November 29, 2022

Alberta Transportation
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 C003; H872:06, km 0.278 Burma Park Slide
Section C – 2022 Fall Readings

1 GENERAL

Five standpipe piezometers (SPs) (SP92-12, SP92-13, and SP07-11 through SP07-13) were read at the C003 site in the Central Region on September 8, 2022 by Ms. Katrina Cereno 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 872:06, km 0.278, approximately 0.5 km north of the Battle River crossing and 10 km north of Brownfield, Alberta. The approximate site coordinates are 5806345 N, 471780 E (UTM Zone 12, NAD 83). A site plan is presented in Figure 1.

The geohazard at the C003 site consists of a large, deep-seated landslide along the north valley slope of the Battle River. The slide crosses both lanes of Hwy 857:06 from northwest to southeast. An erosion gulley is also present in the west (southbound) ditch, indicating the presence of highly erodible or dispersive soils. Previous remedial actions at this site include:

- 1998: The installation of 150-mm diameter perforated pipes below the highway and along the west (southbound) ditch to intercept groundwater flows.
- 2003: Paving and subgrade improvements. Since 2003, regular asphalt patching has been required at the site.

Geotechnical site investigations (test pit and drilling programs) were completed at the C003 site in 1990, 1991, 1992, 2000, and 2007. Instruments were installed during the 1992 investigation, and replacement instruments were installed during the 2000 and 2007 investigations. During the 2007 investigation, the encountered stratigraphy was as follows: silty clay interbedded with sand overlying bedrock, which was identified as clay shale with bentonitic and sandstone layers.

AT requested a call-out inspection at the site on June 24, 2022 due to recent movement indicated by pavement distress (e.g., cracking and settlement) and guardrail deflection. KCB completed the

Klohn Crippen Berger Ltd.
109, 4208 97 St NW ▪ Edmonton AB T6E 5Z9 ▪ Canada
t 780.444.0706 ▪ www.klohn.com

call-out inspection on July 12, 2022 and the draft call-out report was issued to AT on September 9, 2022.

1.1 Instrumentation

KCB began reading the instruments at this site in 2021. AT did not request KCB to complete readings before 2021 due to most of the instruments being inoperable, and no significant changes being observed during the Central Region GRMP Section B inspections. Instrumentation installation details are tabulated in Table 1.1. Instrument locations are shown in Figure 1.

Between 1992 and 2007, several slope inclinometers (SIs), pneumatic piezometers (PNs), and SPs were installed to monitor depth of movement and groundwater conditions, respectively. Some of these instruments have since become inoperable (e.g., destroyed, sheared, or lost), including all 14 SIs and 4 PNs as detailed in Table 1.1 (see table notes). Only 5 of 12 SPs remain operable.

Some of the inoperable instruments are protected by above-ground casing protectors or tires backfilled with earth but most of the instruments (including the remaining operable SPs) do not have casing protectors.

The operable SPs were read using an RST Water Level Meter.

Table 1.1 Instrumentation Installation Details

Instrument ID	Instrument Type	Date Installed[1]	UTM Coordinates[2] (m)		Ground Surface Elevation[2] (m)	Stick Up (m)	Depth[1] (mbgs[3])	Depth Sheared[1] (mbgs[3])	Condition
			Northing	Easting					
~~SI92-01~~	~~SI~~	~~Sep. 24, 1992~~	~~Unknown~~	~~Unknown~~	~~655~~	~~0.9~~	~~37.5~~	~~9.5~~	~~Inoperable[4]~~
~~SI92-02~~	~~SI~~	~~Sep. 24, 1992~~	~~Unknown~~	~~Unknown~~	~~650~~	~~1.2~~	~~16.4~~	~~5.8~~	~~Inoperable[4]~~
~~SI92-03~~	~~SI~~	~~Sep. 25, 1992~~	~~Unknown~~	~~Unknown~~	~~659~~	~~0.9~~	~~40.5~~	~~12.0~~	~~Inoperable[4]~~
~~SI92-04~~	~~SI~~	~~Sep. 26, 1992~~	~~Unknown~~	~~Unknown~~	~~653~~	~~0.9~~	~~34.4~~	~~9.5~~	~~Inoperable[4]~~
~~SI92-05~~	~~SI~~	~~Sep. 27, 1992~~	~~Unknown~~	~~Unknown~~	~~650~~	~~0.9~~	~~25.3~~	~~N/A~~	~~Inoperable[5]~~
~~SI92-06~~	~~SI~~	~~Sep. 28, 1992~~	~~Unknown~~	~~Unknown~~	~~649~~	~~1.0~~	~~16.2~~	~~4.0~~	~~Inoperable[4]~~
~~SI92-07~~	~~SI~~	~~Sep. 28, 1992~~	~~Unknown~~	~~Unknown~~	~~658~~	~~1.2~~	~~19.5~~	~~13.0~~	~~Inoperable[4]~~
~~SI00-08~~	~~SI~~	~~Nov. 14, 2000~~	~~Unknown~~	~~Unknown~~	~~658~~	~~0.6~~	~~23.7~~	~~11.5~~	~~Inoperable[4]~~
~~SI00-09~~	~~SI~~	~~Nov. 13, 2000~~	~~Unknown~~	~~Unknown~~	~~657~~	~~0.6~~	~~20.7~~	~~11.0~~	~~Inoperable[4]~~
~~SI00-10~~	~~SI~~	~~Nov. 14, 2000~~	~~Unknown~~	~~Unknown~~	~~653~~	~~0.6~~	~~17.6~~	~~7.5~~	~~Inoperable[4]~~
~~SI07-11~~	~~SI~~	~~Oct. 23, 2007~~	~~Unknown~~	~~Unknown~~	~~658~~	~~0.6~~	~~23.6~~	~~11.8~~	~~Inoperable[4]~~
~~SI07-12~~	~~SI~~	~~Oct. 24, 2007~~	~~Unknown~~	~~Unknown~~	~~656~~	~~0.66~~	~~20.5~~	~~12.0~~	~~Inoperable[4]~~
~~SI07-13~~	~~SI~~	~~Oct. 24, 2007~~	~~Unknown~~	~~Unknown~~	~~653~~	~~0.7~~	~~17.5~~	~~8.0~~	~~Inoperable[4]~~
~~SI07-14~~	~~SI~~	~~Oct. 24, 2007~~	~~Unknown~~	~~Unknown~~	~~650~~	~~0.8~~	~~14.5~~	~~12.9~~	~~Inoperable[4]~~
~~PN92-8A~~	~~PN~~	~~Sep. 24, 1992~~	~~Unknown~~	~~Unknown~~	~~656~~	~~N/A~~	~~17.7~~	~~N/A~~	~~Inoperable[8]~~
~~PN92-10A~~	~~PN~~	~~Sep. 25, 1992~~	~~Unknown~~	~~Unknown~~	~~658~~	~~N/A~~	~~21.2~~	~~N/A~~	~~Inoperable[8]~~
~~PN92-12A~~	~~PN~~	~~Sep. 26, 1992~~	~~Unknown~~	~~Unknown~~	~~653~~	~~N/A~~	~~14.9~~	~~N/A~~	~~Inoperable[8]~~
~~PN92-15A~~	~~PN~~	~~Sep. 27, 1992~~	~~Unknown~~	~~Unknown~~	~~649~~	~~N/A~~	~~12.2~~	~~N/A~~	~~Inoperable[8]~~
~~SP92-08~~	~~SP~~	~~Sep. 24, 1992~~	~~Unknown~~	~~Unknown~~	~~655~~	~~0.69~~	~~18.7~~	~~Unknown~~	~~Inoperable[6]~~
~~SP92-09~~	~~SP~~	~~Sep. 26, 1992~~	~~Unknown~~	~~Unknown~~	~~655~~	~~1.2~~	~~5.5~~	~~Unknown~~	~~Inoperable[6]~~
~~SP92-10~~	~~SP~~	~~Sep. 26, 1992~~	~~Unknown~~	~~Unknown~~	~~658~~	~~0.8~~	~~6.1~~	~~N/A~~	~~Inoperable[6]~~
~~SP92-11~~	~~SP~~	~~Sep. 26, 1992~~	~~Unknown~~	~~Unknown~~	~~658~~	~~1.1~~	~~10.0~~	~~N/A~~	~~Inoperable[6]~~
SP92-12	SP	Sep. 26, 1992	5806320	471788	654	1.2	16.4	N/A	Operable
SP92-13	SP	Sep. 26, 1992	5806320	471788	654	0.9	7.6	N/A	Operable
~~SP92-14~~	~~SP~~	~~Sep. 27, 1992~~	~~Unknown~~	~~Unknown~~	~~649~~	~~1.0~~	~~5.1~~	~~Unknown~~	~~Inoperable[6]~~

~~SP92-15~~	~~SP~~	~~Sep. 27, 1992~~	~~Unknown~~	~~Unknown~~	~~649~~	~~1.1~~	~~12.2~~	~~Unknown~~	~~Inoperable[6]~~
SP07-11	SP	Oct. 23, 2007	5806382	471788	658	0.8	13.9	N/A	Operable
SP07-12	SP	Oct. 24, 2007	5806320	471788	656	0.8	11.5	N/A	Operable
SP07-13	SP	Oct. 24, 2007	5806290	471788	653	0.7	9.9	N/A	Operable
~~SP07-14~~	~~SP~~	~~Oct. 24, 2007~~	~~5806259~~	~~471787~~	~~650~~	~~0.7~~	~~5.4~~	~~N/A~~	~~Inoperable[7]~~

Notes:

[1] Instrument installation details taken from reports prepared by previous consultants or AT.

[2] Coordinates and ground surface elevations have not been surveyed. Ground surface elevations were estimated from July 2018 survey data and coordinates were taken with a handheld GPS with a horizontal accuracy of ± 5 m.

[3] Meters below ground surface (mbgs).

[4] SI92-01 through SI92-07 (excluding SI92-05), SI00-08 through SI00-10, and SI07-11 through SI07-14 have all sheared at depths between approximately 4 m and 13 m below ground surface.

[5] SI92-05 was damaged near top of casing in 2006.

[6] SP92-08, SP92-09, SP92-14, and SP92-15 are blocked. SP92-10 and 11 are damaged.

[7] SP07-14 was buried between the fall 2021 and spring 2022 readings.

[8] PN92-8A, PN92-10A, PN92-12A, and PN92-15A are damaged (no air return).

2 INTERPRETATION

2.1 General

For the operable SPs, the recorded water levels were converted to an equivalent water/piezometric elevation and plotted relative to ground surface elevation and each instruments screen elevation. No data plot is provided for SP07-13 because it has been dry since installation.

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

No data is available for the instruments at this site between 1994 and 2000, or 2011 and 2020 except for one reading taken in 2019.

2.2 Zones of Movement

No operable SIs remain at the site. SI92-01 through SP92-07 (excluding SI92-05, which was damaged before shearing), SI00-08 through SI00-10, and SI07-11 through SI07-14 have all sheared at depths between approximately 4 m and 13 m below ground surface (approximately elevation 643 m to 647 m).

Table 2.1 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)
SP92-12	Sep. 26, 1992	Jun. 24, 2022	Sep. 08, 2022	654	16.4	1.8	1.8	0.0
SP92-13	Sep. 26, 1992	Jun. 24, 2022	Sep. 08, 2022	654	7.6	1.7	1.8	-0.1
SP07-11	Oct. 24, 2007	Jun. 24, 2022	Sep. 08, 2022	658	13.9	2.1	2.0	0.1
SP07-12	Oct. 24, 2007	Jun. 24, 2022	Sep. 08, 2022	656	11.5	1.7	2.9	-1.2
SP07-13	Oct. 24, 2007	Jun. 24, 2022	Sep. 08, 2022	653	9.9	N/A – instrument was dry	4.2	4.2

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

2.3 Interpretation of Monitoring Results

No instrumentation data is available for the site between 1994 and 2000, or 2011 and 2020 except for one reading taken in 2019. Additionally, all the SIs are inoperable.

Based on the available historical data, the zone of movement recorded in the SIs appeared to be relatively discrete and occurring at or just above the contact with bedrock in the overlying clay or sand. Prior to being sheared, some of these instruments recorded moderate to high rates of movement (between 30 mm/year and 55 mm/year). Due to ongoing movement at the site and the frequent shearing of instruments, the operable SPs may be damaged below the current measured water level. This may impact the reliability and interpretation of the current and future readings of the SPs if the instruments become blocked or water is flowing through cracks in the casing above or below the screen elevation.

Water levels recorded in all the SPs (except SP07-11, see below) in the fall of 2022 were 2.2 m to 2.4 m higher than the fall of 2021 and within 0.1 m of the spring 2022 readings (except SP07-12, which recorded a 1.2 m decrease). These instruments were not read between 2011 and 2020, except for one reading taken in 2019, so it is difficult to assess the long-term trends of these instruments. The elevated water levels recorded in these instruments in June and September 2022 are likely due to wet weather in June and July 2022 as 2021 and the spring of 2022 were relatively dry. The previous period of wet weather occurred in 2020 and no readings are available for this period for comparison. Based on the piezometer data, it is likely that the recent movement observed at the site occurred in response to elevated groundwater levels within the slide mass.

The variation in water level recorded in SI92-12, SP92-13, and SP07-12 is likely due to these instruments being installed on either side of a culvert that receives flows from a wet area upslope and to the east of the instruments. Whereas water levels recorded in the instrument upslope to the north (SP07-11) have remained relatively steady since the spring of 2021 and are similar to water levels recorded in 2011.

Historically, SP07-13 (instrument downslope to the south) has been dry since installation. However, a water level approximately 4.2 m below ground surface was recorded in this instrument during the fall 2022 readings. More data is needed to assess the recent water level trend for this instrument.

Previously, KCB thought the movement being recorded in the SIs may be due to localized sliding. However, upon review of aerial photos taken using our Unmanned Aerial Vehicle (UAV) and site observations made during the 2021 Section B inspection and 2022 call-out inspection, the extent and depth of sliding appears to be larger than previously thought. The C003 site appears to be in a more active zone of sliding within a larger landslide mass along the north valley slope of the Battle River. However, it is difficult to assess the current movement trends for the site since all the SIs are inoperable. AT could consider installing one replacement SI at this site to further our understanding of movement depths and rates at this site.

3 RECOMMENDATIONS

3.1 Future Work

All operable instruments should continue to be read twice per year (spring and fall).

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

Recommendations for this site include:

- Complete a drilling and instrumentation installation program to install:
  - one SI to below bottom-of-river elevation (and the previously installed SIs) to assess if a deeper basal plane underlies the C003 site; and
  - four to six vibrating wire piezometers (VWPs) in the east and west highway ditches with data loggers to assess for short-term fluctuations (i.e., increases and decreases) in water level in response to periods of heavy or prolonged rainfall or freshet infiltration that would not be captured by the current bi-annual reading frequency of the site.
- Complete a desktop study and a design for the site, that includes installing a new drainage system on the west ditch of the highway that is deeper than the current system to lower the groundwater table, and protecting (e.g., armoring with riprap) the west highway ditch against erosion.

3.2 Instrument Repairs and Maintenance

The following instrument maintenance is needed:

- The bottom casing depth of the SPs should be measured and compared to the installation depth to assess if the instruments have sheared. A camera inspection could also be completed to assess for cracking along the length of the instruments casing.
- Above-ground casing protectors should be installed for the remaining active standpipe piezometers. KCB will assess the feasibility of installing casing protectors by hand during the spring 2023 readings. If they cannot be installed by hand (e.g., soil too dense), casing protectors could be installed during a future drilling and instrumentation installation program.

4 CLOSING

This report is an instrument of service of Klohn Crippen Berger (KCB). The report has been prepared for the exclusive use of Alberta Transportation (Client) for the specific application to the Central Region Geohazard Risk Management Program (Contract No. CON0022160), and it may not be relied upon by any other party without KCB's written consent.

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

Use of or reliance upon this instrument of service by the Client is subject to the following conditions:

1. The report is to be read in full, with sections or parts of the report relied upon in the context of the whole report.
2. The observations, findings and conclusions in this report are based on observed factual data and conditions that existed at the time of the work and should not be relied upon to precisely represent conditions at any other time.
3. The report is based on information provided to KCB by the Client or by other parties on behalf of the client (Client-supplied information). KCB has not verified the correctness or accuracy of such information and makes no representations regarding its correctness or accuracy. KCB shall not be responsible to the Client for the consequences of any error or omission contained in Client-supplied information.
4. KCB should be consulted regarding the interpretation or application of the findings and recommendations in the report.
5. This report is electronically signed and sealed and its electronic form is considered the original. A printed version of the original can be relied upon as a true copy when supplied by the author or when printed from its original electronic file.

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

KLOHN CRIPPEN BERGER LTD.

November 29 2022
I.D. # 58463

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

James Lyons, P.Eng.
Civil Engineer

PERMIT TO PRACTICE
KLOHN CRIPPEN BERGER LTD.
RM SIGNATURE: _____
RM APEGA ID #: 187607
DATE: 29 Nov. 2022
PERMIT NUMBER: P009196
The Association of Professional Engineers and Geoscientists of Alberta (APEGA)

JL:bb

ATTACHMENTS
Figure
Appendix I Instrumentation Plots

FIGURE

Legend

- Slope Inclinometer (SI)
- Standpipe Piezometer (SP)
- Culvert
- Fence
- Guardrail

0 50 Meters

NOTES:
1. HORIZONTAL DATUM: NAD83
2. GRID ZONE: UTM Zone 12N
3. IMAGE SOURCE: World Imagery, ESRI ArcGIS Online Souce date January 2018 (Paintearth County No. 18)
4. Strikethrough indicates instrument is inactive.

CLIENT: Alberta

Klohn Crippen Berger

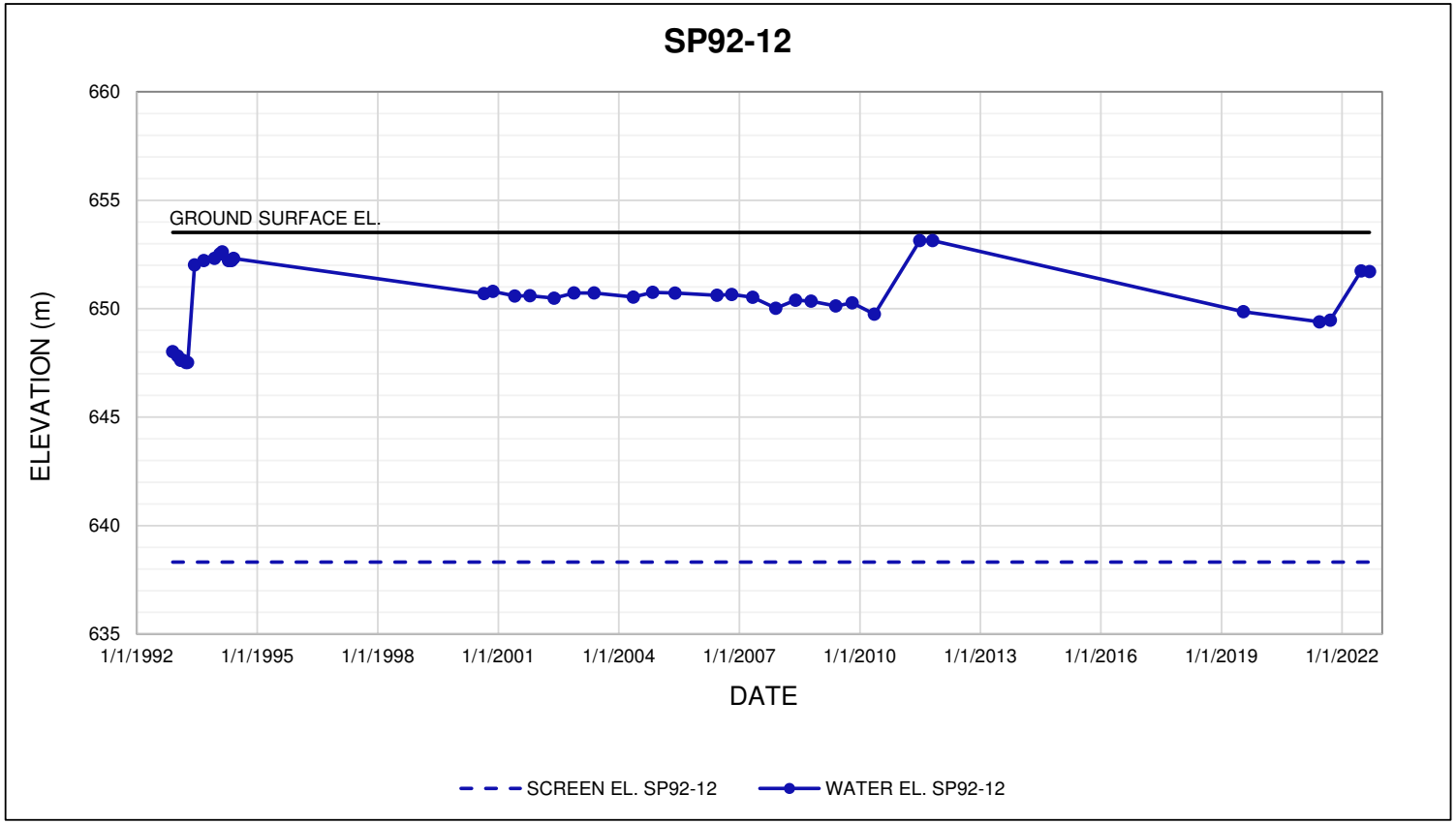
PROJECT: CENTRAL REGION GEOHAZARD RISK MANAGEMENT PROGRAM

TITLE: Site Plan
C003 - Burma Park Slide
Hwy 872:06, km 0.278

SCALE	PROJECT No.	FIG No.
1:1,000	A05116A02	1

APPENDIX I

Instrumentation Plots



CLIENT

Alberta

Klohn Crippen Berger

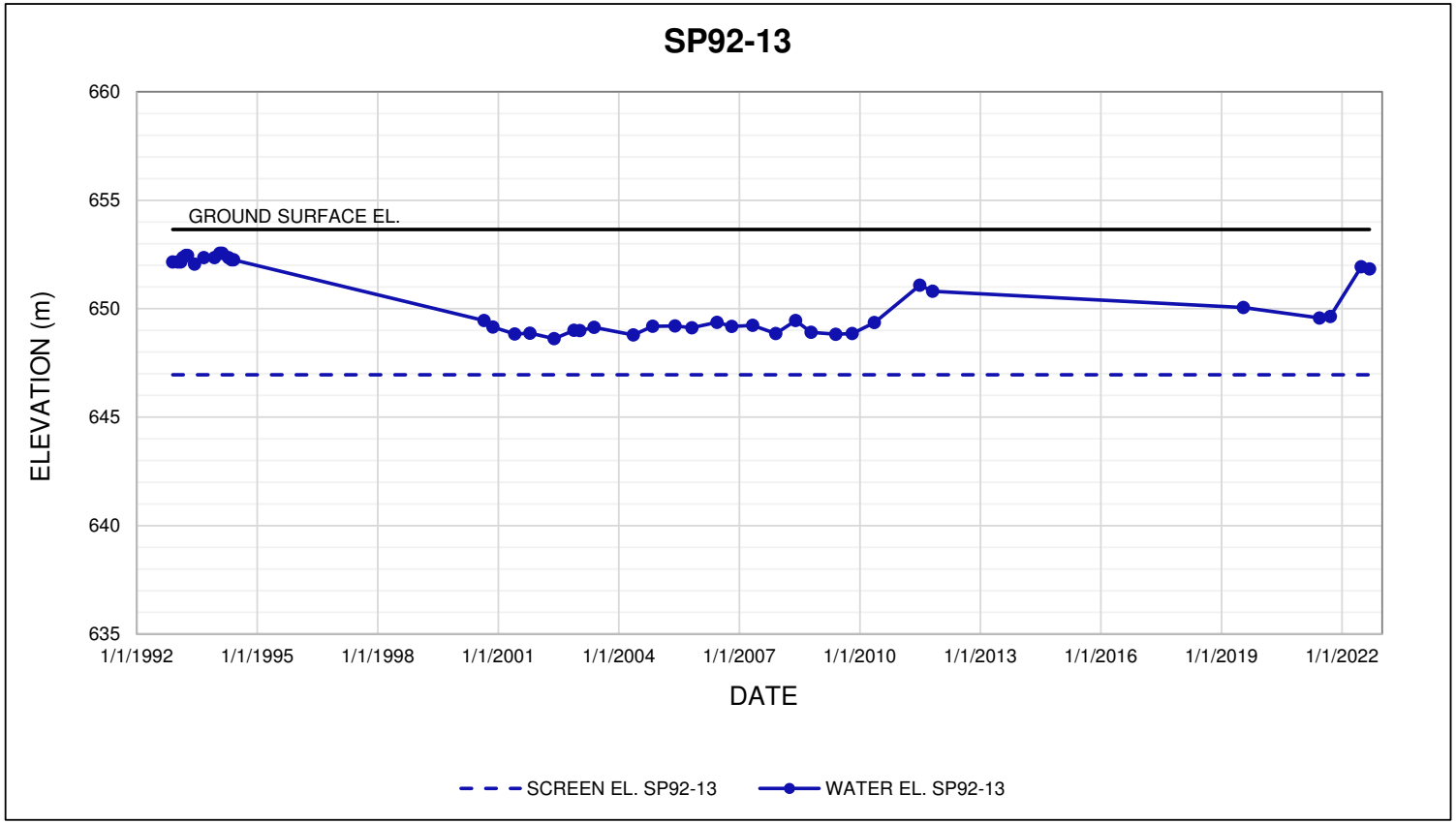
PROJECT

CENTRAL REGION GEOHAZARD RISK MANAGEMENT PROGRAM

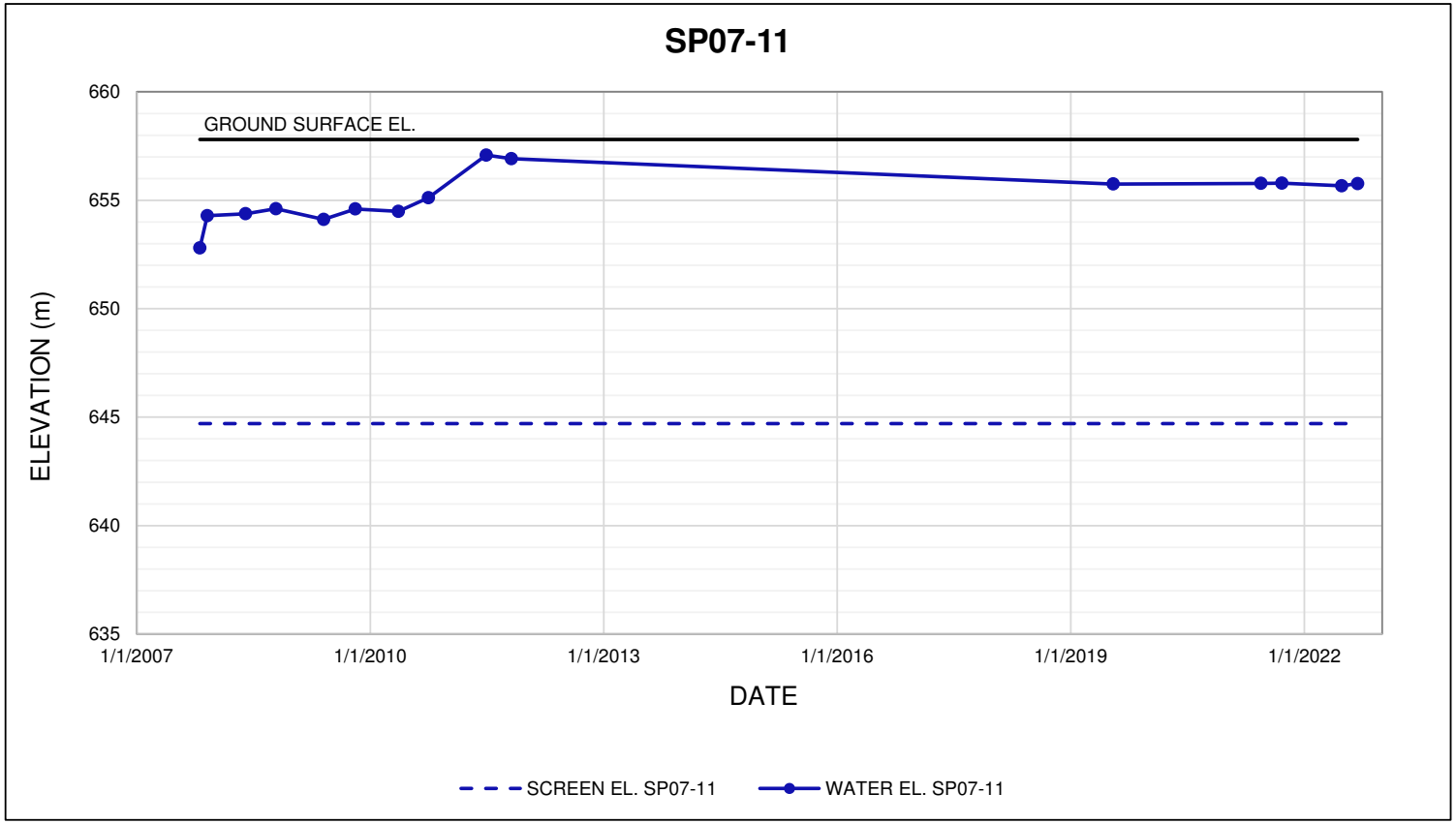
TITLE

Piezometer Data
C003 - Burma Park Slide
Hwy 872:06; km 0.278

SCALE	PROJECT No.	FIG No.
	A05116A02	I-1



CLIENT: Alberta / Klohn Crippen Berger	PROJECT: CENTRAL REGION GEOHAZARD RISK MANAGEMENT PROGRAM	
	TITLE: Piezometer Data C003 - Burma Park Slide Hwy 872:06; km 0.278	
	SCALE	PROJECT No. A05116A02 / FIG No. I-2



CLIENT

Alberta

Klohn Crippen Berger

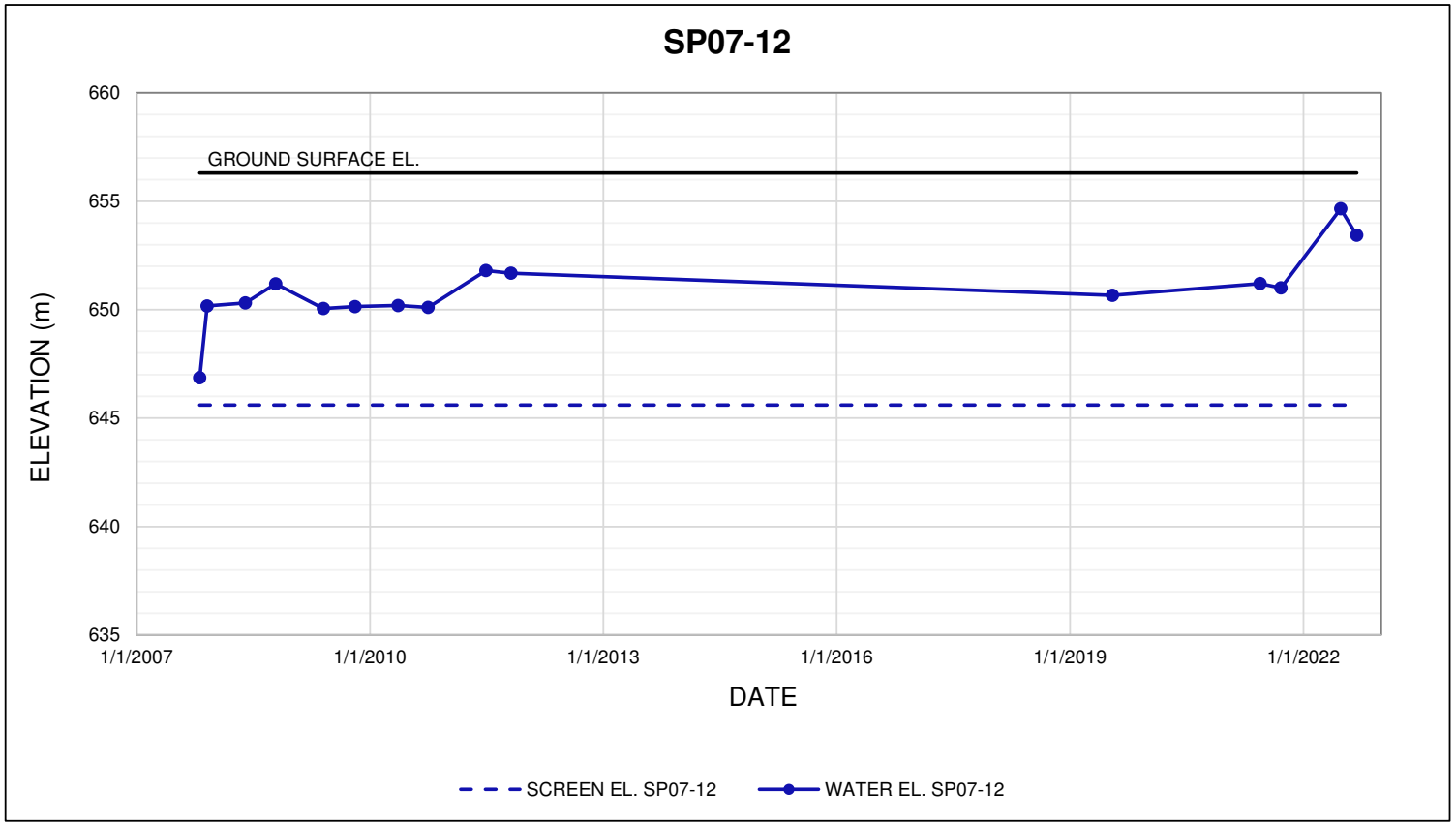
PROJECT

CENTRAL REGION GEOHAZARD RISK MANAGEMENT PROGRAM

TITLE

Piezometer Data
C003 - Burma Park Slide
Hwy 872:06; km 0.278

SCALE	PROJECT No.	FIG No.
	A05116A02	I-3



CLIENT

Alberta

Klohn Crippen Berger

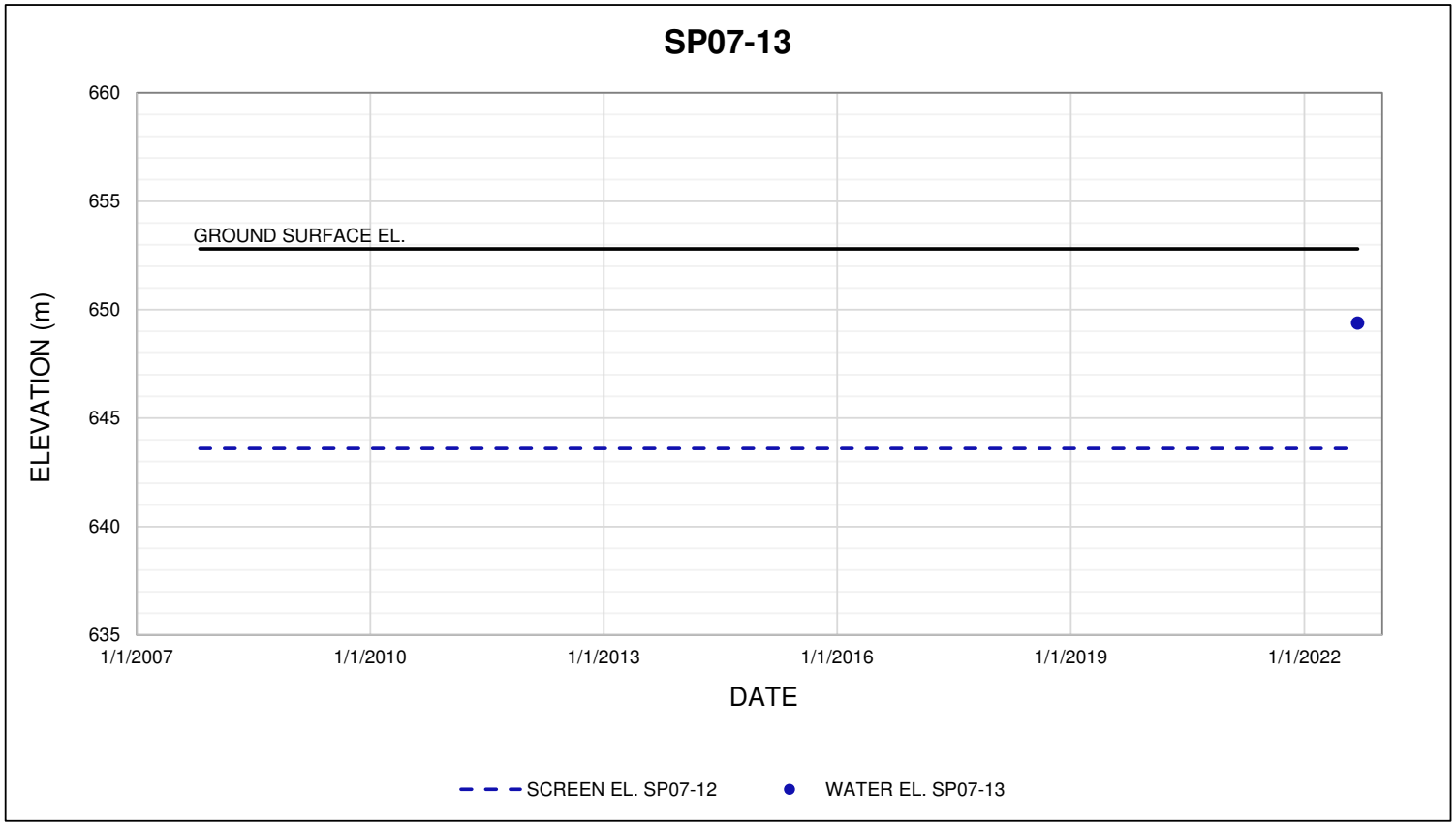
PROJECT

CENTRAL REGION GEOHAZARD RISK MANAGEMENT PROGRAM

TITLE

Piezometer Data
C003 - Burma Park Slide
Hwy 872:06; km 0.278

SCALE	PROJECT No.	FIG No.
	A05116A02	I-4



CLIENT

Alberta

Klohn Crippen Berger

PROJECT

CENTRAL REGION GEOHAZARD RISK MANAGEMENT PROGRAM

TITLE

Piezometer Data
C003 - Burma Park Slide
Hwy 872:06; km 0.278

SCALE	PROJECT No.	FIG No.
	A05116A02	I-5