Project Number: 6-CD109.55

Landslide Monitoring Report – Brockville

29 June 2023

CONFIDENTIAL

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Disclaimers and Limitations

This report **('Report')** has been prepared by WSP New Zealand Limited exclusively for Dunedin City Council **('Client')** in relation to the landslide monitoring at selected sites in Dunedin (Landslide Monitoring Long-Term SoW DCC Reference 9662). The scope of this report is to present the survey monitoring results and recommendations for future surveys for the site **('Purpose')**. The findings in this Report are based on and subject to the assumptions specified in the Report. WSP accepts no liability whatsoever for any reliance on or use of this Report, in whole or in part, for any use or purpose other than the Purpose or any use or reliance on the Report by any third party.

Executive Summary

A survey of the Brockville site was undertaken in December 2022 to assess the extent of movements compared with previous surveys. Deformations found to exceed the accuracy of the survey (±15 mm horizontal, ±20 mm vertical) are presented in Table 1.

Table 1: Summary of recorded displacements.

	Horizontal	Vertical
Displacements from the previous survey	<15 mm	-30 – -22 mm
Displacements from the original survey	17 – 20 mm	-48 – +32 mm

The results indicate that deformation is continuing. We recommend the next survey to be undertaken in late-2023 and a review of the viability of remote monitoring be completed in conjunction with WSP.

1 Introduction

WSP New Zealand Limited (WSP) have been commissioned by Dunedin City Council (DCC) to undertake monitoring of 12 landslide sites around Dunedin. The purpose of monitoring is to identify the trend and magnitude of movements and provide recommendations for future monitoring.

This report presents a summary of the factual survey monitoring results for the Brockville site, as well as monitoring recommendations. A mark displacement diagram is provided in Appendix A.

2 Survey Monitoring

2.1 Monitoring History

Previous surveyors Clark Fortune McDonald (CFM) set-up the Brockville monitoring site, installed marks and carried out a baseline survey in 28-29 July 2020. The first comparative monitor was carried out by WSP Surveyors on 17 November 2021. The third survey to date covered in this report was carried out on 20th December 2022.

2.2 Methodology

The equipment used were 2 x Trimble R8-3 GNSS receivers and one Trimble R8-2 receiver utilising static methodology of 1-hour occupations logging data at a rate of 1 second.

2.2.1 Field Survey

The R8-2 receiver was used as a local base station logging continuously throughout the day over existing control point IS Fraser's Gully. Initially, the two R8-3 receivers were set up on the control marks IS Dalziel Rd and IS Reservoir to confirm the accuracy of the survey. Following this, the two receivers were moved following a 1-hour occupation to monitor marks as distant as possible to establish long baselines. Simultaneous mark observations would overlap for as long as 30 minutes creating a strong, braced network of local baselines.

Each monitor mark was setup using a wooden tripod with optical plumet. Receiver heights on control points were measured by steel tape.

2.2.2 Office Processing

Baselines were processed using Trimble Business Centre post-processing software. Static data from permanent base stations OUSD and DUND were combined with the local base station static data from IS Fraser's Gully.

Either TBC or SNAP are appropriate software to use for processing this monitor. A multi constrained adjustment holding DUND, IS Dalziel Rd, IS Frasers Gully & IS Reservoir fixed was used to isolate 3 vectors that contained greater error than expected, these were enabled as a check only, resulting in a Network Reference Factor of 1.12, passing the Chi-Square test and proving acceptable fit of control mark coordinates to measurement. A minimally constrained adjustment holding OUSD fixed was used in the reporting of results with a Reference Factor of 1.04 proving the network errors are close to anticipated for the method. Having a CORS station nearby (3.5km) with 1 hour static baselines makes for a good permanent off-site reference and check on local control. See appendix for processing report.

2.2.3 Geodetic Parameters

The survey was completed in NZ Geodetic Datum 2000 North Taieri circuit in accordance with previous surveys. Vertical datum is the WGS84 Ellipsoid heights. Deformation model has been applied. Further details are included in Appendix D, it is important these parameters are maintained for future monitors.

2.3 Accuracy

The survey has been undertaken to the following accuracy:

- Horizontal position: +/- 15mm (@ 95% CI)
- Vertical position: +/- 20mm (@ 95% CI)

These accuracies apply to marks with reasonable sky visibility.

2.4 Future Monitoring

We note that some of the marks, in particular MIS1, MIS6 and MIS8 are located in challenging GNSS environments and while new technology receivers will go some way to improve accuracy, in future alternative survey methods or alternative marks may need to be considered in order to maintain survey accuracy.

3 Monitoring Results

The cumulative results spreadsheet is presented in Appendix C. A summary of the monitoring results is presented in Table 2.

Table 2: Summary of deformation monitoring results since the previous and base surveys.

	Deformation since previous survey		Deformation since base survey	
	Horizontal	Vertical	Horizontal	Vertical
Average	< 15mm	<20 mm	<15mm	<20 mm
Maximum	< 15 mm	-30 mm	20 mm	-48 mm

4 Rainfall Data

A summary of the rainfall data since the previous survey is presented below in Figure 1. The rainfall data was retrieved from the NIWA (National Institute of Water and Atmospheric Research) National Climate Database website (CliFlo.niwa.co.nz) using the Musselburgh Station (Agent ID #15752).

Mean monthly rainfall is calculated for the “Dunedin Area” using the available data from Musselburgh Station from the earliest rainfall measurement (August 1997) to the time of the latest survey iteration (December 2022).

A significant rainfall during July 2022 is evident in Figure 5, whereby 234 mm was recorded in the calendar month, including 98 mm on 13 – 14 July and 95 mm on 26 – 28 July 2022.

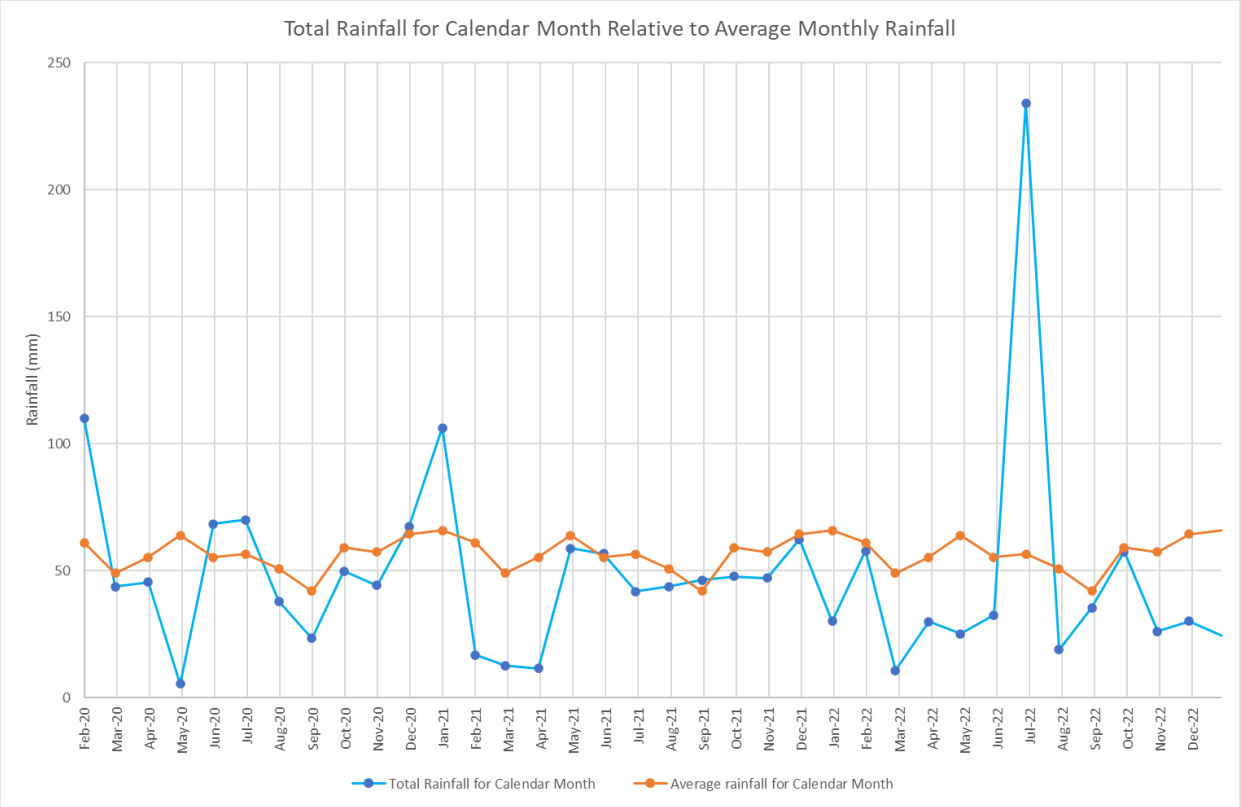


Figure 1: Measured monthly rainfall compared with average monthly rainfall (CliFlo.niwa.co.nz).

5 Conclusions and Recommendations

The maximum displacements recorded since the base survey was completed are as follows:

- 20 mm horizontally,
- -48 mm vertically.

As surveying of this site had begun in July 2020 with only two subsequent survey iterations, it is not possible to establish a conclusive assessment of the long-term deformation rate. The trend that has been exhibited across most of the marks over the previous two survey iterations has shown that the marks are moving in the north-west direction.

Due to the above, additional surveys will be required to provide more detail of the nature and rate of movements occurring across the marks. It is recommended that the surveys occur one or two-yearly intervals. Surveys should continue to adopt the methods described in Section 2 to facilitate capturing a reliable history of survey data.

Appendix A
Mark Displacement Diagram

LEGEND

LANDSLIDE - OTAGO REGION (CERTAINTY)

- DEFINITE
- LIKELY
- POSSIBLE
- NOT ASSESSED
- NO INFORMATION

INDICATIVE LANDSLIDE EXTENTS ARE BASED ON "REVISED LANDSLIDE DATABASE FOR THE COASTAL SECTOR OF THE DUNEDIN CITY DISTRICT" BY BARRELL, D.J.A., SMITH LITTLE, B., GLASSEY, P.J. GNS SCIENCE CONSULTANCY REPORT 2017/41, JULY 2017, SOURCED FROM THE OTAGO REGIONAL COUNCIL (ORC) NATURAL HAZARDS PORTAL.

OTHER

+/- Xmm = CUMULATIVE VERTICAL DISPLACEMENT SINCE THE BASE SURVEY

CUMULATIVE HORIZONTAL DISPLACEMENT SINCE THE BASE SURVEY (1:1000 SCALE)

SURVEY MARKER

REVISION	AMENDMENT	APPROVED	DATE
A	2022 DEFORMATION MONITORING DATA	SK	10/01/2023

DUNEDIN CITY COUNCIL | kaunihera a-rohe o Ōtepoti

wsp
Dunedin Office
+64 3 471 5500
Private Bag 1913
Dunedin 9016
New Zealand

CIVIL

SCALES: N.T.S
ORIGINAL SIZE: A1

DRAWN	SURVEYED	APPROVED
J.W	C.H	S.K

DRAWING VERIFIED	DESIGN VERIFIED	APPROVED DATE
C.H	S.K	10/01/2023

2022 SURVEY RESULTS

PROJECT
DUNEDIN CITY COUNCIL
BROCKVILLE ROAD
LONG TERM LANDSLIDE MONITORING

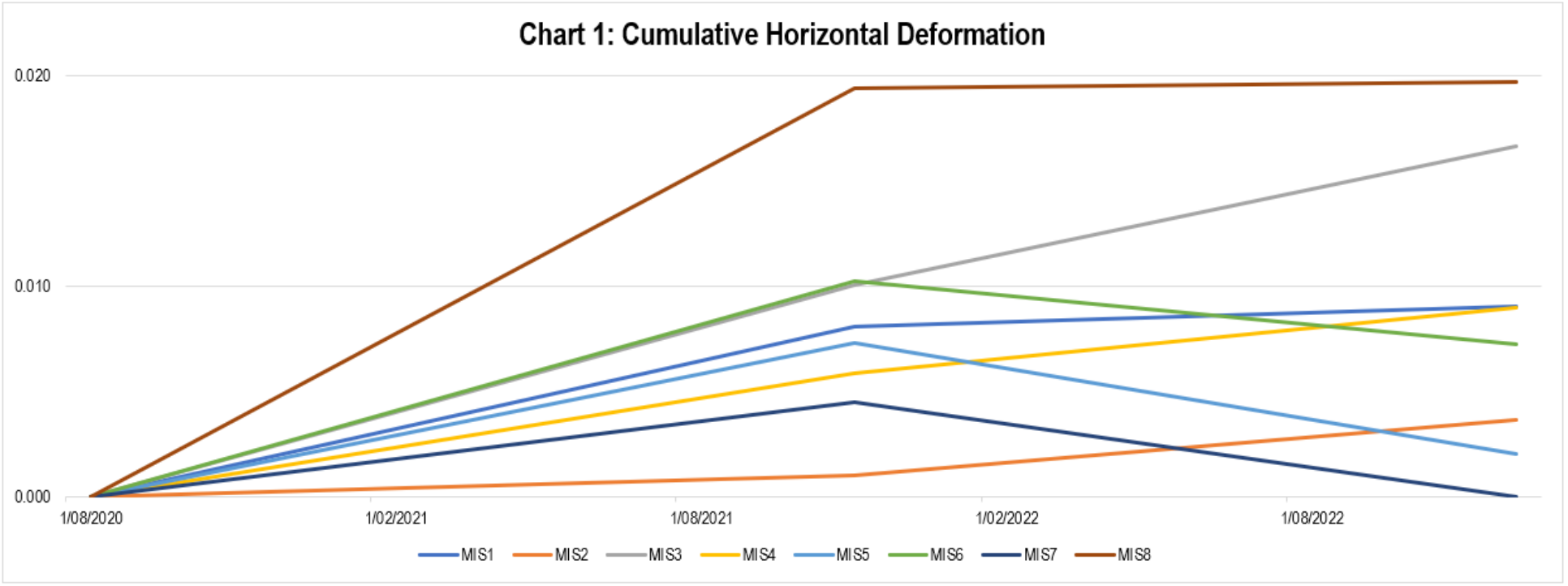
TITLE
CUMULATIVE LANDSLIDE DISPLACEMENTS
BROCKVILLE ROAD

WSP PROJECT NO.	PROJ-ORIG-VOL-LOC-TYPE	SHEET NO.	REVISION
6-CD109.55	6-CD109.55	C01	A

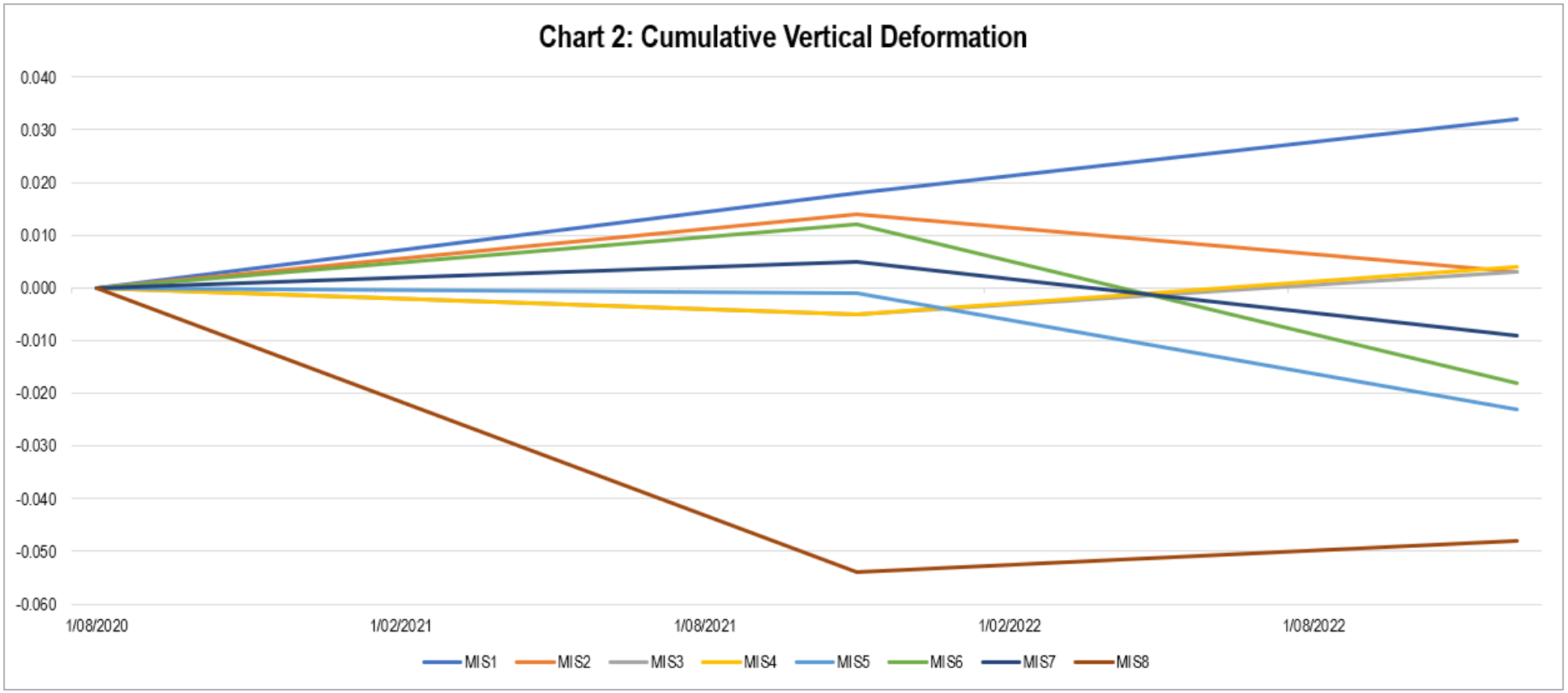
Original sheet size A1 (841x594) Plot Date 2023-06-12 at 10:31:29 AM \\corp\anz\ProjectsNZ\6c\6-CD109.55 LTES Long-term Landslide Monitoring\Home\03_Delivery\Site Plans - DWG\Brockville.dwg Layout2

Appendix B
Selected Monitoring Charts

BROCKVILLE LANDSLIDE MONITORING 2022



BROCKVILLE LANDSLIDE MONITORING 2022



Appendix C
Cumulative Monitoring Results Spreadsheet

SURVEY DATA			
POINT ID	*EASTING*	*NORTHING*	*HEIGHT*
OUSD	417735.027	799072.945	26.150
IS Frasers G.	413294.384	799712.154	283.432
IS Dalziel Rd	413509.321	800234.214	291.865
IS Reservoir	412926.747	799127.943	308.724
MIS1	414105.537	799322.150	235.949
MIS2	414314.921	799430.225	199.039
MIS3	414532.863	799551.180	174.723
MIS4	414692.795	799541.132	167.045
MIS5	414731.223	799443.720	157.151
MIS6	414660.983	799411.248	171.822
MIS7	414606.554	799276.212	162.002
MIS8	414448.573	799218.934	174.566

PRESENT TO PREVIOUS				
EASTING	*NORTHING*	*HORIZONTAL*	*BEARING*	*HEIGHT*
0.004	0.000	0.004	90	0.014
0.000	0.003	0.003	0	-0.011
-0.004	0.004	0.006	315	0.008
0.004	0.003	0.005	53	0.009
0.007	-0.006	0.009	131	-0.022
0.000	-0.006	0.006	180	-0.030
0.007	-0.002	0.007	106	-0.014
0.005	0.003	0.006	59	0.006
0.003	**0.000**	**0.006**	**Averages**	**-0.005**
		0.009	**Max**	**0.014**
			Min	**-0.030**

PRESENT TO ORIGINAL				
EASTING	*NORTHING*	*HORIZONTAL*	*BEARING*	*HEIGHT*
0.000	0.000			0.000
-0.005	-0.004	0.006	231	-0.009
0.001	0.002	0.002	27	0.005
-0.004	-0.005	0.006	219	-0.018
-0.009	0.001	0.009	276	0.032
-0.003	0.002	0.004	304	0.003
-0.009	0.014	0.017	327	0.003
-0.004	0.008	0.009	333.435	0.004
0.002	0.000	0.002	90	-0.023
-0.006	0.004	0.007	303.690	-0.018
0.000	0.000	0.000	-	-0.009
-0.018	0.008	0.020	293.962	-0.048
-0.006	**0.005**	**0.008**	**Averages**	**-0.007**
		0.020	**Max**	**0.032**
			Min	**-0.048**

CUMULATIVE DEFORMATION HORIZONTAL										
SURVEY NO.	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*
DATE	*5/08/2020*	*18/11/2021*	*20/12/2022*							
MIS1	0.000	0.008	0.009							
MIS2	0.000	0.001	0.004							
MIS3	0.000	0.010	0.017							
MIS4	0.000	0.006	0.009							
MIS5	0.000	0.007	0.002							
MIS6	0.000	0.010	0.007							
MIS7	0.000	0.004	0.000							
MIS8	0.000	0.019	0.020							

CUMULATIVE DEFORMATION HEIGHT										
SURVEY NO.	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*
DATE	*5/08/2020*	*18/11/2021*	*20/12/2022*							
MIS1	0.000	0.018	0.032							
MIS2	0.000	0.014	0.003							
MIS3	0.000	-0.005	0.003							
MIS4	0.000	-0.005	0.004							
MIS5	0.000	-0.001	-0.023							
MIS6	0.000	0.012	-0.018							
MIS7	0.000	0.005	-0.009							
MIS8	0.000	-0.054	-0.048							

Appendix D
Geodetic Parameters

Summary

Coordinate system group:	New Zealand/NZGD2000
Zone:	North Taieri 2000
Datum transformation:	New Zealand Geodetic 2000 (Molodensky)
Global reference datum:	NZGD2000
Global reference epoch:	2000
Displacement model:	NZGD2000 Deformation Model (20180701)
Geoid model:	None
RTX calibration:	No

Figure B1: Coordinate System

Datum Transformation

Method:	Molodensky
Translation X:	0.000 m
Translation Y:	0.000 m
Translation Z:	0.000 m
Local ellipsoid used:	Geodetic Ref System 1980
Local ellipsoid semi-major axis:	6378137.000 m
Local ellipsoid inverse flattening:	298.257222101

Figure B2: Transformation Parameters

Projection

Name:	Transverse Mercator
Origin latitude:	S45°51'41.00000"
Origin longitude:	E170°16'57.00000"
False easting:	400000.000 m
False northing:	800000.000 m
Scale factor:	0.9999600000
South azimuth system:	No
Positive coordinate direction:	North / East

Figure B3: Projection Settlings

Geoid Model

Geoid model:	None
Geoid model file name:	
Geoid model quality:	Unknown quality

Vertical Datum

Vertical datum:	

Figure B4: Vertical Datum

Appendix E
Network Adjustment Report

Project File Data		Coordinate System	
Name:	\\corp\anz\ProjectsNZ\6c\6-CD109.55 LTES Long-term Landslide Monitoring\Home\03_Delivery\Brockville\Survey\2022\TBC\221220Brockville.vce	Name:	New Zealand/NZGD2000
Size:	137 KB	Zone:	North Taieri 2000
Modified:	22/12/2022 10:30:58 AM (UTC:13)	Datum:	New Zealand Geodetic 2000
Time zone:	New Zealand Standard Time	Global reference datum:	NZGD2000
Reference number:		Global reference epoch:	2000
Description:		Geoid:	
Comment 1:		Vertical datum:	
Comment 2:		Calibrated site:	
Comment 3:			

Additional Coordinate System Details

Local Site Settings			
Project latitude:	?	Ground scale factor:	1
Project longitude:	?	False easting offset:	0.000 m
Project height:	100.000 m	False northing offset:	0.000 m

Network Adjustment Report

Adjustment Settings

Set-Up Errors

GNSS

Error in Height of Antenna: 0.003 m
Centering Error: 0.000 m

Covariance Display

Horizontal:
Propagated Linear Error [E]: U.S.
Constant Term [C]: 0.000 m
Scale on Linear Error [S]: 1.960
Three-Dimensional
Propagated Linear Error [E]: U.S.
Constant Term [C]: 0.000 m
Scale on Linear Error [S]: 1.960

Adjustment Statistics

Number of Iterations for Successful Adjustment: 2
Network Reference Factor: 1.04
Chi Square Test (95%): Passed
Precision Confidence Level: 95%
Degrees of Freedom: 81

Post Processed Vector Statistics

Reference Factor: 1.04
Redundancy Number: 81.00
A Priori Scalar: 1.00

Control Coordinate Comparisons

Values shown are control coordinates minus adjusted coordinates.

Point ID	ΔEasting (Meter)	ΔNorthing (Meter)	ΔElevation (Meter)	ΔHeight (Meter)
101	0.005	0.004	?	0.009
102	-0.001	-0.002	?	-0.005
103	0.004	0.005	?	0.018
DUND	-0.001	-0.003	?	-0.016

Control Point Constraints

Point ID	Type	East σ (Meter)	North σ (Meter)	Height σ (Meter)	Elevation σ (Meter)
OUSD	Grid	Fixed	Fixed		
OUSD	Local			Fixed	
Fixed = 0.000001(Meter)					

Adjusted Grid Coordinates

Point ID	Easting (Meter)	Easting Error (Meter)	Northing (Meter)	Northing Error (Meter)	Elevation (Meter)	Elevation Error (Meter)	Constraint
101	413294.384	0.001	799712.154	0.001	?	?	
102	413509.321	0.004	800234.214	0.004	?	?	
103	412926.747	0.002	799127.943	0.002	?	?	
501	414105.537	0.002	799322.150	0.002	?	?	
502	414314.921	0.001	799430.225	0.002	?	?	
503	414532.863	0.001	799551.180	0.002	?	?	
504	414692.795	0.001	799541.132	0.001	?	?	
505	414731.223	0.002	799443.720	0.002	?	?	
506	414660.983	0.001	799411.248	0.002	?	?	
507	414606.554	0.002	799276.212	0.002	?	?	
508	414448.573	0.002	799218.934	0.003	?	?	
DUND	424425.439	0.001	797475.870	0.001	?	?	
OUSD	417735.027	?	799072.945	?	?	?	ENh

Adjusted Geodetic Coordinates

Point ID	Latitude	Longitude	Height (Meter)	Height Error (Meter)	Constraint
101	S45°51'49.86171"	E170°27'13.35294"	283.432	0.007	
102	S45°51'32.93702"	E170°27'23.26504"	291.865	0.022	
103	S45°52'08.80958"	E170°26'56.36515"	308.724	0.014	
501	S45°52'02.43594"	E170°27'51.00050"	235.949	0.012	
502	S45°51'58.91981"	E170°28'00.69692"	199.039	0.009	
503	S45°51'54.98565"	E170°28'10.78837"	174.723	0.010	
504	S45°51'55.29888"	E170°28'18.20437"	167.045	0.008	
505	S45°51'58.45113"	E170°28'19.99675"	157.151	0.011	
506	S45°51'59.50828"	E170°28'16.74373"	171.822	0.010	
507	S45°52'03.88627"	E170°28'14.23495"	162.002	0.011	
508	S45°52'05.75353"	E170°28'06.91637"	174.566	0.015	
DUND	S45°53'01.19762"	E170°35'49.81244"	386.932	0.008	
OUSD	S45°52'10.20575"	E170°30'39.31292"	26.150	?	ENh

Adjusted ECEF Coordinates

Point ID	X (Meter)	X Error (Meter)	Y (Meter)	Y Error (Meter)	Z (Meter)	Z Error (Meter)	3D Error (Meter)	Constraint
101	-4387775.299	0.005	737906.538	0.001	-4554925.755	0.005	0.007	
102	-4388186.380	0.015	737758.834	0.005	-4554567.894	0.016	0.022	
103	-4387317.808	0.009	738201.161	0.002	-4555351.287	0.010	0.014	
501	-4387602.509	0.008	737054.028	0.002	-4555162.025	0.009	0.012	
502	-4387688.648	0.007	736856.416	0.002	-4555059.938	0.007	0.010	
503	-4387793.971	0.007	736653.379	0.002	-4554957.902	0.007	0.010	
504	-4387808.336	0.006	736493.587	0.001	-4554959.126	0.006	0.009	
505	-4387739.052	0.008	736442.756	0.002	-4555019.798	0.008	0.011	
506	-4387714.409	0.007	736509.768	0.002	-4555053.056	0.007	0.010	
507	-4387603.028	0.008	736545.942	0.002	-4555140.131	0.008	0.011	
508	-4387544.712	0.010	736696.217	0.003	-4555189.293	0.010	0.015	

DUND	-4388120.463	0.006	726671.306	0.001	-4556533.582	0.006	0.009	
OUSD	-4387888.572	?	733421.023	?	-4555178.484	?	?	ENh

Error Ellipse Components

Point ID	Semi-major axis (Meter)	Semi-minor axis (Meter)	Azimuth
101	0.001	0.001	7°
102	0.005	0.004	23°
103	0.003	0.002	174°
501	0.003	0.002	5°
502	0.002	0.001	14°
503	0.003	0.002	7°
504	0.002	0.001	9°
505	0.003	0.002	14°
506	0.002	0.002	11°
507	0.003	0.002	170°
508	0.003	0.003	3°
DUND	0.002	0.001	6°

Adjusted GNSS Observations

Observation ID		Observation	A-posteriori Error	Residual	Standardized Residual
101 --> OUSD (PV78)	Az.	98°04'06"	0.048 sec	-0.002 sec	-0.099
	ΔHt.	-257.282 m	0.007 m	0.001 m	0.187
	Ellip Dist.	4486.578 m	0.001 m	0.001 m	2.871
501 --> 505 (PV2)	Az.	78°52'27"	0.939 sec	-2.592 sec	-2.729
	ΔHt.	-78.798 m	0.012 m	-0.012 m	-1.860
	Ellip Dist.	637.411 m	0.002 m	-0.001 m	-0.242
101 --> 504 (PV10)	Az.	96°50'59"	0.161 sec	0.020 sec	0.380
	ΔHt.	-116.387 m	0.008 m	-0.001 m	-0.163
	Ellip Dist.	1408.883 m	0.001 m	-0.001 m	-2.338
DUND --> 103 (PV76)	Az.	277°57'00"	0.043 sec	-0.024 sec	-0.272
	ΔHt.	-78.208 m	0.015 m	0.015 m	0.566
	Ellip Dist.	11617.179 m	0.002 m	0.010 m	2.304
101 --> 103 (PV19)	Az.	212°03'32"	0.556 sec	-0.269 sec	-1.625
	ΔHt.	25.292 m	0.013 m	0.005 m	0.714
	Ellip Dist.	690.286 m	0.002 m	-0.001 m	-2.287
101 --> 501 (PV13)	Az.	115°33'20"	0.526 sec	0.068 sec	0.303
	ΔHt.	-47.483 m	0.011 m	-0.018 m	-2.258
	Ellip Dist.	900.074 m	0.002 m	0.000 m	-0.481
501 --> 103 (PV3)	Az.	260°30'51"	0.507 sec	-1.332 sec	-2.141
	ΔHt.	72.775 m	0.014 m	-0.014 m	-1.984
	Ellip Dist.	1194.726 m	0.002 m	0.004 m	1.180
506 --> 502 (PV4)	Az.	273°00'12"	1.142 sec	-1.248 sec	-1.867
	ΔHt.	27.217 m	0.009 m	0.000 m	-0.068
	Ellip Dist.	346.595 m	0.001 m	0.000 m	0.171
OUSD --> DUND (PV77)	Az.	103°15'43"	0.040 sec	-0.020 sec	-1.525
	ΔHt.	360.782 m	0.008 m	0.007 m	1.828
	Ellip Dist.	6878.628 m	0.001 m	0.000 m	0.917
504 --> 508 (PV8)	Az.	217°01'33"	1.143 sec	1.421 sec	1.665
	ΔHt.	7.521 m	0.013 m	-0.005 m	-1.284
	Ellip Dist.	404.312 m	0.002 m	0.003 m	1.557
DUND --> 503 (PV68)	Az.	281°37'19"	0.047 sec	0.112 sec	1.644
	ΔHt.	-212.209 m	0.011 m	-0.006 m	-0.429

	Ellip Dist.	10108.272 m	0.002 m	-0.001 m	-0.560
101 --> 503 (PV11)	**Az.**	97°16'58"	0.321 sec	0.197 sec	1.598
	ΔHt.	-108.709 m	0.009 m	0.006 m	1.100
	Ellip Dist.	1248.943 m	0.001 m	0.000 m	0.719
DUND --> 508 (PV72)	**Az.**	279°41'03"	0.055 sec	0.115 sec	1.488
	ΔHt.	-212.366 m	0.016 m	0.004 m	0.106
	Ellip Dist.	10128.344 m	0.002 m	-0.002 m	-0.623
DUND --> 506 (PV74)	**Az.**	280°59'07"	0.046 sec	-0.124 sec	-1.432
	ΔHt.	-215.110 m	0.012 m	0.020 m	0.926
	Ellip Dist.	9954.761 m	0.002 m	-0.001 m	-0.341
OUSD --> 103 (PV88)	**Az.**	270°29'29"	0.094 sec	-0.001 sec	-0.008
	ΔHt.	282.574 m	0.014 m	0.007 m	0.443
	Ellip Dist.	4808.772 m	0.002 m	0.003 m	1.375
OUSD --> 504 (PV79)	**Az.**	278°35'06"	0.089 sec	-0.075 sec	-0.932
	ΔHt.	140.895 m	0.008 m	-0.006 m	-1.008
	Ellip Dist.	3078.160 m	0.001 m	-0.001 m	-1.360
101 --> 502 (PV12)	**Az.**	105°19'13"	0.261 sec	-0.142 sec	-1.348
	ΔHt.	-84.393 m	0.008 m	-0.003 m	-0.548
	Ellip Dist.	1058.803 m	0.001 m	-0.001 m	-1.125
OUSD --> 503 (PV80)	**Az.**	278°19'49"	0.132 sec	0.059 sec	0.409
	ΔHt.	148.573 m	0.010 m	-0.013 m	-1.336
	Ellip Dist.	3237.797 m	0.001 m	0.001 m	0.397
101 --> 506 (PV17)	**Az.**	102°17'41"	0.266 sec	0.100 sec	0.694
	ΔHt.	-111.610 m	0.009 m	0.000 m	-0.005
	Ellip Dist.	1399.387 m	0.001 m	-0.001 m	-1.330
DUND --> 505 (PV75)	**Az.**	281°14'56"	0.052 sec	-0.046 sec	-0.493
	ΔHt.	-229.781 m	0.013 m	0.030 m	1.232
	Ellip Dist.	9892.277 m	0.002 m	0.000 m	-0.017
OUSD --> 502 (PV81)	**Az.**	275°47'59"	0.092 sec	-0.026 sec	-0.281
	ΔHt.	172.889 m	0.009 m	0.001 m	0.129
	Ellip Dist.	3438.843 m	0.001 m	-0.002 m	-1.207
506 --> 503 (PV7)	**Az.**	317°23'15"	2.411 sec	-0.941 sec	-0.362
	ΔHt.	2.901 m	0.009 m	-0.001 m	-0.166
	Ellip Dist.	189.732 m	0.002 m	0.002 m	1.191
DUND --> 504 (PV67)	**Az.**	281°45'16"	0.035 sec	0.049 sec	1.186
	ΔHt.	-219.887 m	0.010 m	0.006 m	0.590
	Ellip Dist.	9949.705 m	0.001 m	-0.001 m	-0.422
DUND --> 502 (PV69)	**Az.**	280°42'52"	0.038 sec	-0.035 sec	-0.616
	ΔHt.	-187.893 m	0.011 m	0.009 m	0.517
	Ellip Dist.	10298.036 m	0.001 m	-0.003 m	-1.106
DUND --> 507 (PV73)	**Az.**	280°09'51"	0.048 sec	0.087 sec	1.038
	ΔHt.	-224.931 m	0.012 m	0.015 m	0.608
	Ellip Dist.	9982.923 m	0.002 m	0.000 m	0.092
OUSD --> 501 (PV82)	**Az.**	273°45'50"	0.140 sec	0.134 sec	0.883
	ΔHt.	209.799 m	0.012 m	-0.015 m	-1.033
	Ellip Dist.	3638.169 m	0.002 m	0.001 m	0.632
DUND --> 501 (PV70)	**Az.**	279°55'02"	0.053 sec	0.091 sec	1.009
	ΔHt.	-150.983 m	0.014 m	-0.020 m	-0.855
	Ellip Dist.	10484.125 m	0.002 m	0.000 m	0.059
101 --> 508 (PV15)	**Az.**	113°00'56"	0.393 sec	0.006 sec	0.029
	ΔHt.	-108.866 m	0.014 m	0.008 m	0.565
	Ellip Dist.	1255.204 m	0.002 m	0.001 m	0.998
101 --> 507 (PV16)	**Az.**	108°15'18"	0.289 sec	-0.031 sec	-0.176
	ΔHt.	-121.431 m	0.010 m	0.009 m	0.952
	Ellip Dist.	1382.743 m	0.002 m	-0.001 m	-0.568
OUSD --> 508 (PV84)	**Az.**	272°22'46"	0.159 sec	-0.009 sec	-0.041
	ΔHt.	148.416 m	0.015 m	-0.006 m	-0.181

	Ellip Dist.	3289.816 m	0.002 m	-0.002 m	-0.917
102 --> DUND (PV71)	**Az.**	104°03'22"	0.080 sec	-0.004 sec	-0.067
	ΔHt.	95.067 m	0.022 m	-0.007 m	-0.453
	Ellip Dist.	11259.622 m	0.004 m	0.002 m	0.892
OUSD --> 102 (PV83)	**Az.**	285°12'08"	0.202 sec	0.006 sec	0.082
	ΔHt.	265.715 m	0.022 m	-0.003 m	-0.426
	Ellip Dist.	4382.528 m	0.003 m	-0.001 m	-0.886
502 --> 505 (PV5)	**Az.**	88°00'40"	1.124 sec	0.613 sec	0.750
	ΔHt.	-41.888 m	0.010 m	0.001 m	0.316
	Ellip Dist.	416.536 m	0.002 m	0.001 m	0.610
OUSD --> 507 (PV85)	**Az.**	273°33'13"	0.139 sec	-0.048 sec	-0.290
	ΔHt.	135.852 m	0.011 m	0.005 m	0.291
	Ellip Dist.	3135.184 m	0.002 m	-0.002 m	-0.742
OUSD --> 506 (PV86)	**Az.**	276°06'59"	0.130 sec	-0.080 sec	-0.458
	ΔHt.	145.672 m	0.010 m	-0.008 m	-0.597
	Ellip Dist.	3092.717 m	0.001 m	-0.001 m	-0.727
504 --> 507 (PV9)	**Az.**	197°53'46"	1.331 sec	-0.128 sec	-0.167
	ΔHt.	-5.043 m	0.009 m	-0.002 m	-0.701
	Ellip Dist.	278.614 m	0.002 m	0.000 m	0.113
507 --> 503 (PV6)	**Az.**	344°51'44"	1.565 sec	0.850 sec	0.247
	ΔHt.	12.722 m	0.012 m	0.006 m	0.613
	Ellip Dist.	284.681 m	0.003 m	0.003 m	0.424
101 --> 505 (PV18)	**Az.**	100°27'33"	0.305 sec	0.077 sec	0.482
	ΔHt.	-126.281 m	0.010 m	0.004 m	0.548
	Ellip Dist.	1461.754 m	0.002 m	0.000 m	-0.545
OUSD --> 505 (PV87)	**Az.**	276°52'22"	0.155 sec	-0.063 sec	-0.315
	ΔHt.	131.001 m	0.011 m	0.008 m	0.467
	Ellip Dist.	3026.712 m	0.002 m	0.000 m	0.063

Histogram of Standardized Residuals

Critical Tau Value: 3.8
Observations Failing the Tau Test: 0