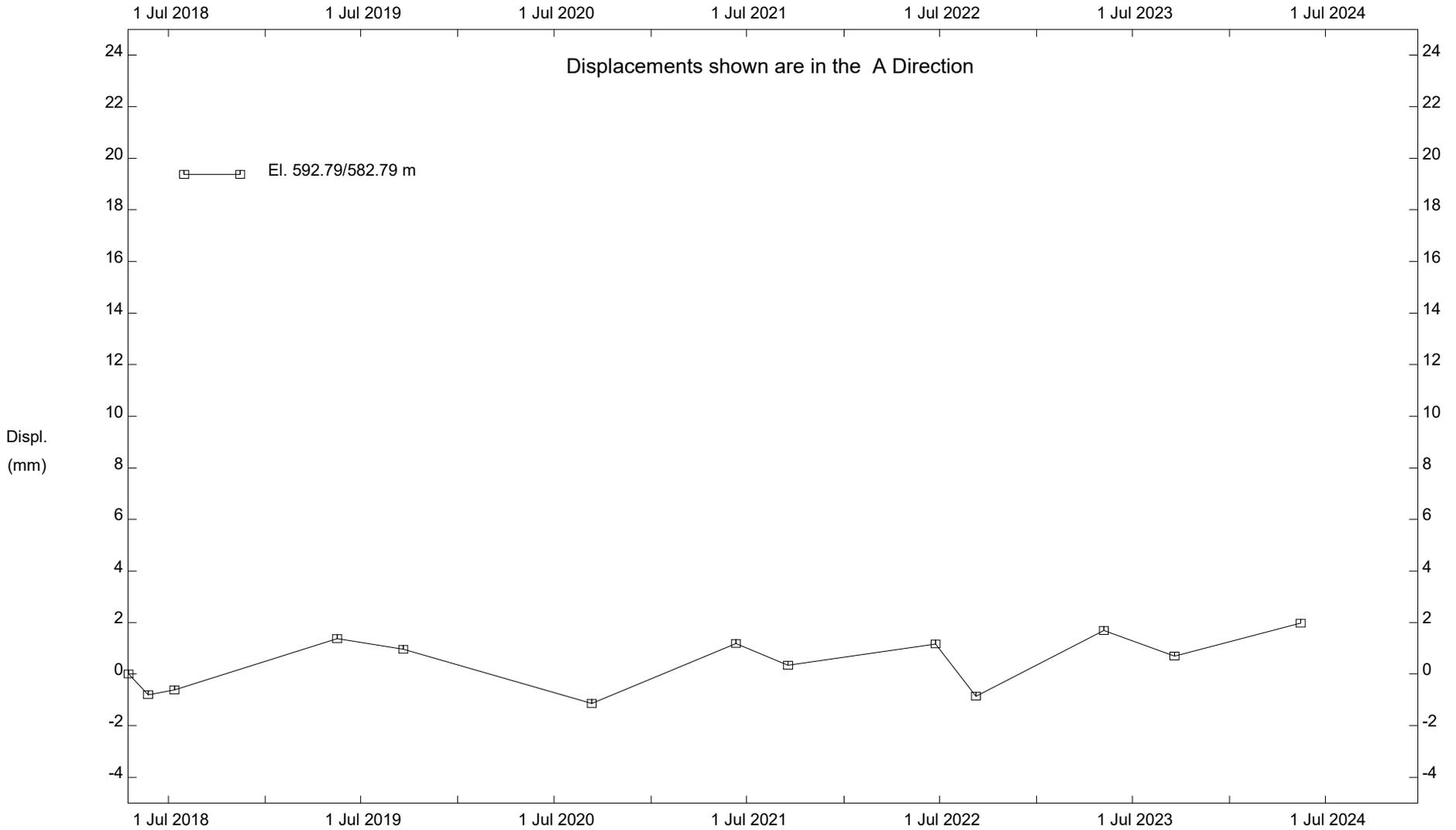
C062; H41:02, Vermilion Backslope, Inclinator SI18-C62-03
Alberta Transportation

Klohn Crippen Berger - Calgary



C062; H41:02, Vermilion Backslope, Inclinator SI18-C62-03
 Alberta Transportation

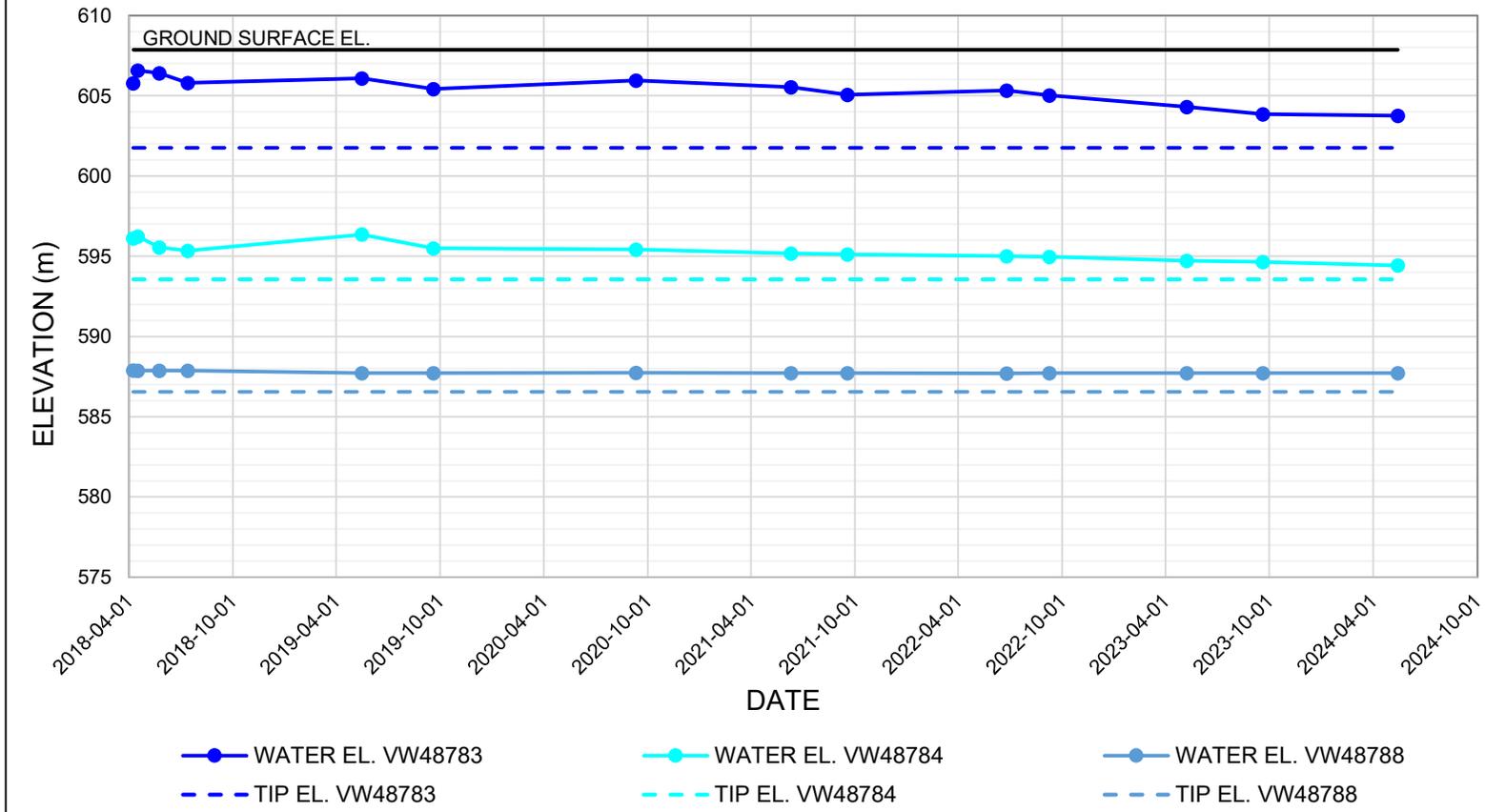
Klohn Crippen Berger - Calgary



C062; H41:02, Vermilion Backslope, Inclinator SI18-C62-03

Alberta Transportation

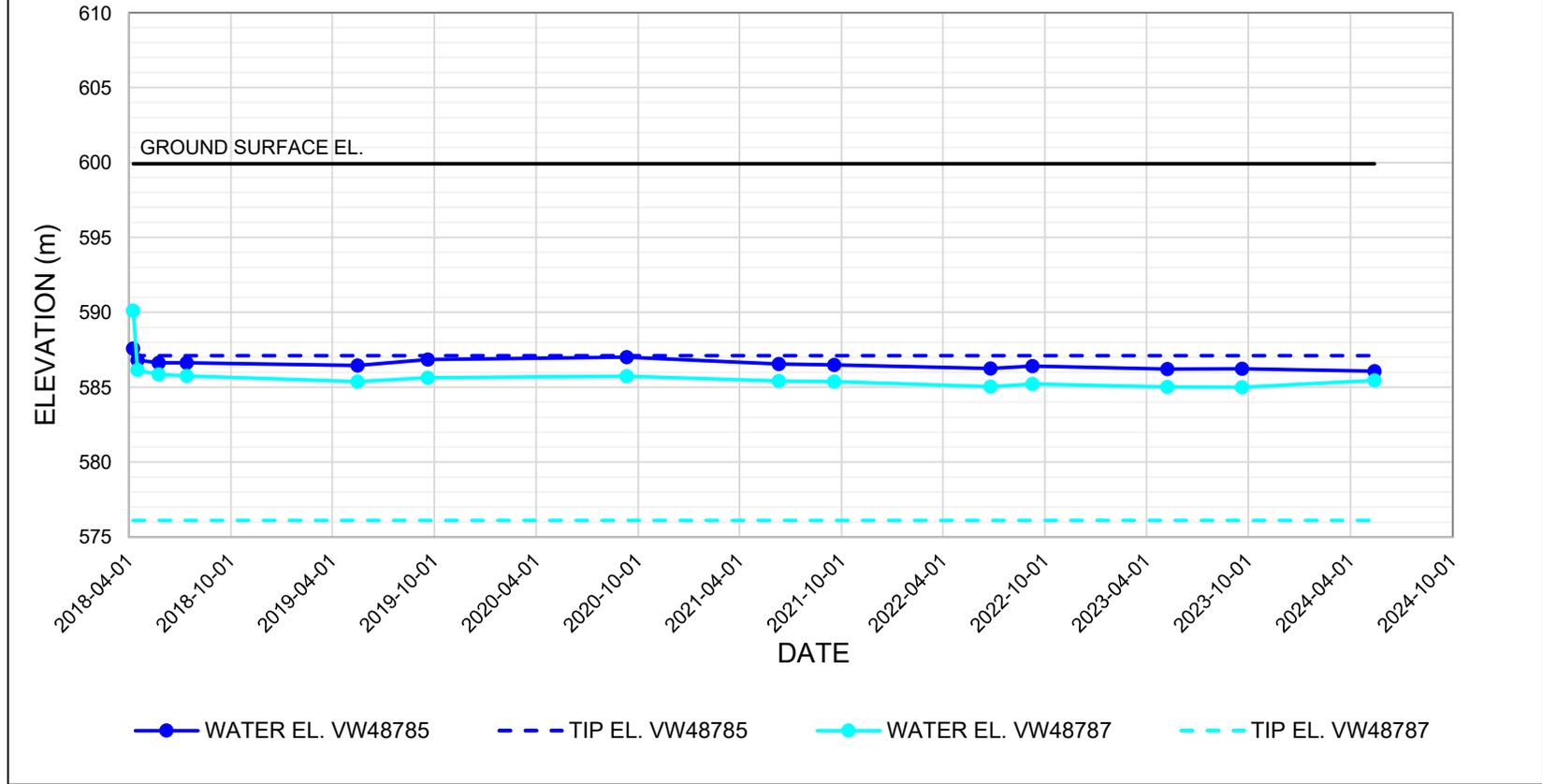
VW48783, VW48784, AND VW48788 (CREST OF SLOPE)



NOTES:
 1. GROUND SURFACE ELEVATION OBTAINED FROM JULY 2018 TOPOGRAPHIC SURVEY COMPLETED BY CHALLENGER GEOMATICS LTD.

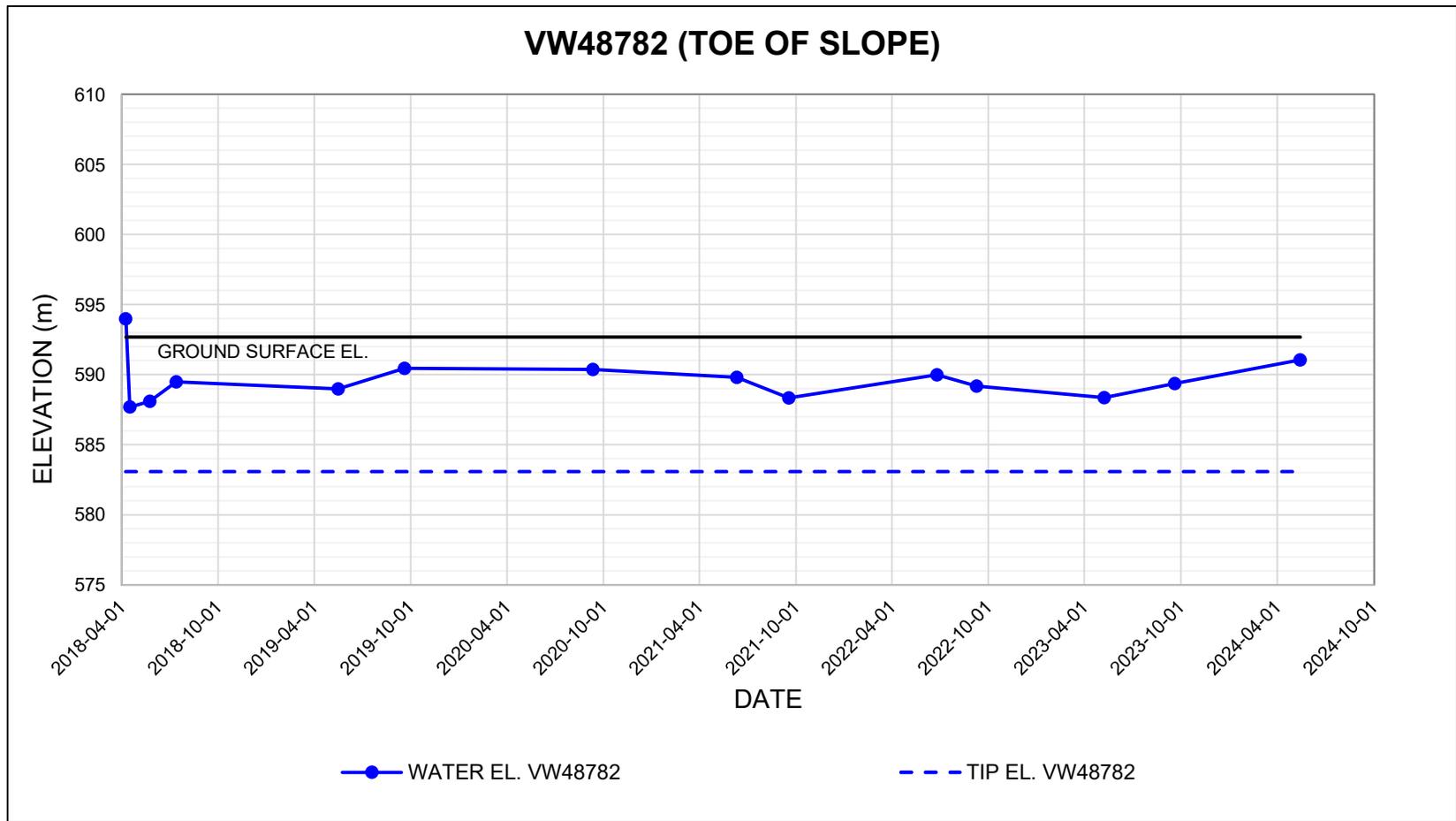
| | | | |
|---|--|-------------|-----------|
| CLIENT   | PROJECT CENTRAL REGION GEOHAZARD RISK MANAGEMENT PLAN | | |
| | TITLE Piezometer Data C062 - Vermillion Backslope Hwy 40:02, km 2.889 | | |
| SCALE | N/A | PROJECT No. | A05116A02 |
| | | FIG No. | I-4 |

VW48785 AND VW48787 (MIDSLOPE)



NOTES:
 1. GROUND SURFACE ELEVATION OBTAINED FROM JULY 2018 TOPOGRAPHIC SURVEY COMPLETED BY CHALLENGER GEOMATICS LTD.

| | | | |
|---|-----|--|-------------|
| CLIENT | | PROJECT | |
|   | | CENTRAL REGION GEOHAZARD RISK MANAGEMENT PLAN | |
| | | TITLE Piezometer Data C062 - Vermillion Backslope Hwy 40:02, km 2.889 | |
| SCALE | N/A | PROJECT No. | A05116A02 |
| | | | FIG No. I-5 |



NOTES:

1. GROUND SURFACE ELEVATION OBTAINED FROM JULY 2018 TOPOGRAPHIC SURVEY COMPLETED BY CHALLENGER GEOMATICS LTD.

| | | | |
|---|-----|---|---------|
| CLIENT | | PROJECT | |
|  | | CENTRAL REGION GEOHAZARD RISK MANAGEMENT PLAN | |
|  | | TITLE | |
| | | Piezometer Data C062 - Vermillion Backslope Hwy 40:02, km 2.889 | |
| SCALE | N/A | PROJECT No. | FIG No. |
| | | A05116A02 | I-6 |