C305– Eastern Running Tunnels

I&M Close out report for Electrolevels at The Post Office Tunnel (Drive Y)

CRL Document Number: C305-DSJ-C2-RGN-CRG03-50387

Supplier Document Number:

Contract MDL reference C08.079

1. Contractor Document Submittal History:

Revision:	Date:	Prepared by:	Checked by:	Approved by:	Reason for Issue:
2.0	[redacted]				For Approval

2a. Stakeholder ReviewRequired? YES ☐ NO ☐

Stakeholder submission required: LU ☐ RfL ☐ NR ☐ LO ☐ DLR ☐ Other: _____

Purpose of submission: For no objection ☐ For information ☐

This document has been reviewed by the following individual for coordination, compliance, integration and acceptance and is acceptable for transmission to the above stakeholder for the above stated purpose.

Sign: _____ Role: _____ Name: _____ Date: _____

Sign: _____ Role: _____ Name: _____ Date: _____

2b. Review by Stakeholder (if required):

Stakeholder Organisation	Job Title	Name	Signature	Date	Acceptance
					☐

3. Acceptance by *Crossrail*.

	Crossrail Review and Acceptance Decal	This decal is to be used for submitted documents requiring acceptance by *Crossrail*.
☑	Code 1.	Accepted. Work May Proceed
☐	Code 2.	Not Accepted. Revise and resubmit. Work may proceed subject to incorporation of changes indicated
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☐	Code 4.	Received for information only. Receipt is confirmed

Reviewed/Accepted by(signature) [redacted] Print Name: [redacted] Position: [redacted] Date: 1/4/16

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GEOCISA UK	C305-CLOUT-14-160115

I&M Close out report for Electrolevels at The Post Office Tunnel (Drive Y)

C305 Crossrail Eastern Running Tunnels

Current Version of the Documents & Signatures :

Revision:	Date:	Prepared by:	Checked by:	Engineering Approved by:
2.0	14-03-2016	[redacted]		

Document History :

Revision:	Date:	Prepared by:	Checked by:	Engineering Approved by:
1.0	23-02-2016	[redacted]		
2.0	14-03-2016			

1. CLOSE OUT REPORT PURPOSE

As stated in the specification: C122-OVE-Z4-RSP-CR001-00007 Rev 7.0, the purpose of this close-out report is to summarise the data from the instrumentation included in this document and to relate the recorded movements to the construction activities which produce any observed changes. For construction activities it is intended excavation of the C305 twin bored tunnels and dewatering of cross passages; impacts from other CRL contracts are not included in this report.

The long term readings have been used to demonstrate that the subsequent movement has reached an acceptably stable rate within the accuracy of the system in order to decommission and/or that C305 works are no longer impacting the area concerned.

As stated in the specifications the settlement rate of 2 mm/yr has been defined. Where this is not achieved this report seeks agreement from all parties that the rate is acceptably low enough to cease monitoring and decommission.

2. LOCATION OF THE WORKS

This report covers the instrumentation and monitoring works in The Post Office (PO) Tunnel, which is part of the Royal Mail Group (RMG) Railway Network (Mail Rail), operating from 1927 to 2003. The Crossrail Drive Y alignment is crossing the PO tunnel at Chainage 78100-78300, underneath Widegate Street.

See Appendix A for the instrument location.

3. DOCUMENTATION SUMMARY

CROSSRAIL NUMBER	DOCUMENT NAME	REASON FOR ISSUE	TYPE AND NUMBER OF INSTRUMENTATION INSTALLED
C305-DSJ-C2-GMS-CRG03-50042	I&M Method Statement Monitoring of Post Office Tunnels – Drive Y: 78100-78300 & 777000-77900	Method statement	50 Electrolevels sensor
C305-DSJ-C2-RGN-CRG03-50383	I&M Installation report for Electrolevels at Post Office Tunnels (Drive Y)	Installation Report	50 Electrolevels sensor

4. SUMMARY OF INSTALLED INSTRUMENTATION ON SITE

The total number of electrolevels installed, as per Installation Report listed in section above, was:

- ✓ 50 sensors: C305-EL104001-S to C305-EL104050-S (corresponding to 51 monitoring points)

Detailed information of the electrolevel system, including commissioning readings, is reported in Appendix B. Baseline readings were taken after commissioning, from 20/11/2014 to 01/01/2015.

Contrary to the method statement, the manual monitoring system composed of sockets couldn't be installed due to asbestos hazard within the PO tunnel lining. Instead, no.18 track levelling points (C305-LT104001 to C305-LT104051 marked on the existing PO Tunnel rails were used to detect any movement.

Refer to Appendix B for the coordinates of track levelling points.

5. CONSTRUCTION ACTIVITY

TBM PASSAGE

DRIVE Y	RINGS	PROJECT CHAINAGE	DATES
Eastbound	3612-3671	78110-78210	09/01/2015 to 12/01/2015
Westbound	3669-3732	78120-78225	15/02/2015 to 20/02/2015

Stoppage period

Eastbound Drive-Y No stoppage
Westbound Drive-Y No stoppage

The periods of TBM passage and stoppage are related to the rings located close to the instrumentation included in this close out report.

CROSS PASSAGE 6

Depressurisation:
Start: 21/2/2015
End: 27/06/2015

Construction:
Start: 29/03/2015
End: 07/06/2015

6. METHODOLOGY

To determine the settlement rate the following methodology was has been used. A Linear Regression has been applied for a defined period using long term readings after TBM construction. This uses the following formula to calculate the gradient or slope of the line:

$$b = \frac{\sum_{i=1}^{n}(X_i - \overline{X}_i) \cdot (Y_i - \overline{Y}_i)}{\sum_{i=1}^{n}(X_i - \overline{X}_i)^2}$$

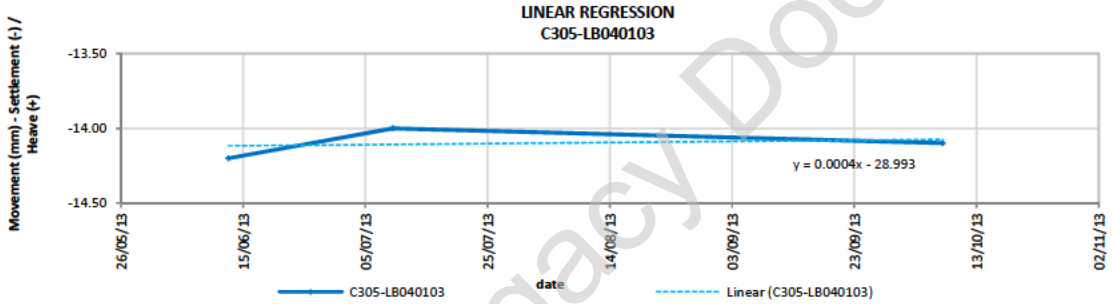
Where:

B =gradient or slope
X (independent variable) = date
Y (dependent variable) = vertical movement

From this, the settlement rate per day can be calculated and rate per year determined (negative values is for settlement, positive is for heave). For these values, the percentage at or below 2 mm/yr will be used to determine the trend of the section/area being considered. Also for comparison, values at or below 3 mm/year are presented to highlight that the rate is close to achieving the 2 mm/yr. Note the percentages of settlement rate presented in the sections below refer to values rounded to the nearest integer.

One example of this calculation can be seen below

	Registered movement (mm)			RATE mm/year
	12/06/2013	09/07/2013	07/10/2013	
C305-LB040103	-14.20	-14.00	-14.10	0.146



CALCULATION - C305-LB040103

X_i	Y_i	$X_i - \overline{X}_i$	$Y_i - \overline{Y}_i$	$(X_i - \overline{X}_i)^2$	$(X_i - \overline{X}_i) \cdot (Y_i - \overline{Y}_i)$
12/06/2013	-14.2	-47.94	-0.10	2298.67	4.794
09/07/2013	-14	-21.03	0.10	442.17	-2.103
07/10/2013	-14.1	68.97	0.00	4757.17	0.000

$\overline{X}_i$		41485.53	
$\overline{Y}_i$		-14.10	
$\sum_{i=1}^{n} (X_i - \overline{X}_i)^2$		7498.00	(2)
$\sum_{i=1}^{n} (X_i - \overline{X}_i) \cdot (Y_i - \overline{Y}_i)$		2.692	(1)
m (SLOPE)	(1)/(2)	0.0004	
Rate (mm/year)	m * 365	0.146	

7. SUMMARY OF THE DATA

The data presented below are the result of automatic monitoring (electrolevel sensors C305-EL104001 to C305-EL104051) and manual monitoring (C305-LT104001 to C305-LT104051).

It has to be noted the automatic monitoring was terminated in June 2015, only four months after WB TBM transit, due to removal of the data logger. This was requested by the asset owner in order for tunnel maintenance activities to be performed. Therefore, the long term monitoring was carried out manually until the end of August 2015.

Hence, the methodology explained in section 6 is applied here only for monitoring points C305-LT104001 to C305-LT104051.

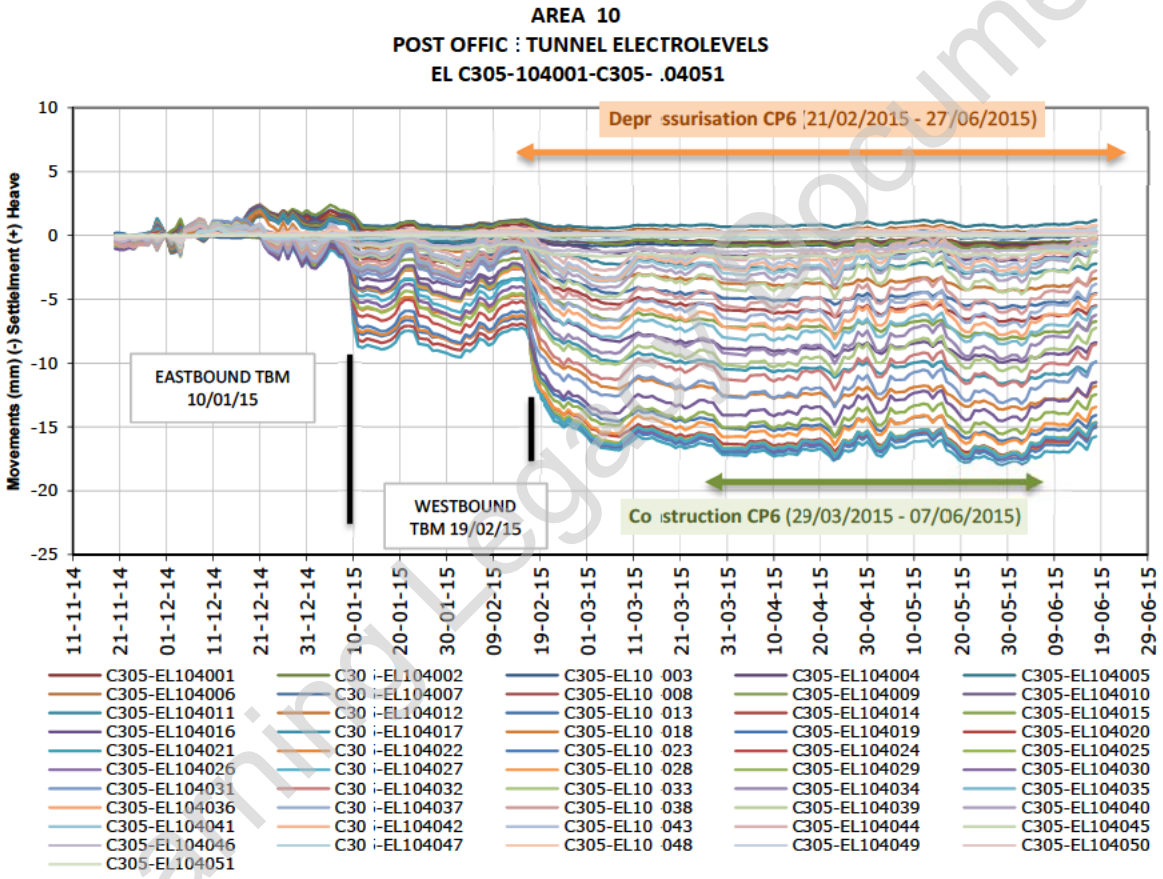
Note: For the following data plots #N/A refers to instances where readings were not taken for that sensor (e.g. damaged sensor, no access, etc).

AUTOMATIC MONITORING

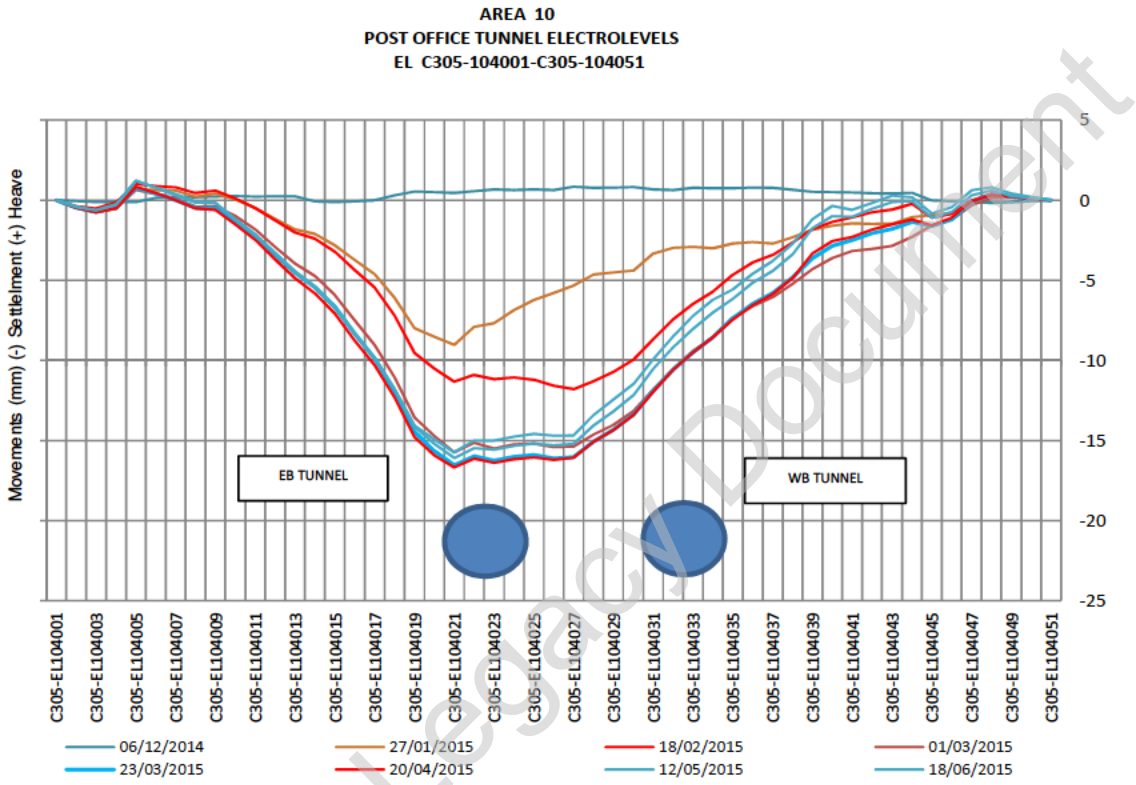
As shown in the charts below, monitoring of the array was affected by the TBM excavation, recording an 8 mm movement due to the eastbound TBM, and additional 8 mm due to the westbound TBM. The impact of the depressurization and the excavation of cross-passage 6 was minimal, around 1 mm.

C305-EL104001 – C305-EL104051

Data are presented below in a "movement vs. time" chart:



Data are presented below in a “transversal profile” chart:

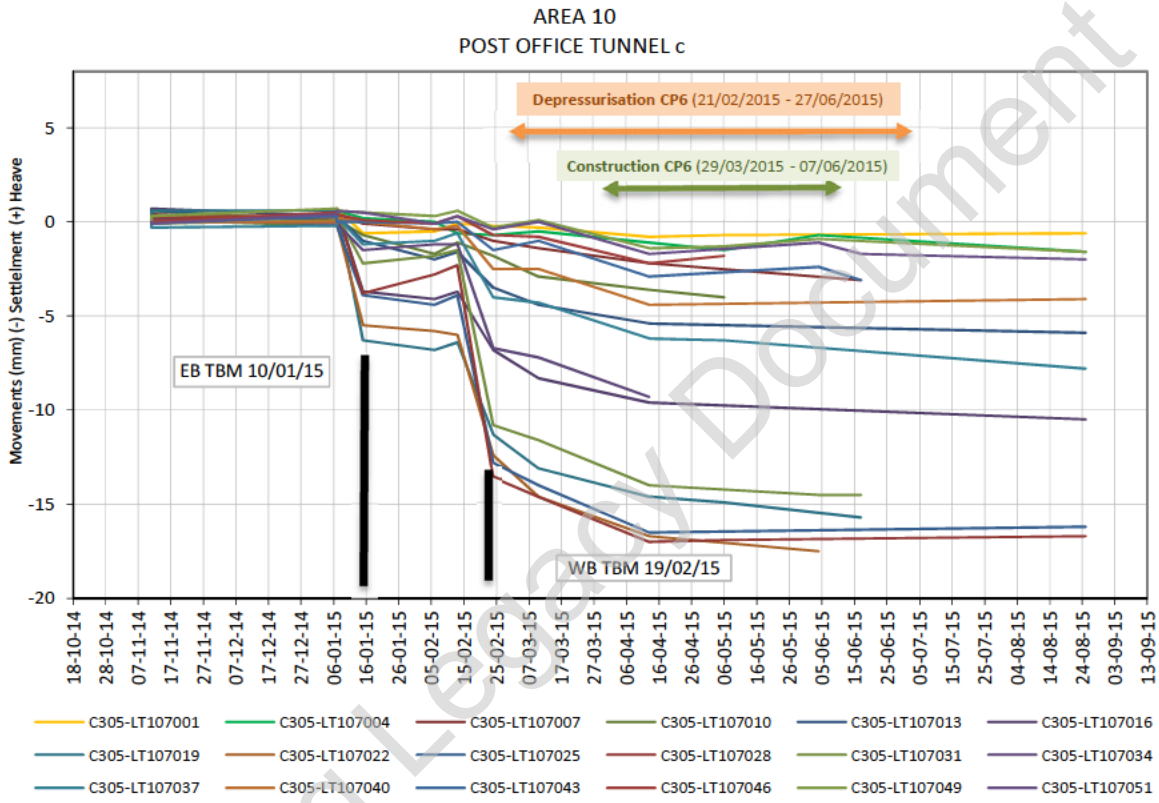


Electrolevel monitoring points recorded a maximum settlement of 18 mm.

MANUAL MONITORING

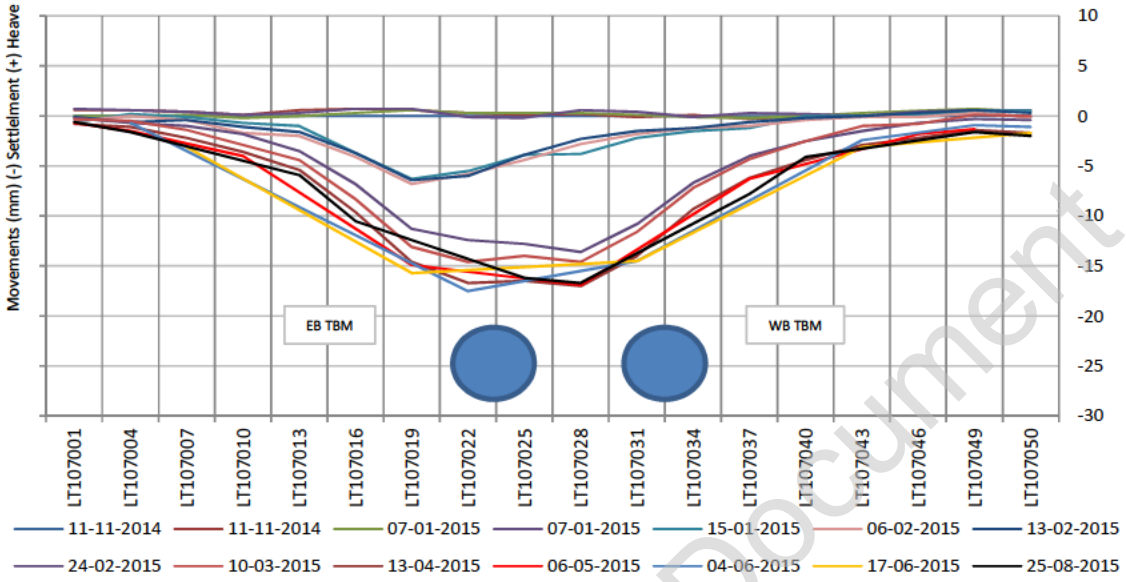
C305-LT107001 – C305-LT107051

Data are presented below in a "movement vs. time" chart:



Data are presented below in a "transversal profile" chart:

AREA 10
Levelling Points POST OFFICE TUNNEL



The maximum recorded settlement was 17.5 mm.

The table below show the predicted annual rate for the Post Office Tunnel using the track levelling manual readings between April 2015 and August 2015.

	Registered movement (mm)		Rate (mm/year)
LT107001	READINGS FROM 13/04/2014 TO 25/08/2015		0.476
LT107004			-1.041
LT107028			0.767
LT107031			-3.008
LT107037			-4.540
LT107043			0.201
LT107049			-0.690
LT107051			-1.112
	Rate less than -2.5 mm/year	% less 2 mm/ year	75%
	Rate greater than -3.5 mm/year	% less 3 mm/ year	88%

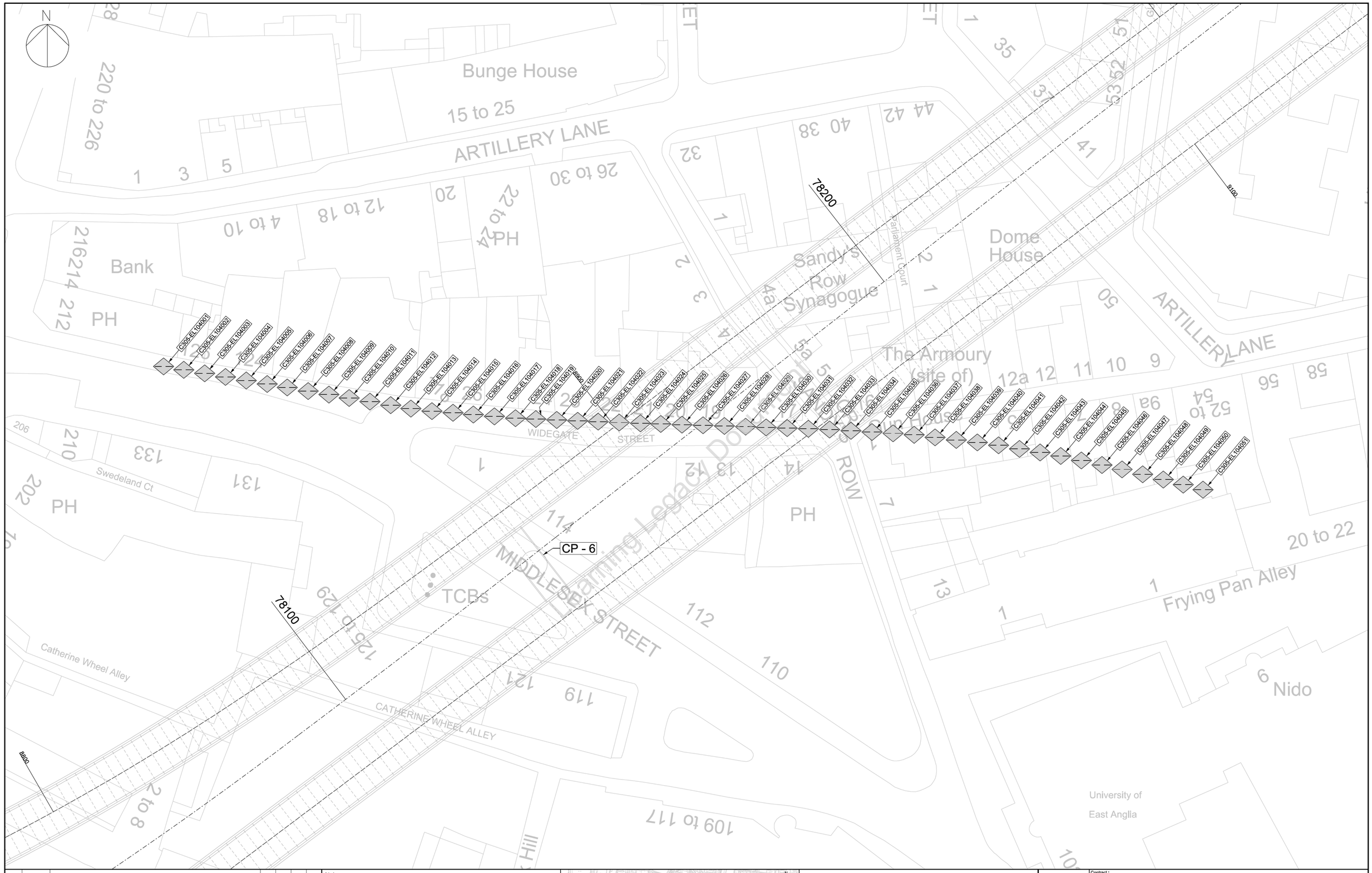
Note: Not all points were read due to time constraints and a representative sample were taken to confirm stability.

8. SUMMARY STATEMENT

It has been agreed between the Project Manager, the Designer, the Contractor and the Sub Contractor that the instrumentation covered herein, for monitoring ground movement effects of Crossrail works, including long term effects, can be closed out for decommissioning as the trends of the monitoring points were approaching or had achieved the specified 2 mm/year settlement rate.

Minutes of the Close Out meeting(s) are attached as Appendix C.

APPENDIX A: INSTRUMENT LOCATION



Rev.	Date	Description	By	Chkd	App	Auth
						-
P01	17/12/2015	First Issue	MD	MD	MD	-
P02	18/12/2015	—	MD	MD	MD	-

Notes

Electrolevel Beam

1:250 @ A1

Crossrail Limited
25 Canada Square
Canary Wharf
London
E14 5LQ

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Contract: Tunnels East - Drive Y LIM to FAR & Drive Z SGJ to PML & Drive G

Originator: Dragados Sisk Joint Venture

Location: Crossrail Tunnels - Drive Y (Limmo Peninsula to Farringdon Stn)

Title: Instrumentation & Monitoring
I&M Installation report for Electrolevels
at Post Office Tunnels (Drive Y)
C305-DSJ-C2-RGN-CRG03-50383

By: M.DAVIS
Chk: M.DAVIS
App: M.DAVIS
Auth: —

Scale: 1:250@ A1

Drawing and CAD file No: C305-DSJ-C2-DDA-CRT00_ST006_1-08296

Rev: P02

Suitability: S4

Fit for authorisation

RESTRICTED

C305-DSJ-C2-DDA-CRT00_ST006_1-08296.dgn 18/12/2015 11:29:13

APPENDIX B: SUMMARY OF INSTRUMENTATION INSTALLED ON SITE

Summary Installed Instrumentation - Electrolevels											
Sensor Type	Sensor ID	Sensor Serial Number	Date Installation	Status	Monitoring ID	Location MONR	Location MONR	Location MONR	Comm. Readings (mm)	Comm. Readings (mm)	Comm. Readings (mm)
						Eastings X (m)	Northings Y (m)	Elevation Z (mATD)	18-11-14	19-11-14	20-11-14
Electrolevel Beam	C305-EL104001-S	14085056	07-11-14	INSTALLED	C305-EL104001	83718.433	36342.448	87.400	0.000	0.000	0.000
Electrolevel Beam	C305-EL104002-S	14085026	07-11-14	INSTALLED	C305-EL104002	83721.390	36341.943	87.394	-0.063	-0.040	-0.060
Electrolevel Beam	C305-EL104003-S	14085030	07-11-14	INSTALLED	C305-EL104003	83724.446	36341.421	87.388	-0.205	-0.127	-0.167
Electrolevel Beam	C305-EL104004-S	14085025	07-11-14	INSTALLED	C305-EL104004	83727.502	36340.899	87.381	-0.128	-0.122	-0.056
Electrolevel Beam	C305-EL104005-S	14085059	07-11-14	INSTALLED	C305-EL104005	83730.558	36340.378	87.380	0.004	-0.026	-0.010
Electrolevel Beam	C305-EL104006-S	14085021	07-11-14	INSTALLED	C305-EL104006	83733.613	36339.856	87.379	-0.185	-0.227	-0.133
Electrolevel Beam	C305-EL104007-S	14083032	07-11-14	INSTALLED	C305-EL104007	83736.571	36339.351	87.377	-0.293	-0.347	-0.242
Electrolevel Beam	C305-EL104008-S	14083031	07-11-14	INSTALLED	C305-EL104008	83739.626	36338.829	87.376	-0.338	-0.368	-0.253
Electrolevel Beam	C305-EL104009-S	14085022	07-11-14	INSTALLED	C305-EL104009	83742.682	36338.307	87.375	0.093	0.025	0.120
Electrolevel Beam	C305-EL104010-S	14084051	07-11-14	INSTALLED	C305-EL104010	83745.639	36337.802	87.374	0.078	0.032	0.138
Electrolevel Beam	C305-EL104011-S	14084052	07-11-14	INSTALLED	C305-EL104011	83748.695	36337.280	87.378	0.081	0.058	0.112
Electrolevel Beam	C305-EL104012-S	14085013	07-11-14	INSTALLED	C305-EL104012	83751.751	36336.758	87.382	0.007	0.009	0.012
Electrolevel Beam	C305-EL104013-S	14085014	07-11-14	INSTALLED	C305-EL104013	83754.708	36336.253	87.387	0.005	0.061	0.045
Electrolevel Beam	C305-EL104014-S	14085053	07-11-14	INSTALLED	C305-EL104014	83757.784	36335.877	87.398	-0.118	-0.072	-0.077
Electrolevel Beam	C305-EL104015-S	14085038	07-11-14	INSTALLED	C305-EL104015	83760.875	36335.641	87.409	-0.210	-0.172	-0.104
					C305-EL104016	83763.864	36335.381	87.421	-0.348	-0.255	-0.177

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Summary Installed Instrumentation - Electrolevels											
Sensor Type	Sensor ID	Sensor Serial Number	Date Installation	Status	Monitoring ID	Location MONR Eastings X (m)	Location MONR Northings Y (m)	Location MONR Elevation Z (mATD)	Comm. Readings (mm) 18-11-14	Comm. Readings (mm) 19-11-14	Comm. Readings (mm) 20-11-14
Electrolevel Beam	C305-EL104016-S	14085039	07-11-14	INSTALLED							
Electrolevel Beam	C305-EL104017-S	14085016	07-11-14	INSTALLED	C305-EL104017	83766.952	36335.112	87.435	-0.256	-0.198	-0.078
Electrolevel Beam	C305-EL104018-S	14085057	07-11-14	INSTALLED	C305-EL104018	83770.040	36334.844	87.448	-0.459	-0.378	-0.216
Electrolevel Beam	C305-EL104019-S	14085002	07-11-14	INSTALLED	C305-EL104019	83773.037	36334.711	87.462	-0.452	-0.347	-0.235
Electrolevel Beam	C305-EL104020-S	14085001	07-11-14	INSTALLED	C305-EL104020	83776.109	36334.583	87.475	-0.417	-0.288	-0.196
Electrolevel Beam	C305-EL104021-S	14085015	07-11-14	INSTALLED	C305-EL104021	83779.181	36334.455	87.487	-0.383	-0.199	-0.128
Electrolevel Beam	C305-EL104022-S	14132029	07-11-14	INSTALLED	C305-EL104022	83782.179	36334.330	87.500	-0.329	-0.221	-0.172
Electrolevel Beam	C305-EL104023-S	14132028	07-11-14	INSTALLED	C305-EL104023	83785.276	36334.203	87.517	-0.512	-0.349	-0.347
Electrolevel Beam	C305-EL104024-S	14132024	07-11-14	INSTALLED	C305-EL104024	83788.374	36334.094	87.535	-0.578	-0.391	-0.379
Electrolevel Beam	C305-EL104025-S	14132025	07-11-14	INSTALLED	C305-EL104025	83791.373	36333.995	87.552	-0.676	-0.498	-0.475
Electrolevel Beam	C305-EL104026-S	14084018	07-11-14	INSTALLED	C305-EL104026	83794.471	36333.897	87.569	-0.752	-0.678	-0.549
Electrolevel Beam	C305-EL104027-S	14132034	07-11-14	INSTALLED	C305-EL104027	83797.569	36333.800	87.585	-1.247	-1.119	-0.979
Electrolevel Beam	C305-EL104028-S	14132027	07-11-14	INSTALLED	C305-EL104028	83800.693	36333.697	87.601	-0.962	-0.931	-0.842
Electrolevel Beam	C305-EL104029-S	14084023	07-11-14	INSTALLED	C305-EL104029	83803.816	36333.594	87.617	-1.101	-0.953	-0.915
Electrolevel Beam	C305-EL104030-S	14132026	07-11-14	INSTALLED	C305-EL104030	83806.814	36333.495	87.632	-1.224	-1.083	-1.127
					C305-EL104031	83809.913	36333.393	87.647	-0.722	-0.594	-0.593

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Summary Installed Instrumentation - Electrolevels											
Sensor Type	Sensor ID	Sensor Serial Number	Date Installation	Status	Monitoring ID	Location MONR Eastings X (m)	Location MONR Northings Y (m)	Location MONR Elevation Z (mATD)	Comm. Readings (mm) 18-11-14	Comm. Readings (mm) 19-11-14	Comm. Readings (mm) 20-11-14
Electrolevel Beam	C305-EL104031-S	14132018	07-11-14	INSTALLED							
Electrolevel Beam	C305-EL104032-S	14132019	07-11-14	INSTALLED	C305-EL104032	83813.011	36333.291	87.656	-0.664	-0.482	-0.561
Electrolevel Beam	C305-EL104033-S	14084045	07-11-14	INSTALLED	C305-EL104033	83816.134	36333.182	87.664	-0.575	-0.338	-0.561
Electrolevel Beam	C305-EL104034-S	14084046	07-11-14	INSTALLED	C305-EL104034	83819.253	36332.993	87.673	-0.695	-0.465	-0.646
Electrolevel Beam	C305-EL104035-S	14132014	07-11-14	INSTALLED	C305-EL104035	83822.347	36332.807	87.678	-0.563	-0.312	-0.514
Electrolevel Beam	C305-EL104036-S	14084058	07-11-14	INSTALLED	C305-EL104036	83825.442	36332.621	87.684	-0.740	-0.526	-0.687
Electrolevel Beam	C305-EL104037-S	14132016	07-11-14	INSTALLED	C305-EL104037	83828.533	36332.403	87.690	-0.638	-0.431	-0.582
Electrolevel Beam	C305-EL104038-S	14086006	07-11-14	INSTALLED	C305-EL104038	83831.610	36332.031	87.706	-0.620	-0.421	-0.530
Electrolevel Beam	C305-EL104039-S	14086002	07-11-14	INSTALLED	C305-EL104039	83834.708	36331.657	87.722	-0.338	-0.114	-0.243
Electrolevel Beam	C305-EL104040-S	14084040	07-11-14	INSTALLED	C305-EL104040	83837.812	36331.282	87.738	-0.476	-0.198	-0.316
Electrolevel Beam	C305-EL104041-S	14084039	07-11-14	INSTALLED	C305-EL104041	83840.908	36330.866	87.750	-0.393	-0.123	-0.262
Electrolevel Beam	C305-EL104042-S	14084043	07-11-14	INSTALLED	C305-EL104042	83843.987	36330.336	87.763	-0.362	-0.098	-0.256
Electrolevel Beam	C305-EL104043-S	14084044	07-11-14	INSTALLED	C305-EL104043	83847.014	36329.815	87.775	-0.385	-0.100	-0.280
Electrolevel Beam	C305-EL104044-S	14084063	07-11-14	INSTALLED	C305-EL104044	83850.045	36329.293	87.787	-0.106	0.105	-0.097
Electrolevel Beam	C305-EL104045-S	14084064	07-11-14	INSTALLED	C305-EL104045	83853.075	36328.646	87.799	-0.244	0.021	-0.170
					C305-EL104046	83856.100	36327.975	87.811	-0.420	-0.134	-0.349

Summary Installed Instrumentation - Electrolevels											
Sensor Type	Sensor ID	Sensor Serial Number	Date Installation	Status	Monitoring ID	Location MONR Eastings X (m)	Location MONR Northings Y (m)	Location MONR Elevation Z (mATD)	Comm. Readings (mm) 18-11-14	Comm. Readings (mm) 19-11-14	Comm. Readings (mm) 20-11-14
Electrolevel Beam	C305-EL104046-S	14084016	07-11-14	INSTALLED							
Electrolevel Beam	C305-EL104047-S	14084057	07-11-14	INSTALLED	C305-EL104047	83859.028	36327.326	87.822	-0.184	0.095	-0.109
Electrolevel Beam	C305-EL104048-S	14084073	07-11-14	INSTALLED	C305-EL104048	83862.069	36326.612	87.832	-0.357	-0.123	-0.217
Electrolevel Beam	C305-EL104049-S	14084015	07-11-14	INSTALLED	C305-EL104049	83865.095	36325.840	87.843	-0.253	-0.151	-0.172
Electrolevel Beam	C305-EL104050-S	14084074	07-11-14	INSTALLED	C305-EL104050	83868.002	36325.097	87.848	-0.124	-0.088	-0.068
					C305-EL104051	83870.909	36324.355	87.853	0.000	0.000	0.000

Note: All elevations or levels presented in this document are metres above tunnel datum (mATD).

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The first levelling track point **C305-LT107001**, located approximately 45 meters away from C305 EB tunnel centre line.
All other points follow southwards at 9 m centre.

Sensor ID	Sensor Location - GPS Reading		
	Eastings X (m)	Northings Y (m)	Elevation Z (mATD)
C305-LT107001	83718.4330	36342.4480	87.4004
C305-LT107004	83754.7080	36336.2530	87.3814
C305-LT107007	83791.3730	36333.9950	87.3772
C305-LT107010	83828.5330	36332.4030	87.3735
C305-LT107013	83865.0950	36325.8400	87.3867
C305-LT107016	83727.5020	36340.8990	87.4207
C305-LT107019	83763.8640	36335.3810	87.4623
C305-LT107022	83800.6930	36333.6970	87.5000
C305-LT107025	83837.8120	36331.2820	87.5523
C305-LT107028	83870.9090	36324.3550	87.6013
C305-LT107031	83736.5710	36339.3510	87.6473
C305-LT107034	83773.0370	36334.7110	87.6728
C305-LT107037	83809.9130	36333.3930	87.6898
C305-LT107040	83847.0140	36329.8150	87.7380
C305-LT107043	83745.6390	36337.8020	87.7754
C305-LT107046	83782.1790	36334.3300	87.8113
C305-LT107049	83819.2530	36332.9930	87.8430
C305-LT107051	83856.1000	36327.9750	87.8531

All elevations or levels presented in this document are metres above tunnel datum (mATD).

APPENDIX C: MINUTES OF THE CLOSE OUT MEETING

I&M Close Out Meeting

Date & Time	25/09/2015 10:00
Meeting No.	7

The purpose of this document is to record agreement to cease monitoring long term monitoring and decommission based on review of the data against the requirements. Agreement from this meeting is then considered acceptance from all parties that the Close Out Report can then be produced based on the data shown and this will be acceptable to the Project Manager.

Attendees:

[redacted] [redacted]

Data Reviewed

Monitoring References	Location	Settlement rate	Agreement to decommission
Area 6 - Limehouse Link Tunnel			
EL060101-EL060128	Westbound	N/A	2mm max, stable since TBM Yes. ~~Annotate~~
EL060201-EL060228	Eastbound	N/A	4mm Max, stable since TBM Yes.
Area 10 - BT Deep Level Tunnels and Shaft			
EL101001-EL101096	Commercial Street and Brushfield Street Tunnel	N/A	Annotate graphs for loss of data / knocked beam. Manual readings need to be reviewed.
EL101101-EL101111	Brushfield Street Adit	N/A	Annotate graphs as above and review with manual readings.
TU106101 - TU106105	Brushfield Street Shaft	N/A	Yes - convert degrees to mm/m
LC101001-LC101003	Brushfield Street Shaft	N/A	Yes -
EL102001-EL102061	Bishopsgate Tunnel	N/A	* Review with manual readings.
Area 10 - Post Office Tunnel			
EL104001-EL104051	Widegate Street/ Middlesex Street	N/A	Yes - electrolevels, data / comms box already removed. Last 2 manual readings < 1mm change.

Notes

- Annotate graphs to highlight knocks, loss of readings
- For BT tunnels set of manual readings needed to confirm long term stability.

Sign off

DSJV	Geocisa	Crossfail	C122
[redacted]	[redacted]	[redacted]	[redacted]