



C305 – Eastern Running Tunnels
I&M Close out report "East India Viaduct (CP14)"
(Drive Y)

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 NR LO For information
 DLR Other _____


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: _____
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2b. Review by Stakeholder (if required):

Stakeholder Organisation	Job Title	Name	Signature	Date	Acceptance
					<input type="checkbox"/>

3. Acceptance by Crossrail:

		Crossrail Review and Acceptance Decal	
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I&M Close out report East India Viaduct CP14 (Drive Y)					
<i>C305 Crossrail Eastern Running Tunnels</i>					
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APPENDIX A: INSTRUMENT LOCATION

APPENDIX B: SUMMARY OF INSTRUMENTATION INSTALLED ON SITE

APPENDIX C: DEFLECTION RATIO

Learning Legacy Document

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 and dewatering of cross passages which produce any observed changes. For construction activities it is intended excavation of the C305 twin bored tunnels and construction of Cross-Passage 14 (excavation and dewatering); 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/year 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

The instrumentation included within this report is located in Area 4, East India to Canary Wharf, between project chainages 84670 and 84380.

See Appendix A for the instrument location.

3. DOCUMENTATION SUMMARY

CROSSRAIL NUMBER	DOCUMENT NAME	REASON FOR ISSUE
C305-DSJ-C2-RGN-CRG03-502092	Installation Report for Lower Lea Crossing Bridge Area and Abutment Wall (Drive Y)	Installation report
C305-DSJ-C-GMS-CR143-50011	Installation Report for I&M Studs Installation East India to Canary Wharf (84400-84350)	Installation report
C305-DSJ-C2-GMS-CRG03-50017	Installation Report for I&M MS Sockets Pilgrims Mews (84400-84500)	Installation report
C305-DSJ-C2-RGN-CRG03-50407	Installation Report for CP13, CP14 & CP15 Piezometer (Drive Y)	Installation report

4. SUMMARY OF INSTALLED INSTRUMENTATION ON SITE

The total number instruments installed as per method statement and RFIs, was:

- 138 – Levelling points
- 7 – Sockets
- 20 – Vibrating wire piezometers

Appendix B includes detailed information of the installed instrumentation, the average value of the commissioning readings included in Appendix B has been used as a baseline for the relative movements illustrated in the graphs of this report.

5. CONSTRUCTION ACTIVITY

TBM PASSAGE

DRIVE Y	RINGS	PROJECT CHAINAGE	DATES
Eastbound	115 – 298	84670 – 84380	07/03/2013 to 28/03/2013
Westbound	115 – 297	84670 – 84380	18/03/2013 to 15/04/2013

Stoppage period

Eastbound Drive-Y	No Stoppage period	
Wesbound Drive Y	Ring 288 (Project chainage 84403)	11/04/2013 to 14/04/2013

CROSSPASSAGE CONSTRUCTION / DEWATERING

CP 14 Dewatering	<p>Phase 1 16th December 2013 to 17th January 2014 – 14 surface ejectors</p> <p>Phase 2 28th July 2014 to 17th November 2014 – 14 surface ejectors</p> <p>Phase 3 2nd April 2015 to 28th July 2015 – 14 surface ejectors + 22 in-tunnel wellpoints</p> <p>(17th November 2014 to 2nd April 2015 no dewatering to due to ground treatment being carried out)</p>
CP 14 Construction	26 th May 2015 to 14 th July 2015
CP 13 Dewatering	26th November 2013 to 3rd August 2015
Limmo Dewatering	4th November 2013 to 14 th March 2016
Canary Wharf Dewatering	It is understood that Canary Wharf dewatering systems were switched on throughout the monitoring period

6. METHODOLOGY

To determine the settlement rate the following methodology has been used. A Linear Regression has been applied for a defined period using long term readings after TBM construction and Cross-passage CP14 construction. This uses the following formula.

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

Where:

B =gradient or slope

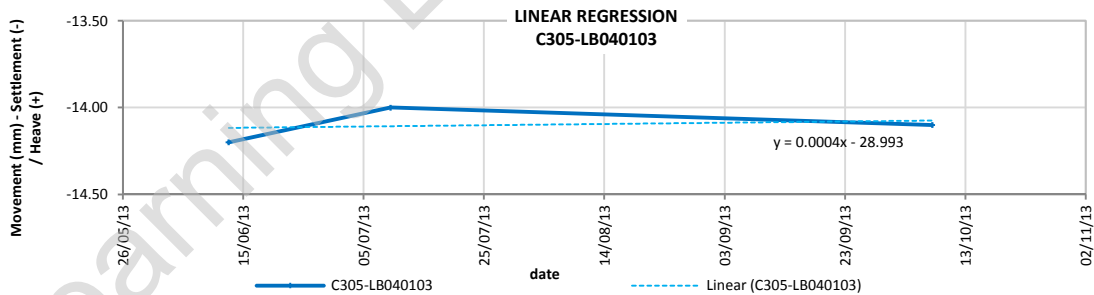
X (independent variable) = date

Y (dependent variable) = vertical movement

From this, the settlement rate per day can be calculated and rate per year determined (negative value is for settlement, positive is for heave). For these values, the percentage at or below 2 mm/year will be used to determine the trend of the section/area being considered. Also for comparison, values at or below 3mm/year are presented to highlight that the rate is close to achieving the 2 mm/year. 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 for one socket and its projection.

	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	$X_i - \bar{X}_i$	$Y_i - \bar{Y}_i$	$(X_i - \bar{X}_i)^2$	$(X_i - \bar{X}_i) \cdot (Y_i - \bar{Y}_i)$
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

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

7. SUMMARY OF THE DATA

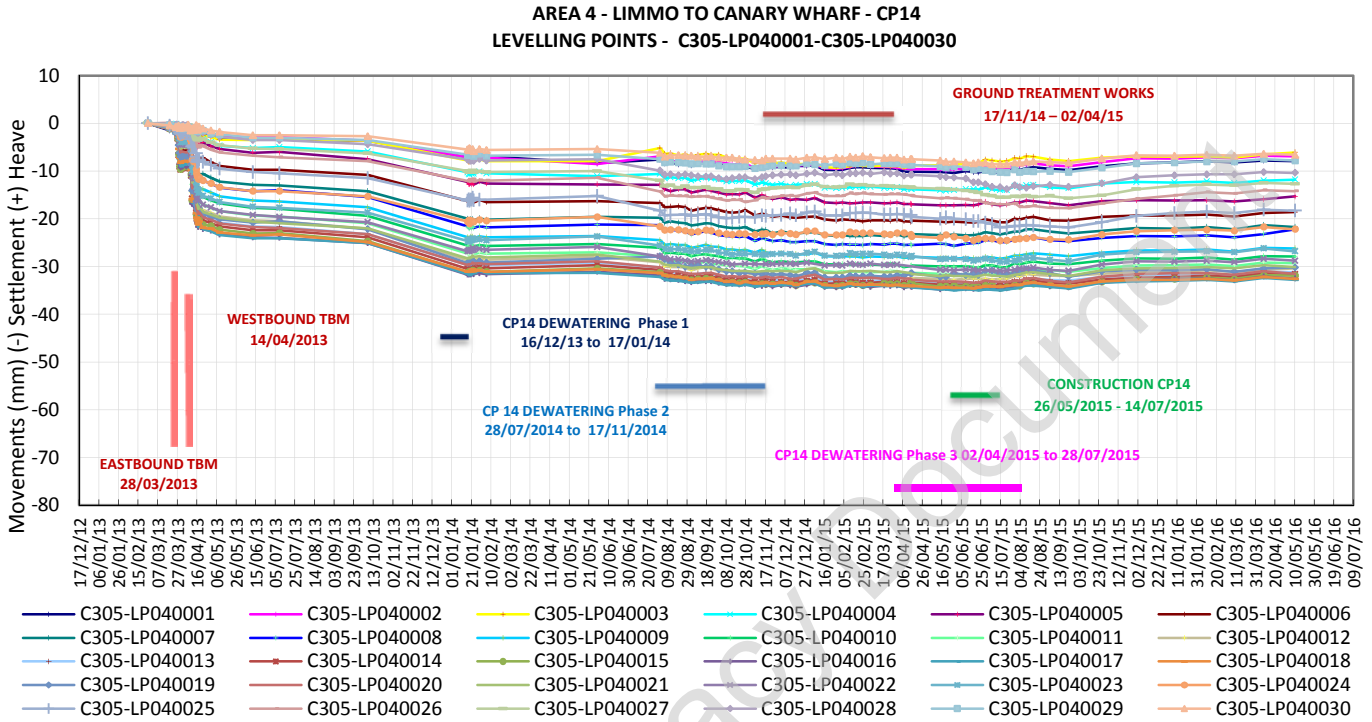
The methodology described for sockets in section 6 is applied here for Levelling points and Sockets to demonstrate that the long term movements after all construction activities have reached or are approaching an acceptably low rate.

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.)

As described in the C122 I&M Plan (C122-OVE-C2-RGN-CRG01-50070), for levelling points situated in the vicinity of 3rd party utility assets, deflection ratio values are provided in appendix C.

LEVELLING POINTS

C305-LP040001 – C305-LP040030



The graph above shows a maximum settlement of -9 mm after the eastbound TBM transit and -25 mm after westbound transit. A total maximum settlement of -35 mm was recorded during CP14 works.

To analyse whether the rate of change in the data has reached an acceptably small rate, the last four readings were used to calculate the annual projection.

The table below shows the annual rate for the levelling points in this array.

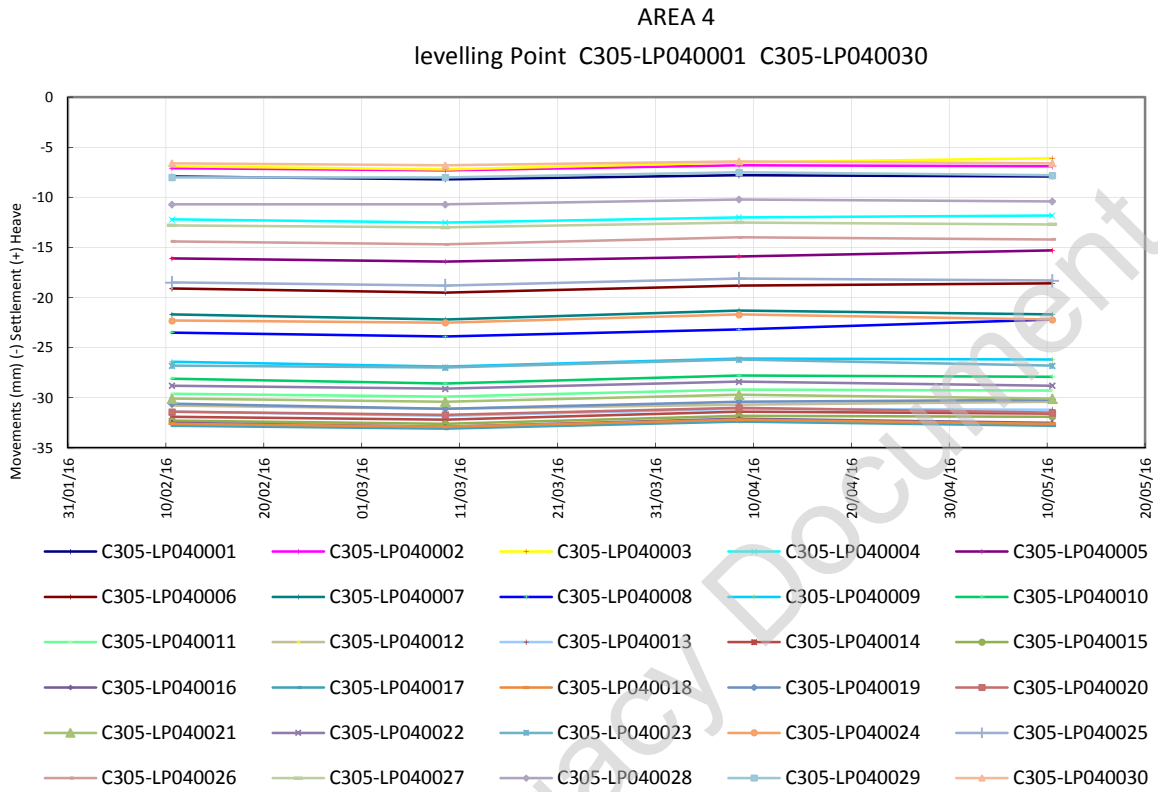
	Registered movement (mm)				mm/year
	10/02/2016	09/03/2016	08/04/2016	10/05/2016	
C305-LP040001	-7.90	-8.20	-7.80	-7.90	0.503
C305-LP040002	-7.10	-7.30	-6.80	-6.90	1.347
C305-LP040003	-6.90	-7.20	-6.50	-6.10	3.829
C305-LP040004	-12.20	-12.50	-12.00	-11.80	2.110
C305-LP040005	-16.10	-16.40	-15.90	-15.30	3.602
C305-LP040006	-19.10	-19.50	-18.80	-18.60	2.726
C305-LP040007	-21.70	-22.20	-21.30	-21.70	1.104
C305-LP040008	-23.50	-23.90	-23.20	-22.20	5.711
C305-LP040009	-26.40	-26.90	-26.10	-26.20	1.737
C305-LP040010	-28.10	-28.60	-27.80	-27.90	1.737

	Registered movement (mm)				mm/year
	10/02/2016	09/03/2016	08/04/2016	10/05/2016	
C305-LP040011	-29.60	-29.90	-29.20	-29.30	1.964
C305-LP040012	-30.80	-31.10	-30.70	-30.40	1.996
C305-LP040013	-31.40	-31.80	-31.10	-31.20	1.607
C305-LP040014	-31.90	-32.20	-31.40	-31.60	2.077
C305-LP040015	-32.30	-32.60	-31.80	-31.90	2.450
C305-LP040016	-32.50	-32.90	-32.10	-32.50	0.974
C305-LP040017	-32.80	-33.10	-32.40	-32.80	0.844
C305-LP040018	-32.60	-32.90	-32.20	-32.60	0.844
C305-LP040019	-30.60	-31.10	-30.40	-30.20	2.369
C305-LP040020	-31.40	-31.70	-31.00	-31.50	0.471
C305-LP040021	-30.10	-30.40	-29.70	-30.10	0.844
C305-LP040022	-28.80	-29.10	-28.40	-28.80	0.844
C305-LP040023	-26.80	-27.00	-26.20	-26.80	0.941
C305-LP040024	-22.30	-22.50	-21.70	-22.20	1.314
C305-LP040025	-18.50	-18.80	-18.10	-18.30	1.590
C305-LP040026	-14.40	-14.70	-14.00	-14.20	1.590
C305-LP040027	-12.80	-13.00	-12.50	-12.70	0.974
C305-LP040028	-10.70	-10.70	-10.20	-10.40	1.687
C305-LP040029	-8.00	-8.00	-7.50	-7.80	1.314
C305-LP040030	-6.60	-6.80	-6.40	-6.60	0.487
	Rate less than -2.5 mm/year			% less 2 mm/ year	100%
	Rate greater than -3.5 mm/year			% less 3 mm/ year	100%

Note: All the movements are in mm. (-) Settlement / (+) Heave

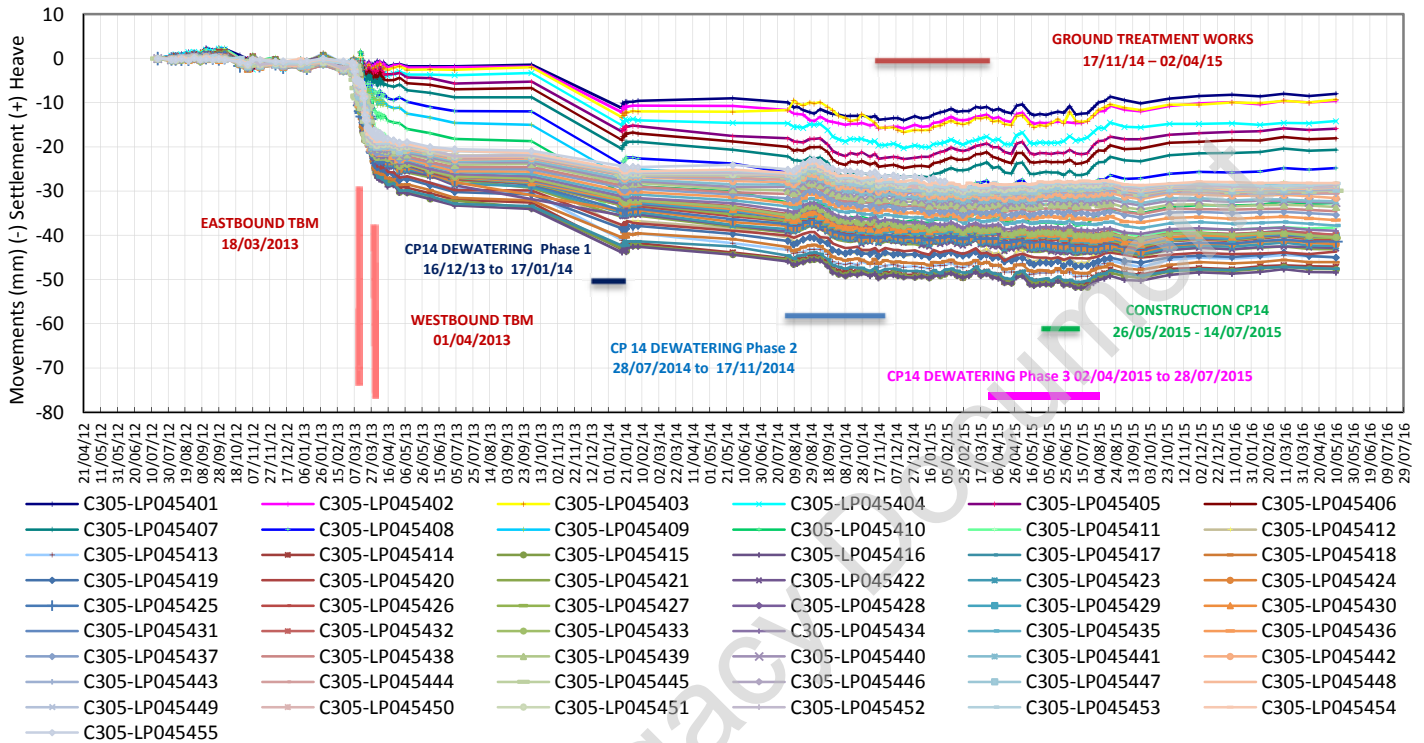
The percentage of levelling points with a settlement rate less than 2 mm/year is 100%, whereas 100% are less than 3 mm/year.

The plot below shows the trend line adjustment for the levelling points in this array.



C305-LP045401 – C305-LP045455

**AREA 4 - LIMMO TO CANARY WHARF - CP14
 LEVELLING POINTS - C305-LP045401-C305-LP045455**



The graph above shows a maximum settlement of -21 mm after the eastbound TBM transit and -34 mm after westbound transit. A total maximum settlement of -52 mm was recorded during CP14 works.

To analyse whether the rate of change in the data has reached an acceptably small rate, the last four readings were used to calculate the annual projection.

The table below shows the annual rate for the levelling points in this array.

	Registered movement (mm)				mm/year
	10/02/2016	09/03/2016	08/04/2016	10/05/2016	
C305-LP045401	-8.60	-8.00	-8.50	-8.00	1.573
C305-LP045402	-10.40	-9.60	-10.00	-9.60	2.400
C305-LP045403	-10.10	-9.60	-10.00	-9.30	2.450
C305-LP045404	-15.00	-14.60	-14.70	-14.20	2.807
C305-LP045405	-16.50	-15.80	-16.20	-15.90	1.670
C305-LP045406	-18.60	-17.80	-18.30	-18.10	1.166
C305-LP045407	-21.20	-20.40	-20.90	-20.70	1.166
C305-LP045408	-25.60	-24.80	-25.20	-24.80	2.400
C305-LP045409	-28.80	-28.10	-28.60	-28.40	0.810

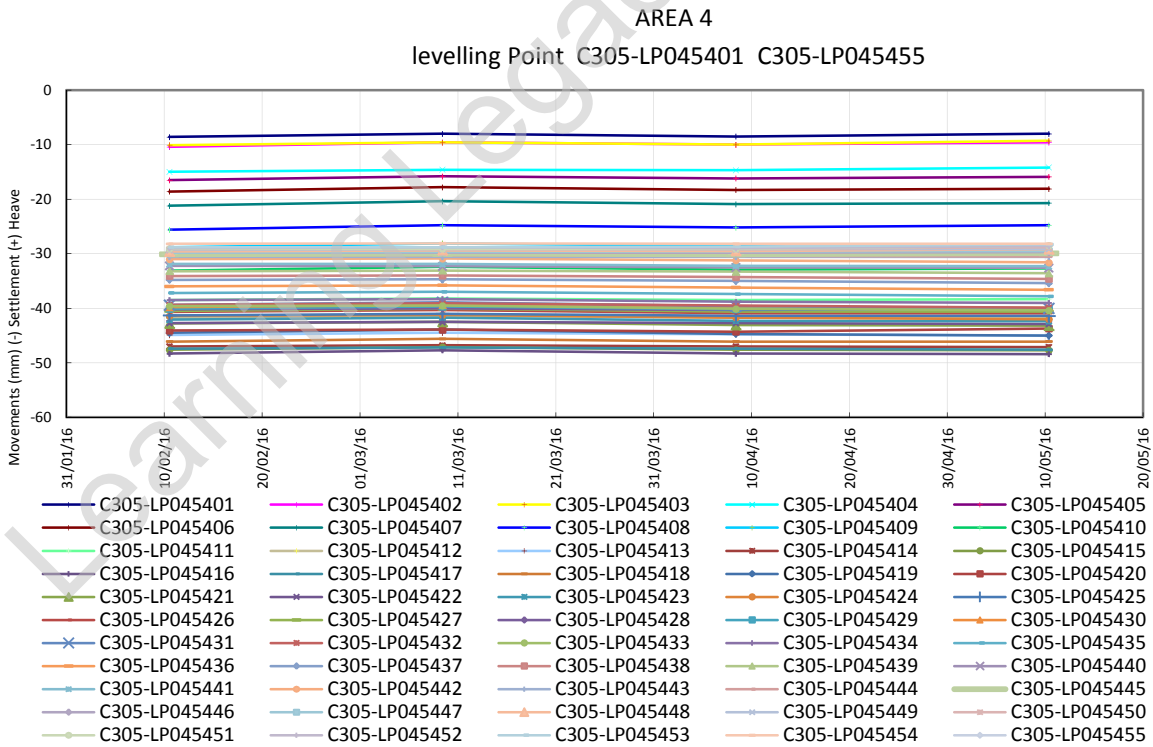
	Registered movement (mm)				mm/year
	10/02/2016	09/03/2016	08/04/2016	10/05/2016	
C305-LP045410	-33.10	-32.40	-32.90	-32.70	0.810
C305-LP045411	-38.50	-38.20	-38.50	-38.30	0.356
C305-LP045412	-41.80	-41.40	-41.70	-41.80	-0.407
C305-LP045413	-44.90	-44.50	-44.80	-45.00	-0.780
C305-LP045414	-47.00	-46.80	-47.00	-47.10	-0.634
C305-LP045415	-47.60	-47.10	-47.60	-47.70	-1.024
C305-LP045416	-48.30	-47.70	-48.30	-48.40	-1.154
C305-LP045417	-47.40	-47.20	-47.40	-47.60	-1.007
C305-LP045418	-46.10	-45.60	-46.10	-46.10	-0.651
C305-LP045419	-44.50	-43.90	-44.70	-45.00	-2.875
C305-LP045420	-44.10	-43.90	-44.30	-43.70	1.006
C305-LP045421	-42.80	-42.50	-43.10	-43.20	-2.225
C305-LP045422	-42.70	-42.50	-42.70	-42.90	-1.007
C305-LP045423	-42.10	-41.70	-42.30	-42.40	-1.868
C305-LP045424	-41.40	-41.20	-41.70	-42.00	-2.841
C305-LP045425	-41.30	-41.00	-41.40	-41.40	-0.877
C305-LP045426	-40.70	-40.30	-40.90	-40.90	-1.494
C305-LP045427	-40.50	-40.10	-40.60	-40.60	-1.008
C305-LP045428	-40.20	-40.00	-40.30	-40.00	0.373
C305-LP045429	-40.10	-39.70	-40.20	-40.10	-0.634
C305-LP045430	-39.80	-39.40	-39.80	-39.90	-0.894
C305-LP045431	-39.40	-38.90	-39.60	-40.00	-3.118
C305-LP045432	-39.40	-39.10	-39.50	-39.90	-2.371
C305-LP045433	-39.60	-39.50	-40.10	-40.40	-3.685
C305-LP045434	-38.50	-38.30	-38.80	-39.00	-2.468
C305-LP045435	-37.20	-37.00	-37.40	-37.80	-2.728
C305-LP045436	-36.00	-35.80	-36.20	-36.60	-2.728
C305-LP045437	-34.80	-34.70	-35.00	-35.40	-2.597
C305-LP045438	-34.10	-34.00	-34.30	-34.60	-2.224
C305-LP045439	-33.20	-33.10	-33.30	-33.60	-1.737
C305-LP045440	-32.20	-32.30	-32.50	-32.60	-1.704
C305-LP045441	-31.90	-31.90	-32.20	-32.30	-1.834
C305-LP045442	-31.00	-30.90	-31.20	-31.60	-2.597
C305-LP045443	-30.60	-30.60	-30.60	-30.60	0.000
C305-LP045444	-30.30	-30.30	-30.40	-30.50	-0.860
C305-LP045445	-30.10	-30.00	-30.10	-29.90	0.617
C305-LP045446	-29.80	-29.80	-29.80	-29.70	0.373

	Registered movement (mm)				mm/year
	10/02/2016	09/03/2016	08/04/2016	10/05/2016	
C305-LP045447	-29.80	-29.70	-29.60	-29.50	1.217
C305-LP045448	-29.60	-29.40	-29.50	-29.20	1.347
C305-LP045449	-29.30	-29.20	-29.20	-29.10	0.730
C305-LP045450	-29.20	-29.00	-29.10	-28.80	1.347
C305-LP045451	-29.10	-29.10	-29.10	-28.50	2.240
C305-LP045452	-29.00	-28.80	-29.00	-28.60	1.233
C305-LP045453	-28.80	-28.80	-28.70	-28.30	1.980
C305-LP045454	-28.20	-28.10	-28.20	-28.20	-0.130
C305-LP045455	#N/A	#N/A	#N/A	#N/A	-
	Rate less than -2.5 mm/year			% less 2 mm/ year	85.2%
	Rate greater than -3.5 mm/year			% less 3 mm/ year	98%

Note: All the movements are in mm. (-) Settlement / (+) Heave

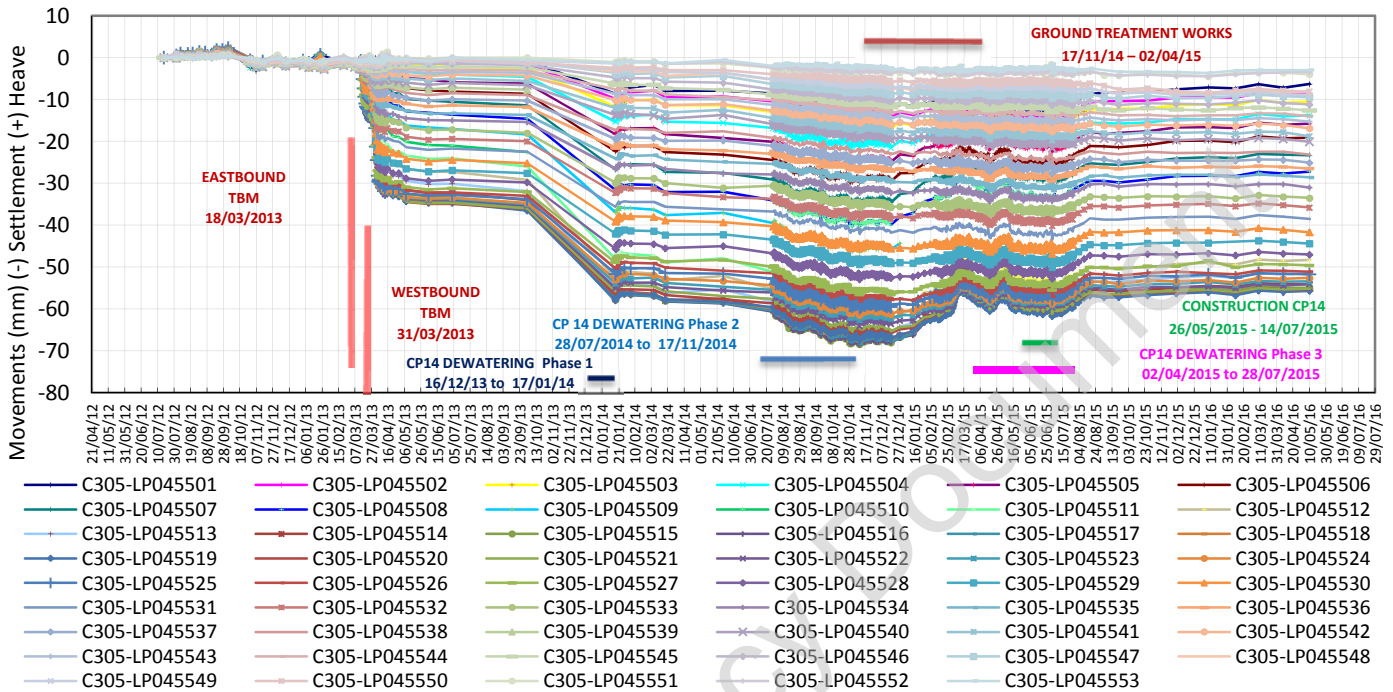
The percentage of levelling points with a settlement rate less than 2 mm/year is 85.2%, whereas 98% are less than 3 mm/year.

The plot below shows the trend line adjustment for the levelling points in this array.



C305-LP045501 – C305-LP045553

**AREA 4 - LIMMO TO CANARY WHARF - CP14
 LEVELLING POINTS - C305-LP045501-C305-LP045553**



The graph above shows a maximum settlement of -14 mm after the eastbound TBM transit and -37 mm after westbound transit. A total maximum settlement of -69 mm was recorded during CP14 works.

To analyse whether the rate of change in the data has reached an acceptably small rate, the last four readings were used to calculate the annual projection.

The table below shows the annual rate for the levelling points in this array.

	Registered movement (mm)				mm/year
	10/02/2016	09/03/2016	08/04/2016	10/05/2016	
C305-LP045501	-7.40	-6.40	-7.20	-6.30	3.033
C305-LP045502	-9.60	-8.40	-9.00	-8.60	2.855
C305-LP045503	-11.30	-10.10	-10.80	-10.50	1.994
C305-LP045504	-14.80	-13.50	-14.00	-13.80	2.952
C305-LP045505	-16.80	-15.50	-16.10	-15.80	2.838
C305-LP045506	-20.20	-18.80	-19.30	-19.10	3.309
C305-LP045507	-24.00	-23.00	-23.20	-23.30	2.222
C305-LP045508	-28.30	-27.30	-27.70	-27.20	3.488
C305-LP045509	#N/A	#N/A	#N/A	#N/A	-

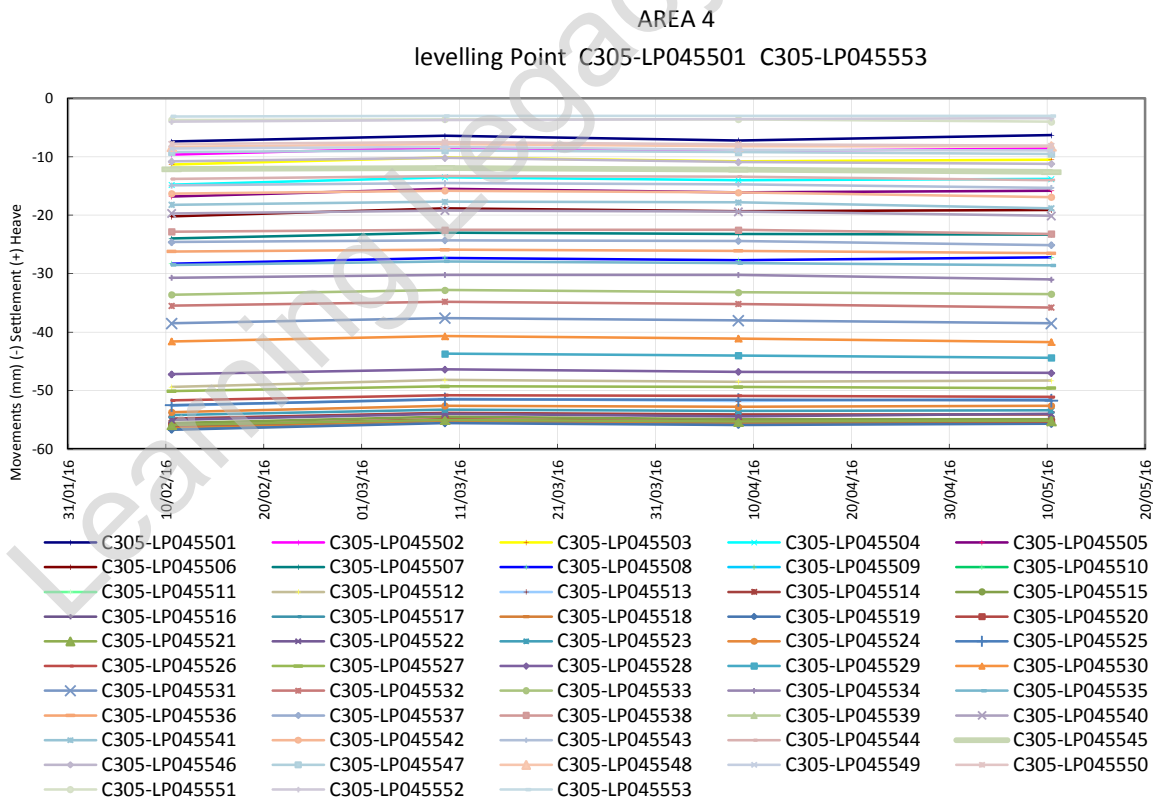
	Registered movement (mm)				mm/year
	10/02/2016	09/03/2016	08/04/2016	10/05/2016	
C305-LP045510	#N/A	#N/A	#N/A	#N/A	-
C305-LP045511	#N/A	#N/A	#N/A	#N/A	-
C305-LP045512	-49.40	-48.20	-48.50	-48.30	3.569
C305-LP045513	-52.60	-51.40	-51.80	-51.40	3.829
C305-LP045514	-54.80	-53.80	-54.10	-54.10	2.108
C305-LP045515	-55.60	-54.50	-54.90	-54.90	1.978
C305-LP045516	-56.10	-55.00	-55.40	-55.50	1.605
C305-LP045517	-56.40	-55.20	-55.60	-55.60	2.335
C305-LP045518	-56.30	-55.20	-55.50	-55.50	2.465
C305-LP045519	-56.70	-55.60	-55.90	-55.70	3.212
C305-LP045520	-56.00	-54.90	-55.30	-55.30	1.978
C305-LP045521	-55.90	-55.00	-55.30	-55.20	2.125
C305-LP045522	-55.00	-54.00	-54.40	-54.00	3.115
C305-LP045523	-54.20	-53.30	-53.50	-53.40	2.612
C305-LP045524	-53.70	-52.60	-52.80	-52.60	3.699
C305-LP045525	-52.50	-51.50	-51.60	-51.70	2.709
C305-LP045526	-51.70	-50.80	-50.90	-51.10	1.979
C305-LP045527	-50.10	-49.30	-49.40	-49.60	1.622
C305-LP045528	-47.20	-46.40	-46.80	-47.00	0.160
C305-LP045529	#N/A	-43.70	-44.00	-44.40	-4.130
C305-LP045530	-41.60	-40.70	-41.10	-41.70	-0.976
C305-LP045531	-38.50	-37.60	-38.00	-38.50	-0.603
C305-LP045532	-35.50	-34.80	-35.20	-35.80	-1.690
C305-LP045533	-33.60	-32.80	-33.20	-33.50	-0.213
C305-LP045534	-30.70	-30.20	-30.20	-31.00	-1.202
C305-LP045535	-28.50	-27.90	-28.20	-28.60	-0.813
C305-LP045536	-26.20	-25.90	-26.10	-26.50	-1.397
C305-LP045537	-24.60	-24.30	-24.40	-25.10	-2.030
C305-LP045538	-22.80	-22.50	-22.50	-23.20	-1.543
C305-LP045539	#N/A	#N/A	#N/A	#N/A	-
C305-LP045540	-19.70	-19.20	-19.40	-20.10	-1.803
C305-LP045541	-18.20	-17.70	-17.80	-18.80	-2.436
C305-LP045542	-16.30	-15.80	-16.10	-16.90	-2.664
C305-LP045543	-14.90	-14.50	-14.70	-15.30	-1.787
C305-LP045544	-13.80	-13.30	-13.40	-14.00	-0.943
C305-LP045545	-12.10	-11.90	-12.20	-12.60	-2.241
C305-LP045546	-10.80	-10.20	-10.90	-11.20	-2.389

	Registered movement (mm)				mm/year
	10/02/2016	09/03/2016	08/04/2016	10/05/2016	
C305-LP045547	-9.20	-8.90	-9.20	-9.50	-1.511
C305-LP045548	-8.30	-7.80	-8.20	-8.20	-0.164
C305-LP045549	-8.60	-8.30	-8.80	-8.90	-1.738
C305-LP045550	-7.80	-7.50	-7.90	-8.10	-1.625
C305-LP045551	-3.70	-3.60	-3.60	-4.00	-1.137
C305-LP045552	-4.00	-3.70	#N/A	-3.40	2.326
C305-LP045553	-3.10	-3.00	#N/A	-3.00	0.339
	Rate less than -2.5 mm/year		% less 2 mm/ year		95.9%
	Rate greater than -3.5 mm/year		% less 3 mm/ year		97.9%

Note: All the movements are in mm. (-) Settlement / (+) Heave

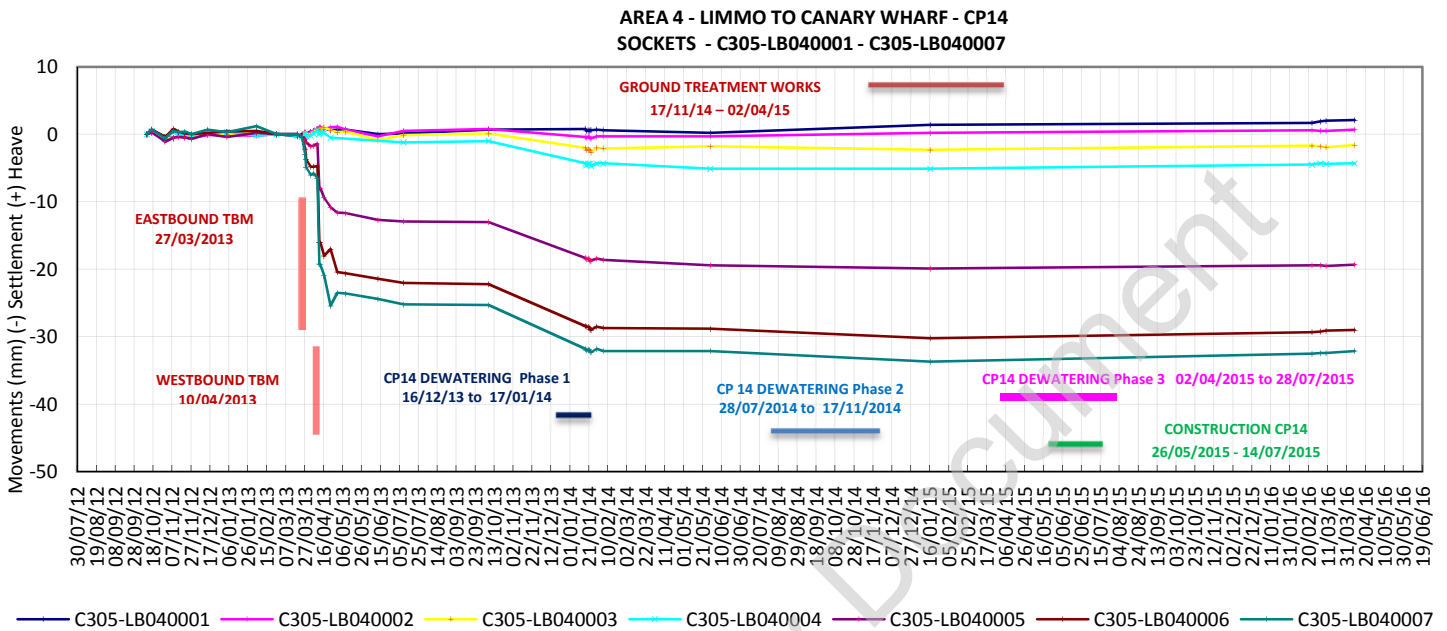
The percentage of levelling points with a settlement rate less than 2 mm/year is 95.9%, whereas 97.9% are less than 3 mm/year.

The plot below shows the trend line adjustment for the levelling points in this array.



SOCKETS

C305-LB040001 - C305-LB040007



The graph above shows a maximum settlement of -7 mm after the eastbound TBM transit and -25 mm after westbound transit. A total maximum settlement of -34 mm was recorded during CP14 works.

To analyse whether the rate of change in the data has reached an acceptably small rate, the last four readings were used to calculate the annual projection.

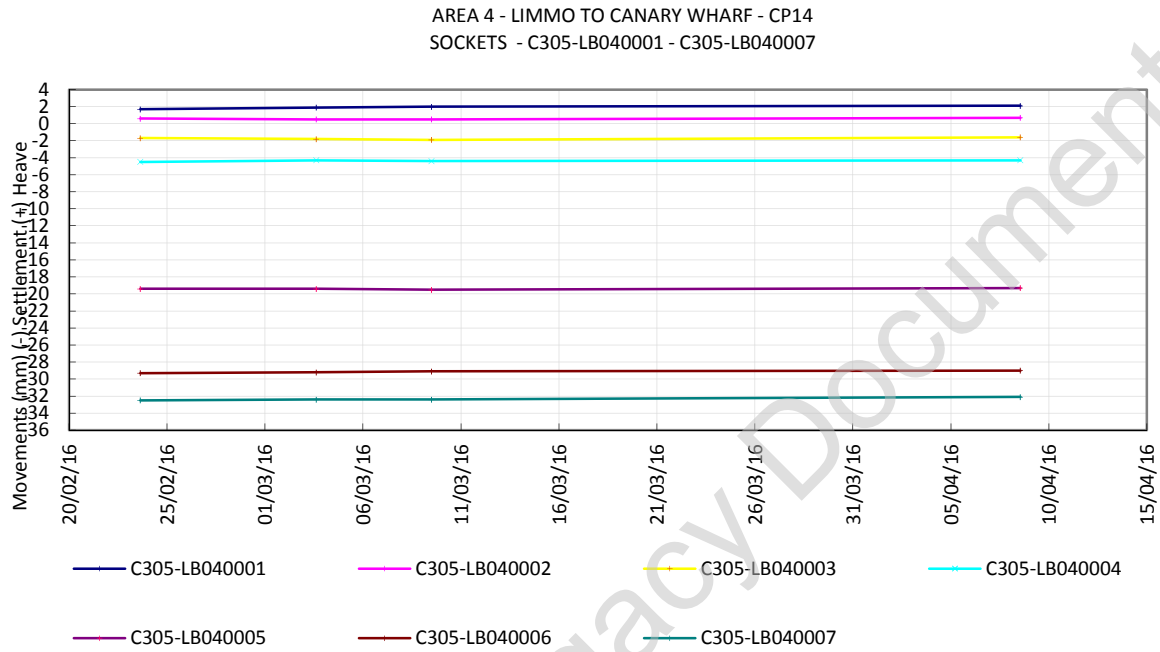
The table below shows the annual rate for the sockets in this array.

	Registered movement (mm)				mm/year
	23/02/2016	03/03/2016	09/03/2016	08/04/2016	
C305-LB040001	1.70	1.90	2.00	2.10	2.810
C305-LB040002	0.60	0.50	0.50	0.70	1.229
C305-LB040003	-1.70	-1.80	-1.90	-1.60	1.304
C305-LB040004	-4.50	-4.30	-4.40	-4.30	1.179
C305-LB040005	-19.40	-19.40	-19.50	-19.30	0.965
C305-LB040006	-29.30	-29.20	-29.10	-29.00	2.258
C305-LB040007	-32.50	-32.40	-32.40	-32.10	3.223
	Rate less than -2.5 mm/year			% less 2 mm/ year	100%
	Rate greater than -3.5 mm/year			% less 3 mm/ year	100%

Note: All the movements are in mm. (-) Settlement / (+) Heave

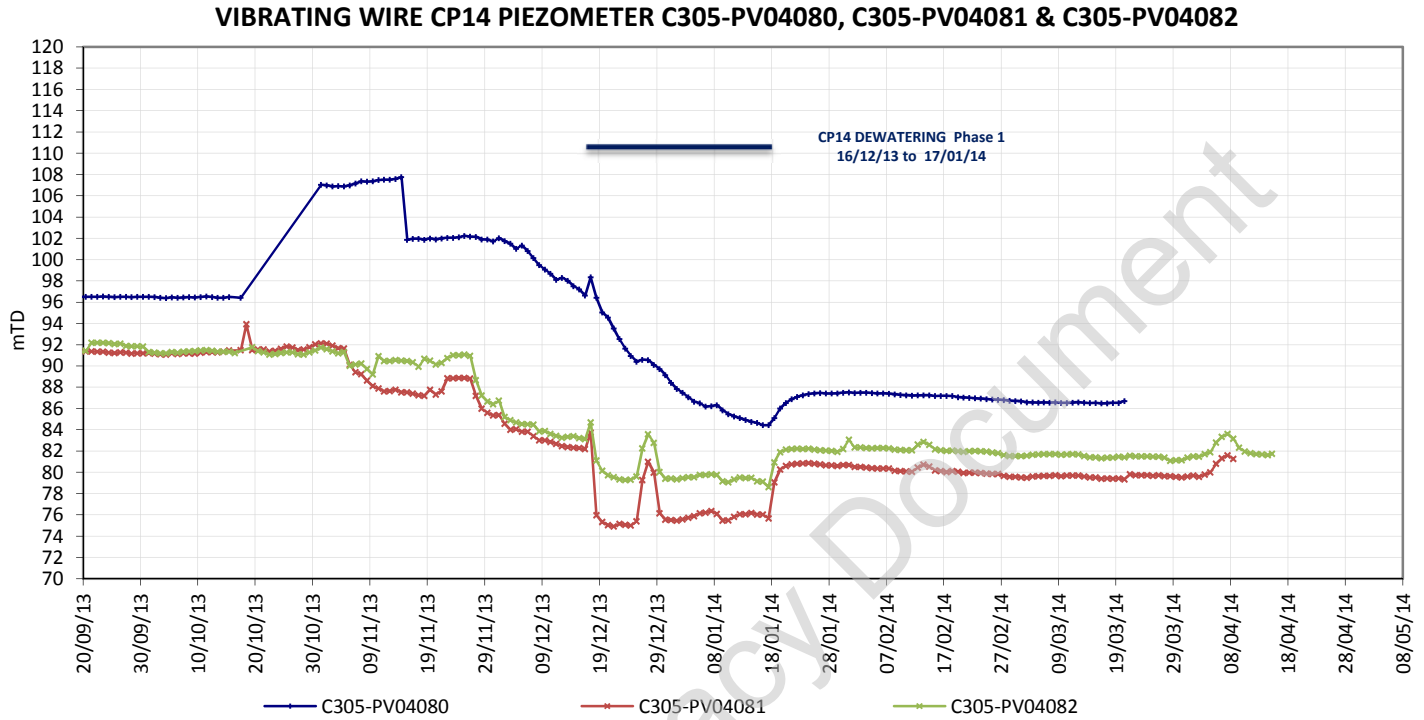
The percentage of levelling points with a settlement rate less than 2 mm/year is 100%, whereas 100% are less than 3 mm/year.

The plot below shows the trend line adjustment for the sockets in this array.



VIBRATING WIRE PIEZOMETERS

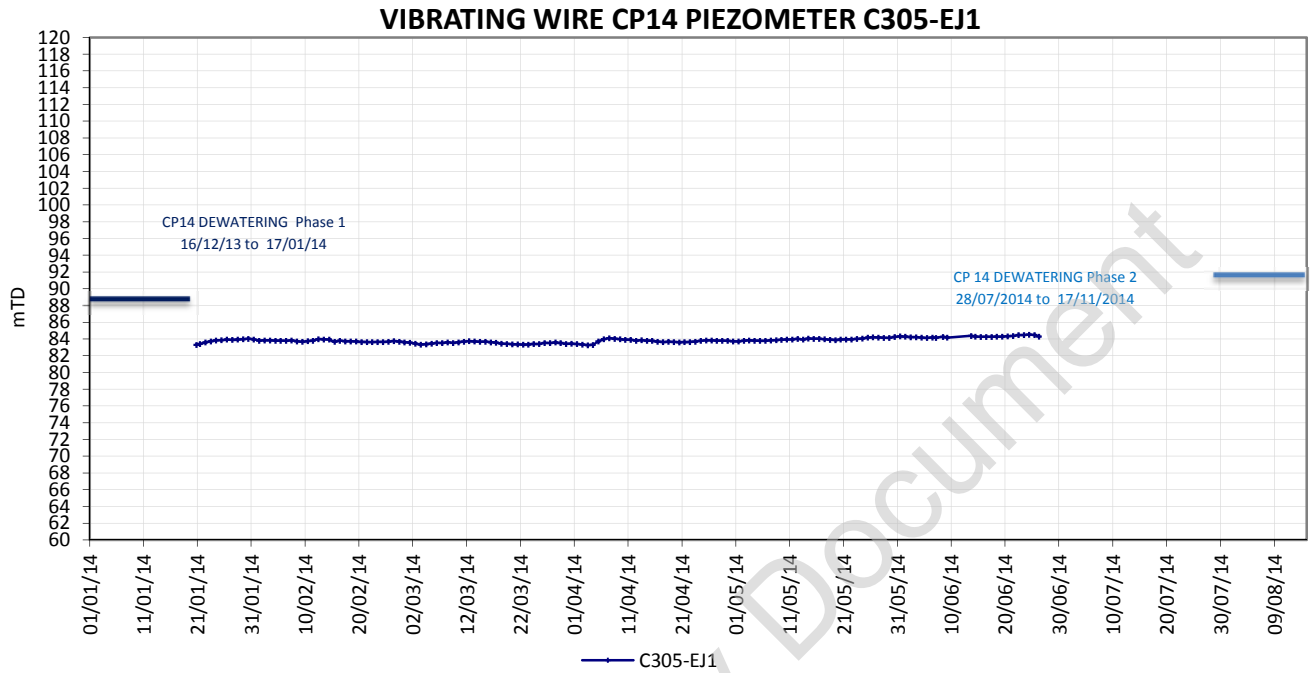
C305-PV04080, C305-PV04081 & C305-PV04082



The piezometers included in the graph above were used to monitor CP14 Phase 1 dewatering.

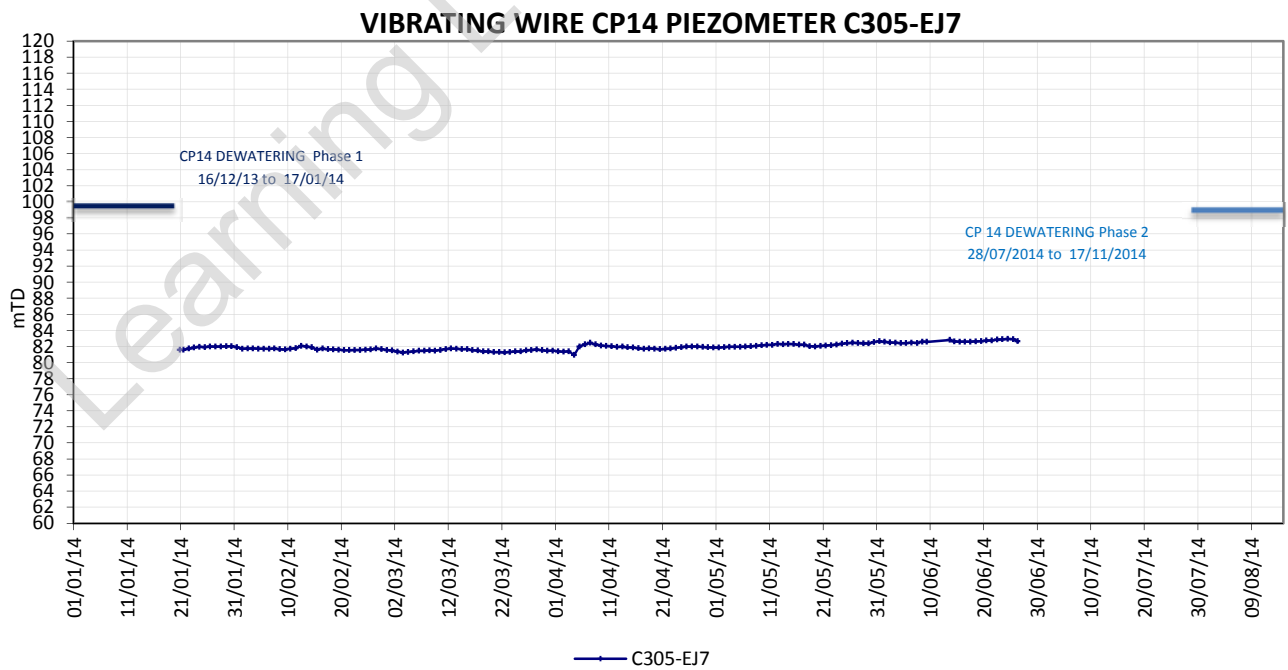
After initial testing period (October – November 2013), the ground water level for the above piezometers shows a drop when the dewatering (phase1) at CP14 started; -18 m for C305-PV04080, -16 m for C305-PV04081 and -13 m for C305-PV04082 respectively. After dewatering (phase 1) the water level recovered to 86.71 m (C305-PV04080), 81.27 m (C305-PV04081) and 81.74 m (C305-PV04082) respectively.

C305-EJ1



This piezometer was used to monitor the time period between CP14 Phase 1 and Phase 2 dewatering. The graph above shows a steady water level at 84.29 m.

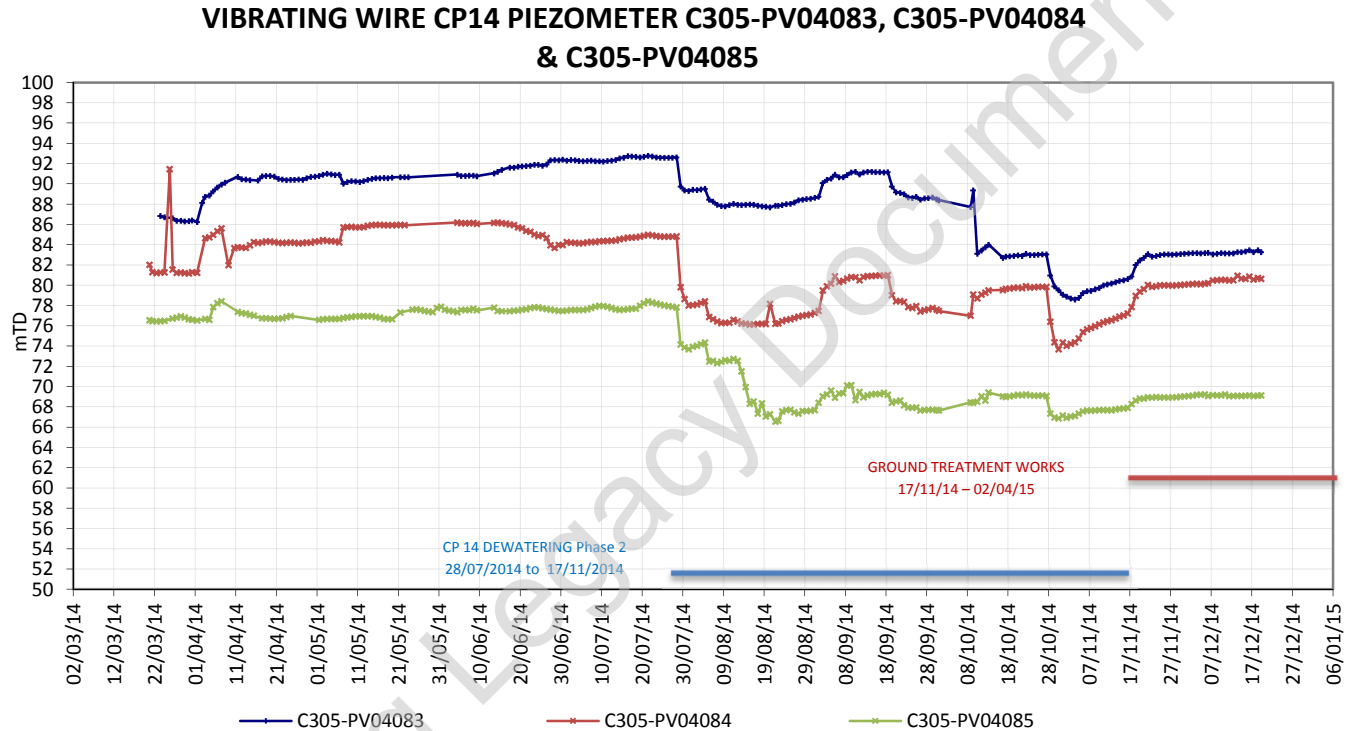
C305-EJ7



This piezometer was used to monitor the time period between CP14 Phase 1 and Phase 2 dewatering.

The graph above shows a steady water level at 82.67 m.

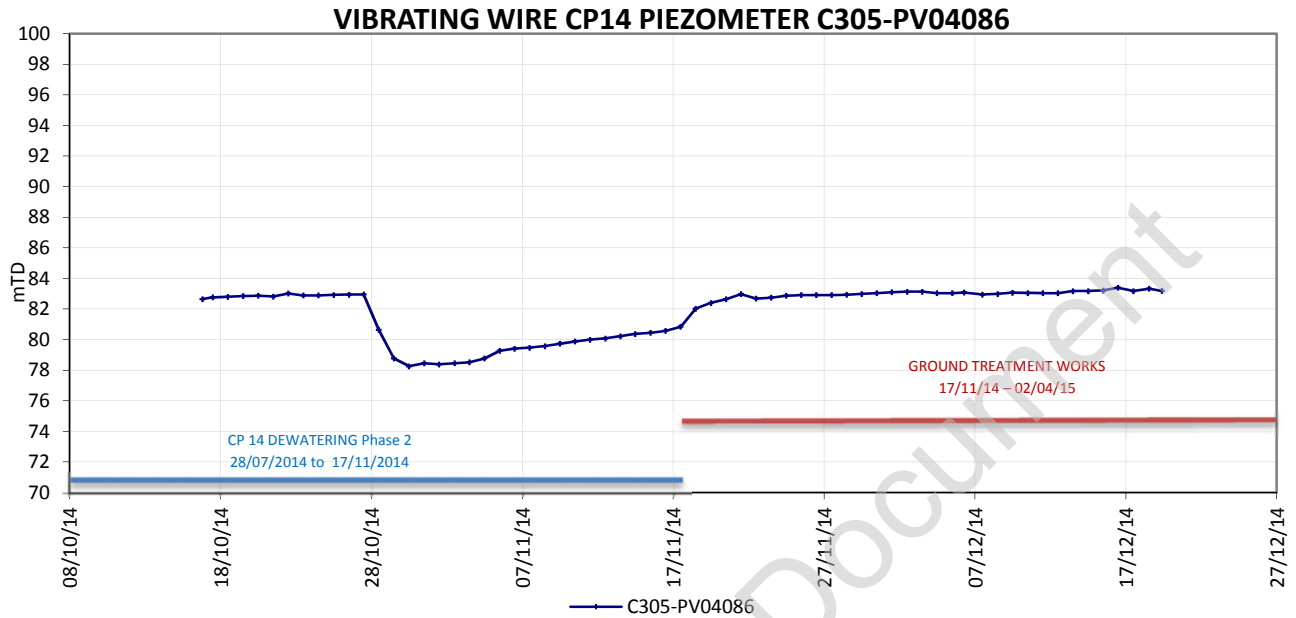
C305-PV04083, C305-PV04084 & C305-PV04085



The piezometers included in the graph above were used to monitor CP14 Phase 2 dewatering and were damaged by the ground treatment works.

The graph above shows a drop in the water level for the above piezometers when the dewatering (phase 2) at CP14 started; -14 m for C305-PV04083, -11 m for C305-PV04084 and -10 m for C305-PV04085 respectively. After dewatering (phase 2) the water level recovered to 83.28 m (C305-PV04083), 80.62 m (C305-PV04084) and 69.12 m (C305-PV04085) respectively.

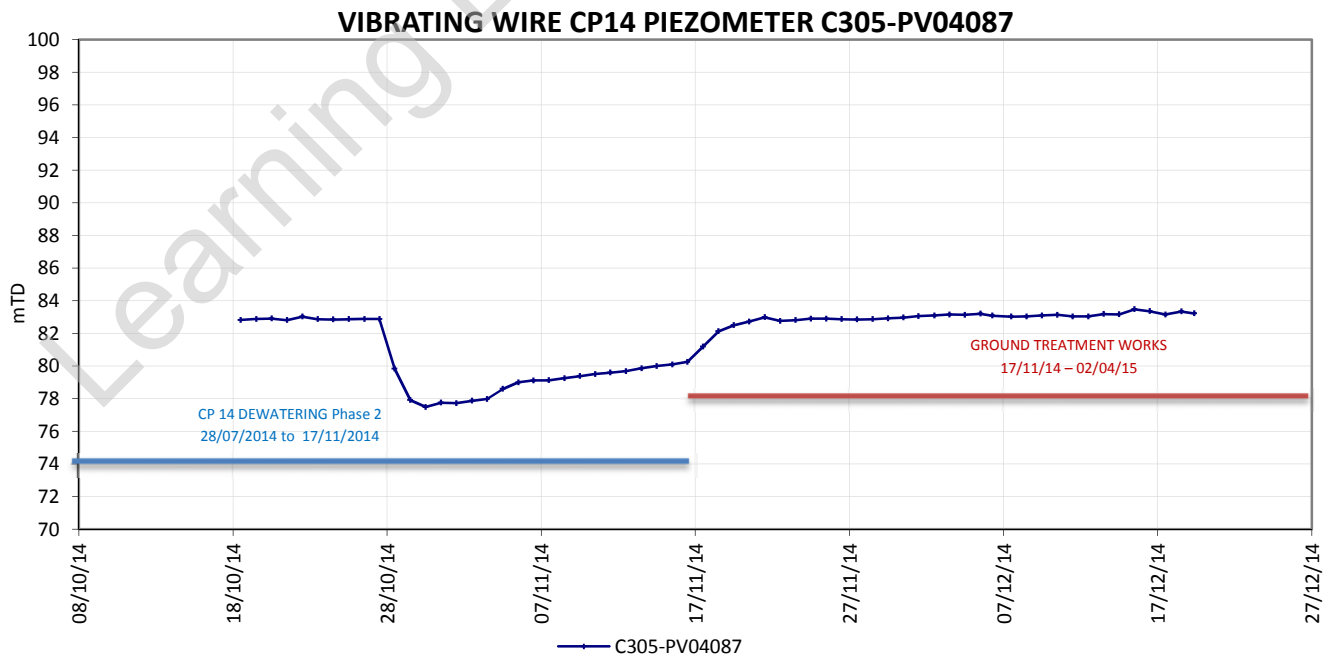
C305-PV04086



This piezometer was used to monitor CP14 Phase 2 dewatering and was damaged by the ground treatment works.

The graph above shows a drop in the water level (-5 m) during the dewatering (phase 2) of CP14. After dewatering (phase 2) the water level recovered to 83.19 m.

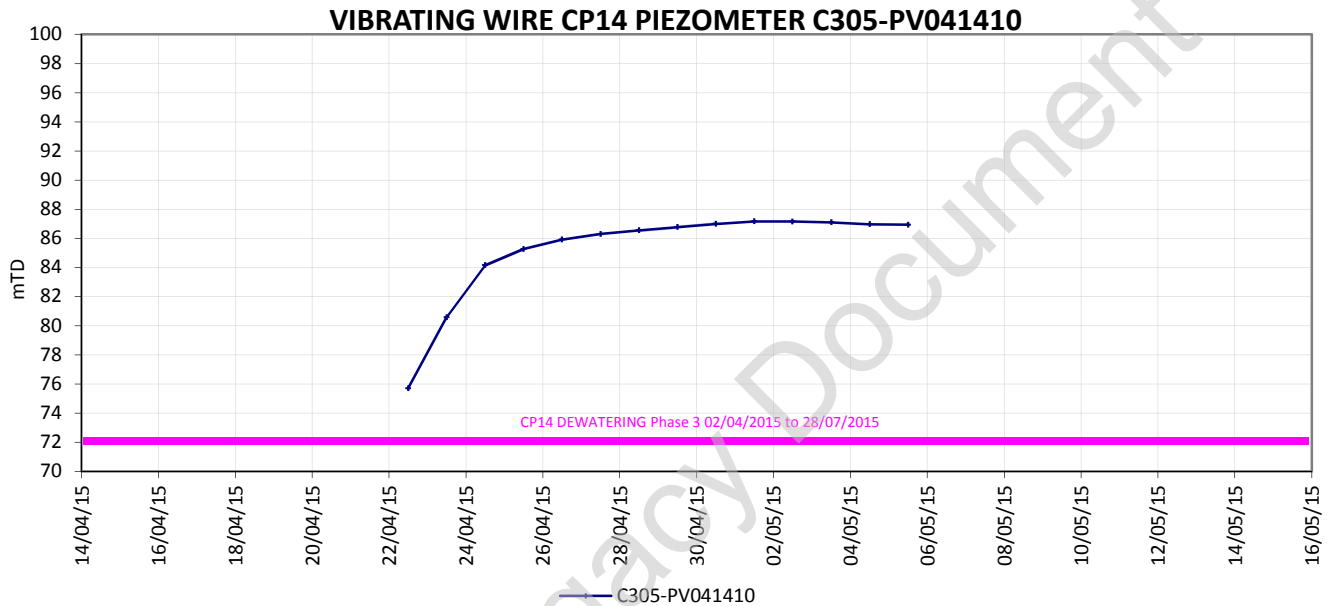
C305-PV04087



This piezometer was used to monitor CP14 Phase 2 dewatering and was damaged by the ground treatment works.

The graph above shows a drop in the water level (-6 m) during the dewatering (phase 2) of CP14. The water level recovered to 83.22 m.

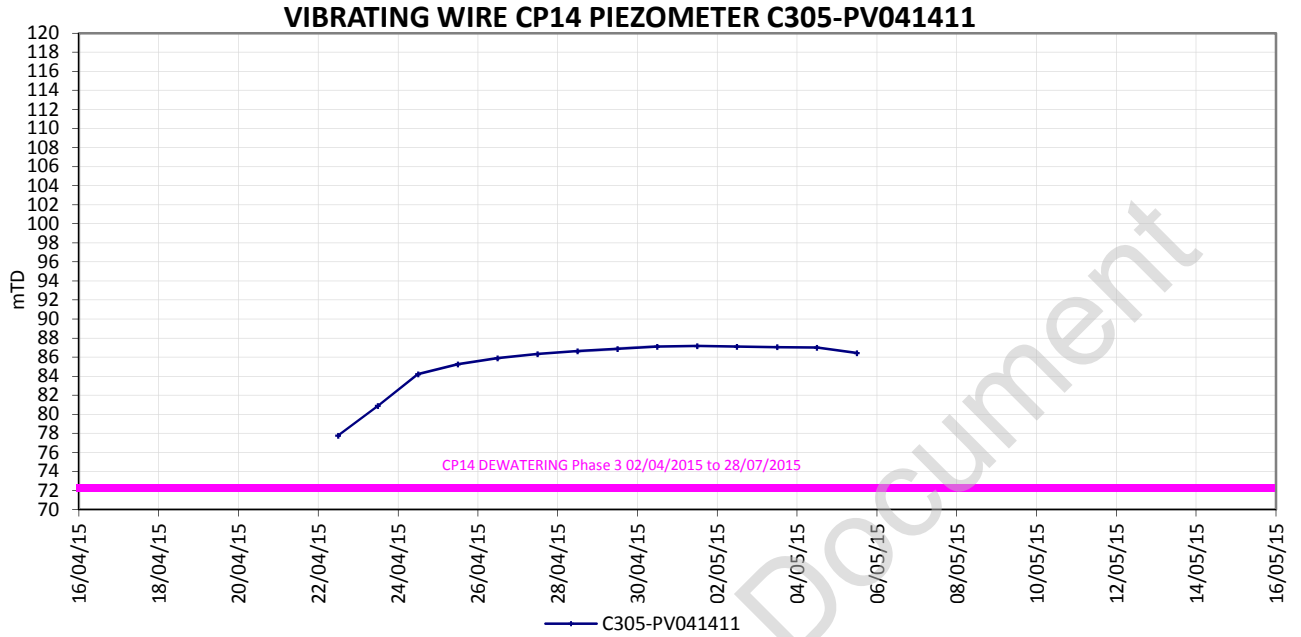
C305-PV041410



This piezometer was used to monitor the ground water level recovery test that was carried out in C305-EJ14 during CP14 Phase 3 dewatering.

The graph above shows a progressive rise in the water level (+12 m) during CP14 dewatering (phase 3).

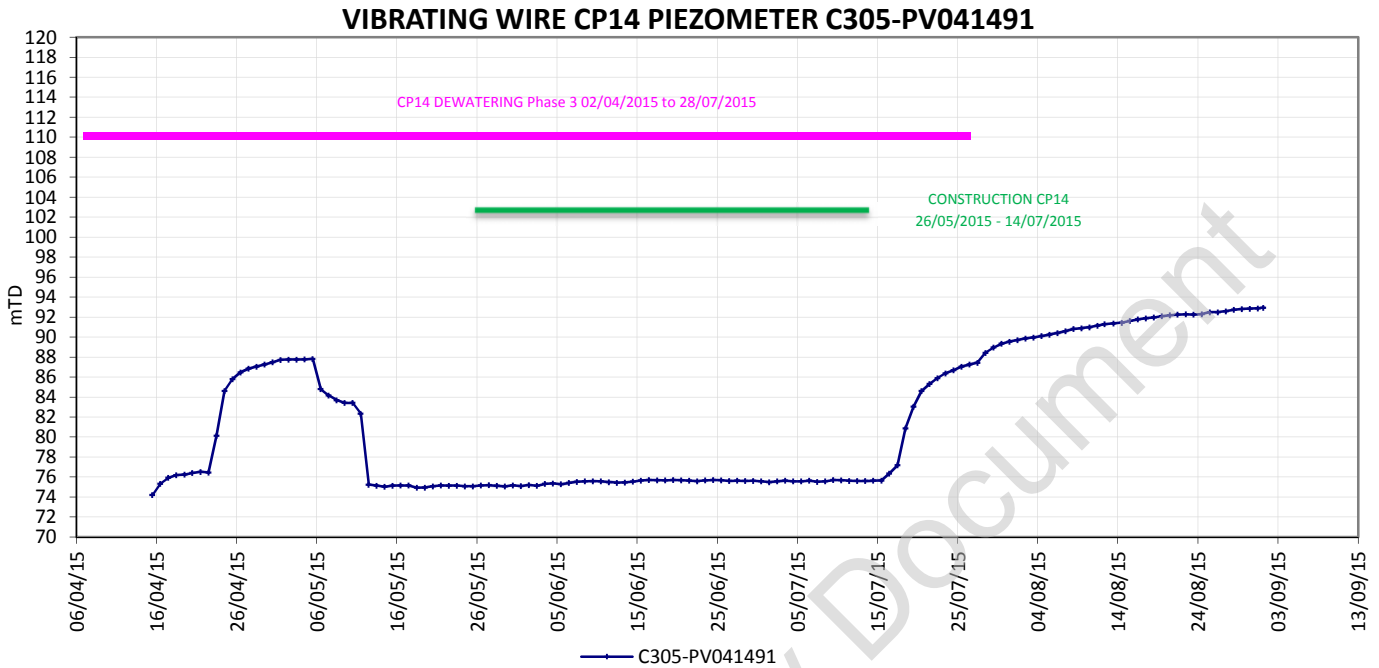
C305-PV041411



This piezometer was used to monitor the ground water level recovery test that was carried out in C305-EJ1 during CP14 Phase 3 dewatering.

The graph above shows a progressive rise in the water level (+9 m) during CP14 dewatering (phase 3).

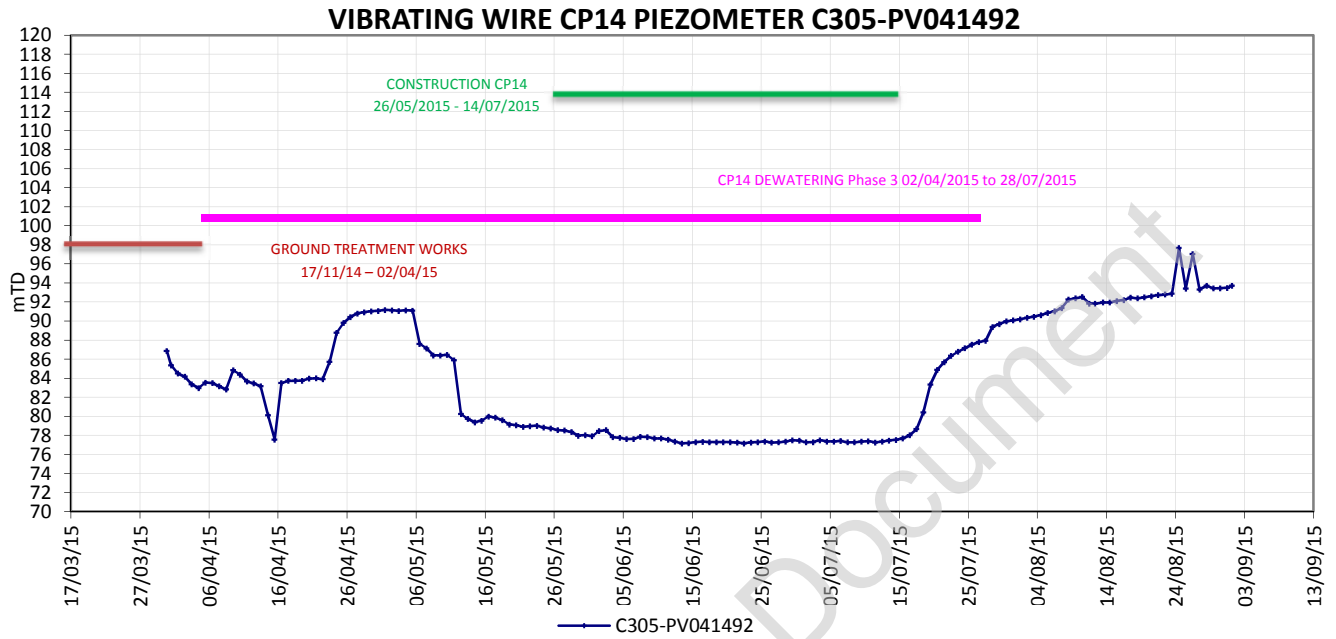
C305-PV041491



This piezometer was used to monitor CP14 Phase 3 dewatering and CP14 construction.

After initial testing period (April – May 2015), the ground water level for the above piezometer shows a steady level at 75m during CP14 works and a progressive rise in the water level (+18 m) after completion of CP14 works. The water level recovered to 92.94 m.

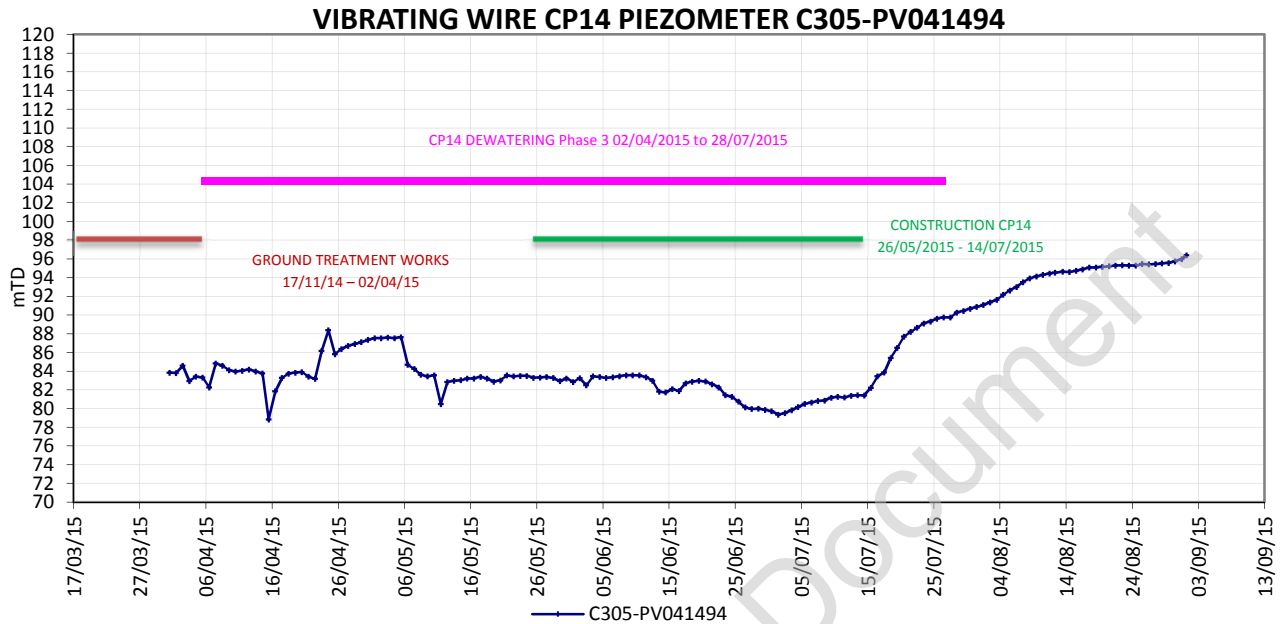
C305-PV041492



This piezometer was used to monitor CP14 Phase 3 dewatering and CP14 construction.

After initial testing period (April – May 2015), the ground water level for the above piezometer shows a steady level at 77 m during CP14 works and a progressive rise in the water level (+16 m) after completion of CP14 works. The water level recovered to 93.7 m.

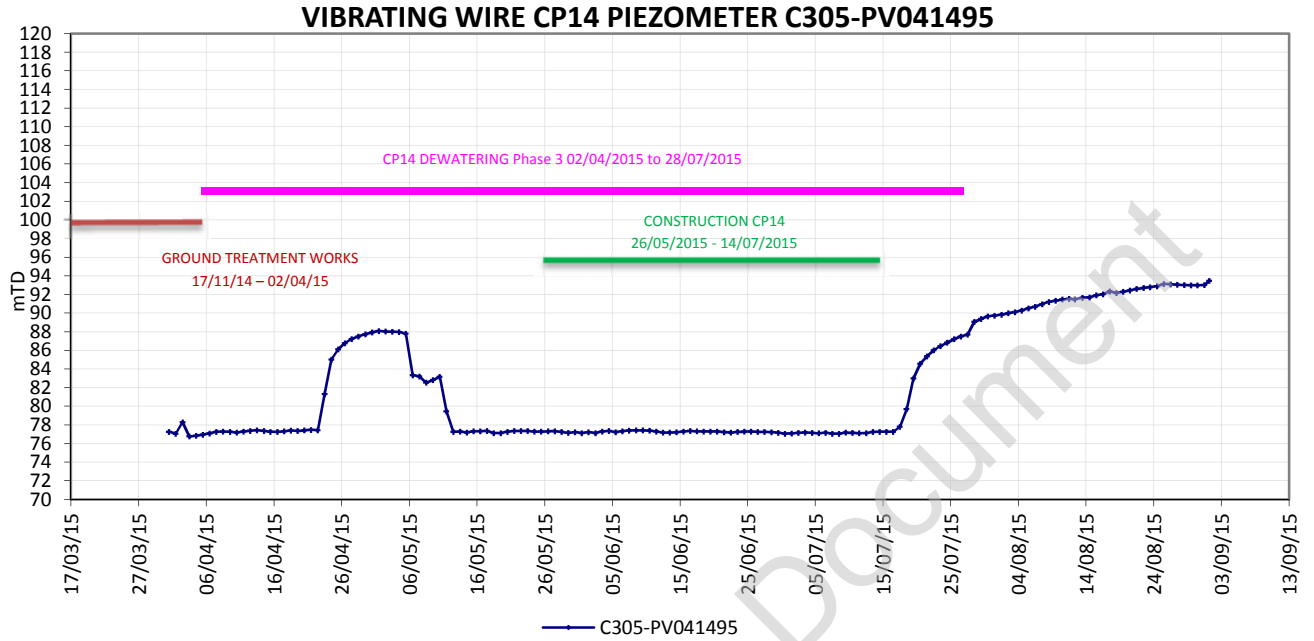
C305-PV041494



This piezometer was used to monitor CP14 Phase 3 dewatering and CP14 construction.

After initial testing period (April – May 2015), the ground water level for the above piezometer shows a ranges between 80 m and 83 m. The graph above shows a progressive rise in the water level (+15 m) after completion of CP14 works. The water level recovered to 96.4 m.

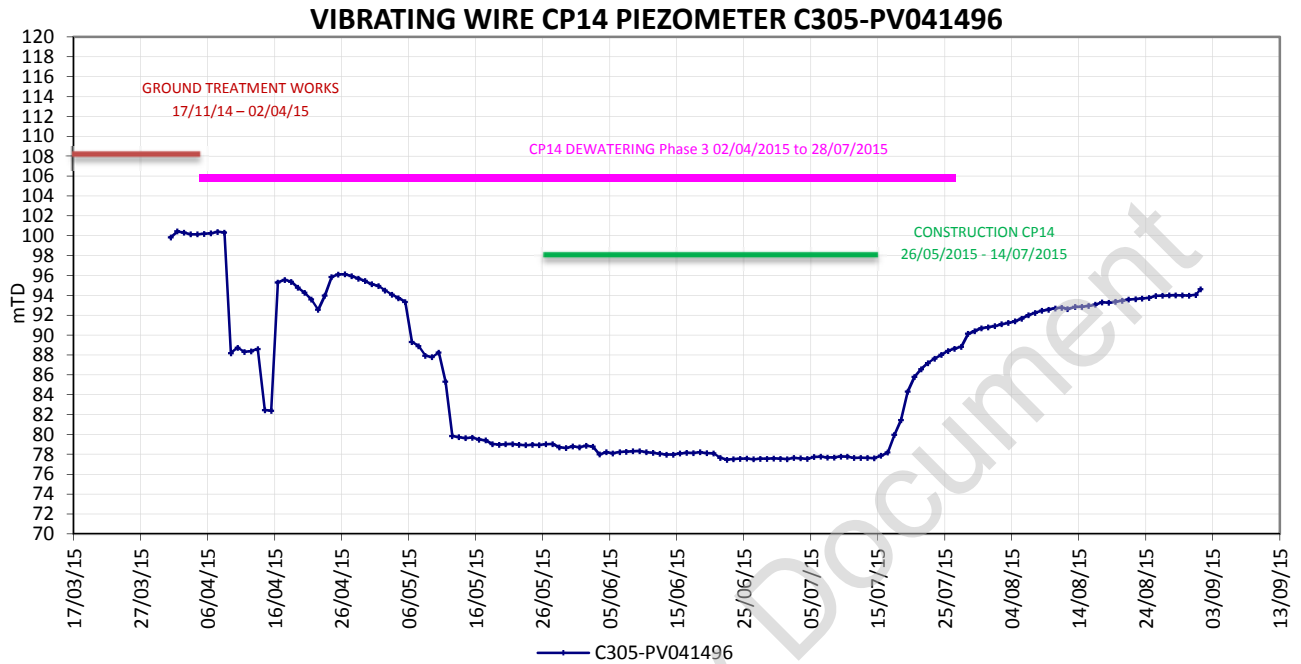
C305-PV041495



This piezometer was used to monitor CP14 Phase 3 dewatering and CP14 construction.

After initial testing period (April – May 2015), the ground water level for the above piezometer shows a steady level at 77 m during CP14 works and a progressive rise in the water level (+15 m) after completion of CP14 works. The water level recovered to 93.47 m.

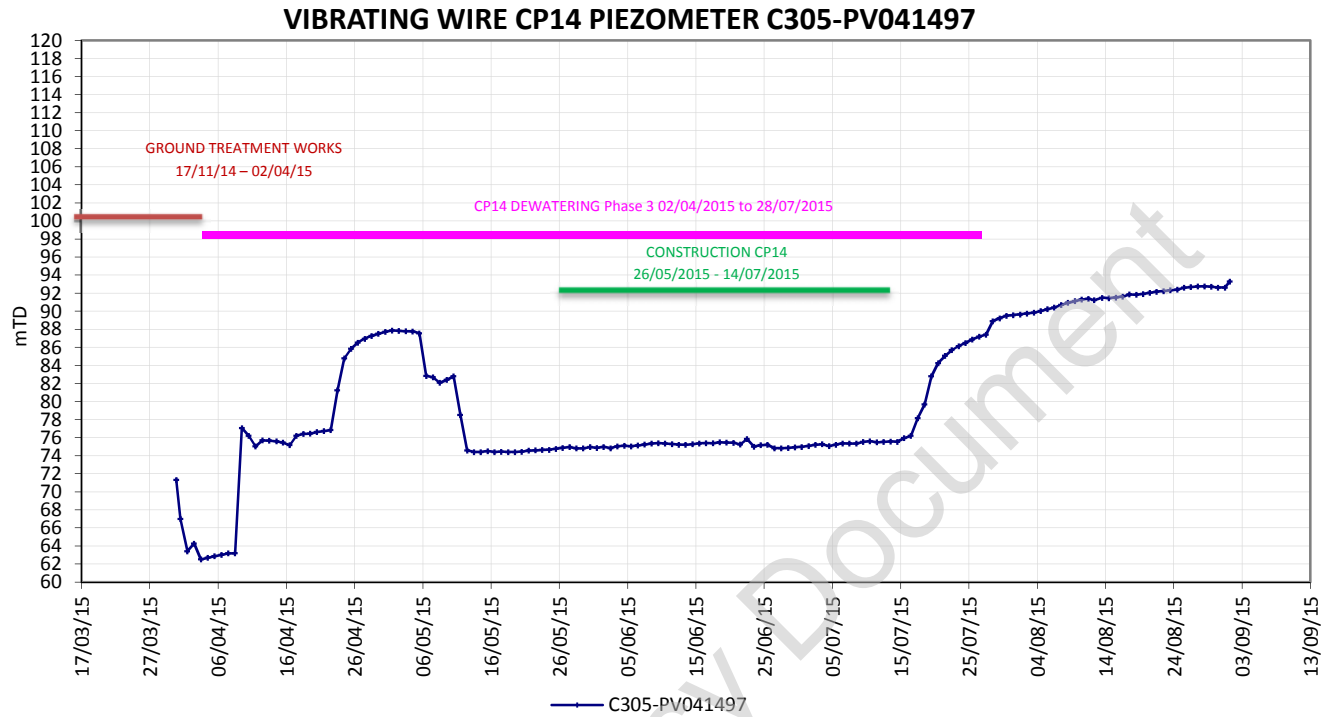
C305-PV041496



This piezometer was used to monitor CP14 Phase 3 dewatering and CP14 construction.

After initial testing period (April – May 2015), the ground water level for the above piezometer shows a steady level at 78 m during CP14 works and a progressive rise in the water level (+16 m) after completion of CP14 works. The water level recovered to 94.63 m.

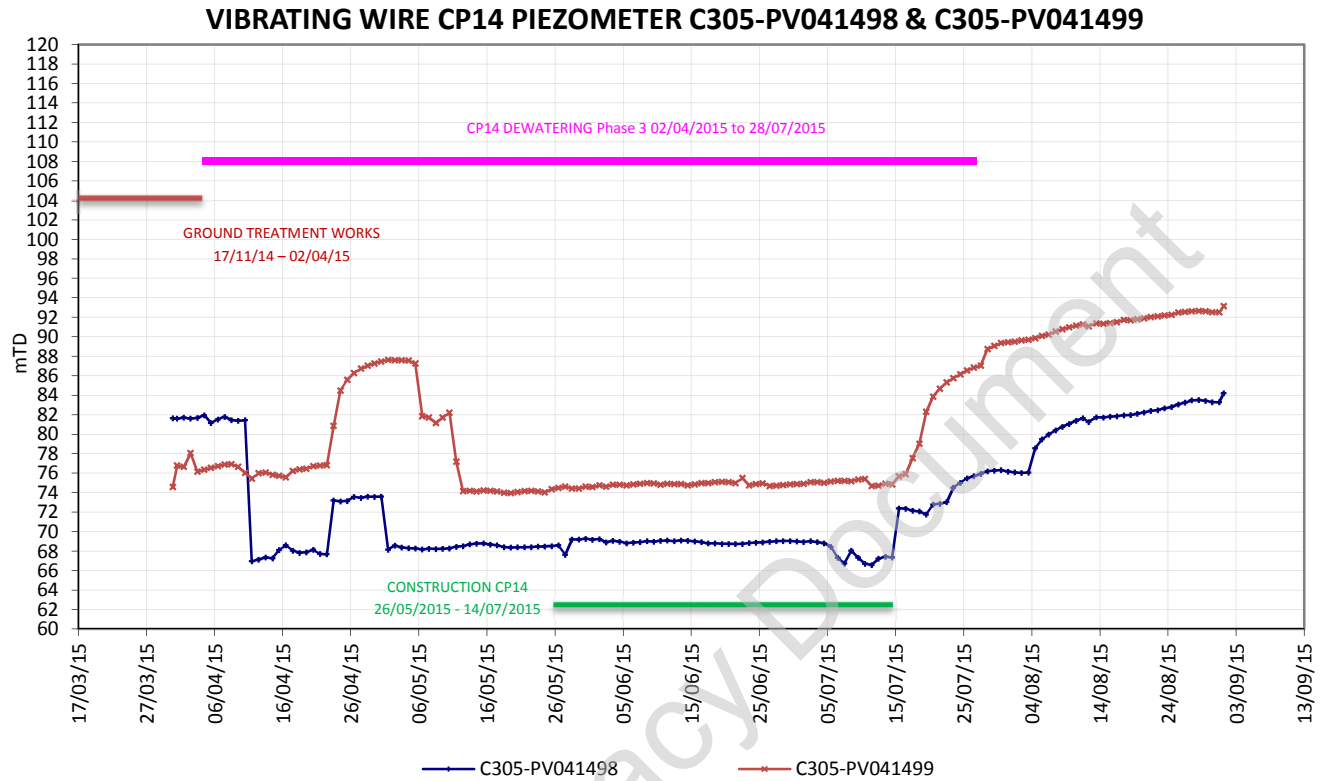
C305-PV041497



This piezometer was used to monitor CP14 Phase 3 dewatering and CP14 construction.

After initial testing period (April – May 2015), the ground water level for the above piezometer shows a steady level at 75 m during CP14 works and a rise (+18 m) after completion of CP14 works. The water level recovered to 93.28 m.

C305-PV041498 & C305-PV041499



The piezometers included in the graph above were used to monitor CP14 Phase 3 dewatering and CP14 construction.

After initial testing period (April – May 2015), the ground water level for the above piezometers shows a steady level at 69 m for C305-PV041498 and 75 m for C305-PV041499 during CP14 works. There was a rise in the water level after completion of CP14 works; +17 m for C305-PV041498 and +19 m for C305-PV041499 respectively. The water level recovered to 84.21 m (C305-PV041498) and 93.15 m (C305-PV041499) respectively.

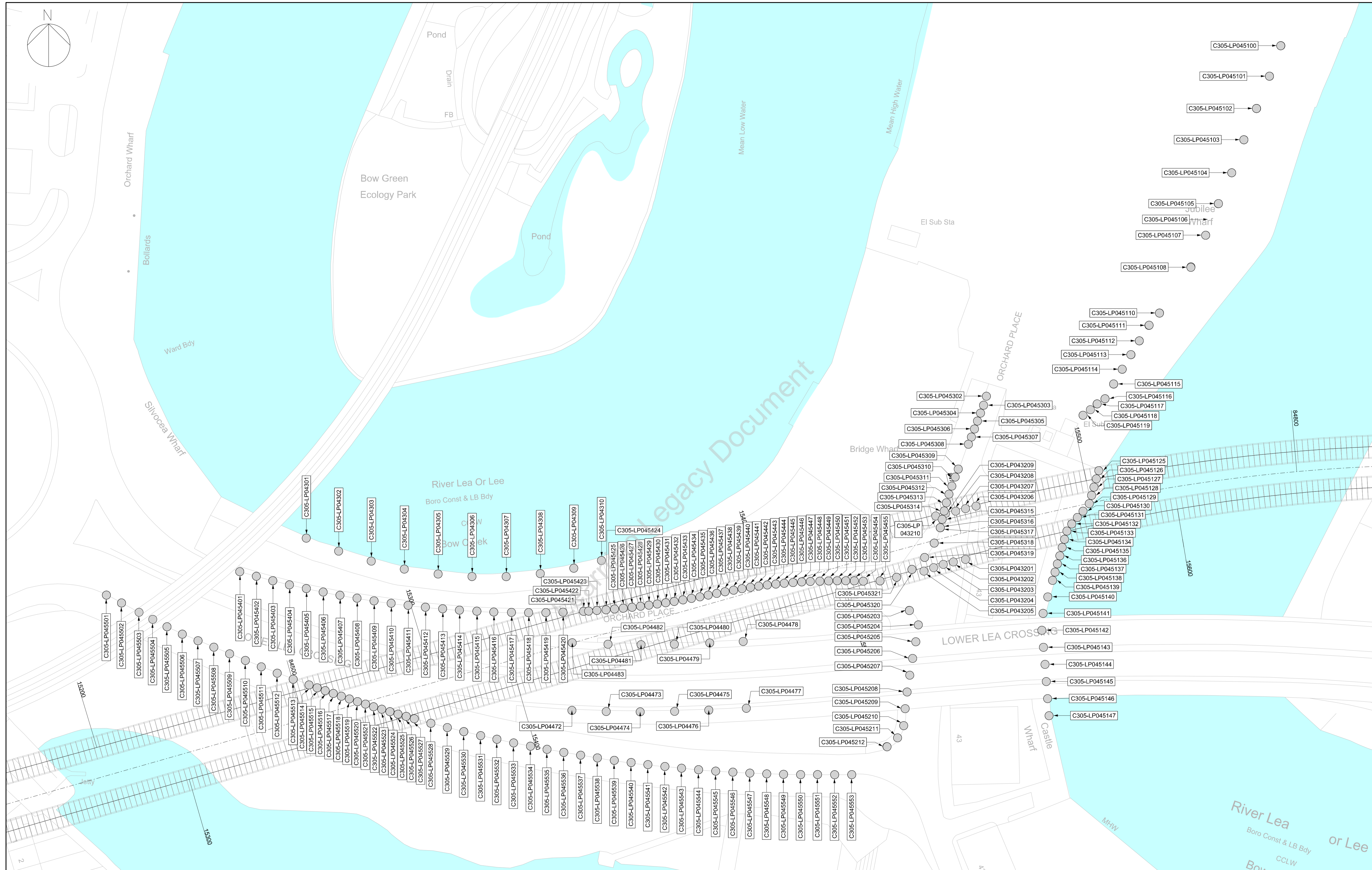
8. SUMMARY STATEMENT

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 trend of the monitoring points was approaching or had achieved the specified 2mm/year settlement rate.

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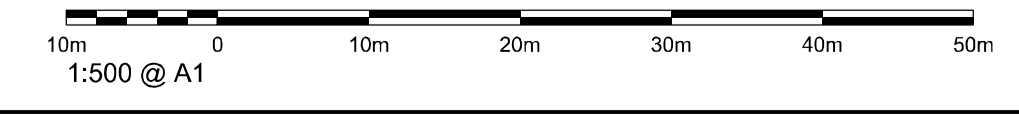
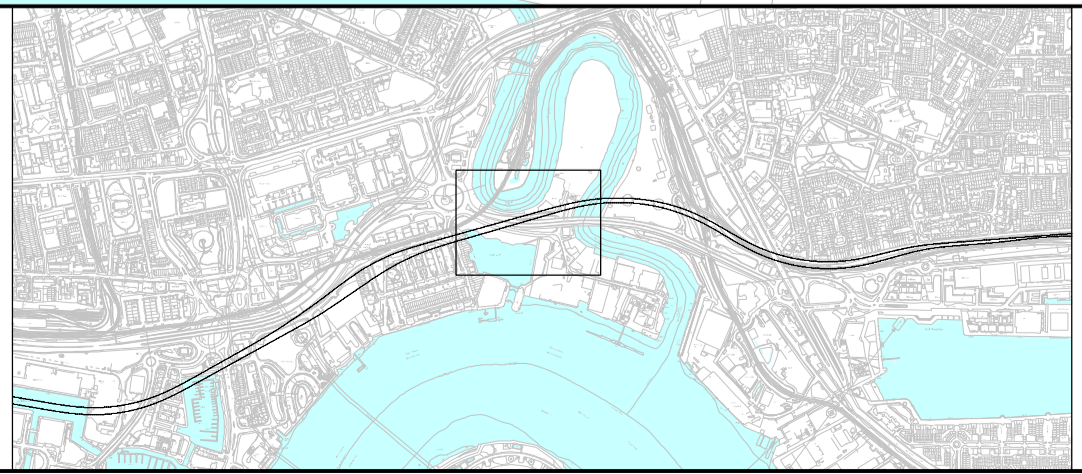
**APPENDIX A:
INSTRUMENT LOCATION**



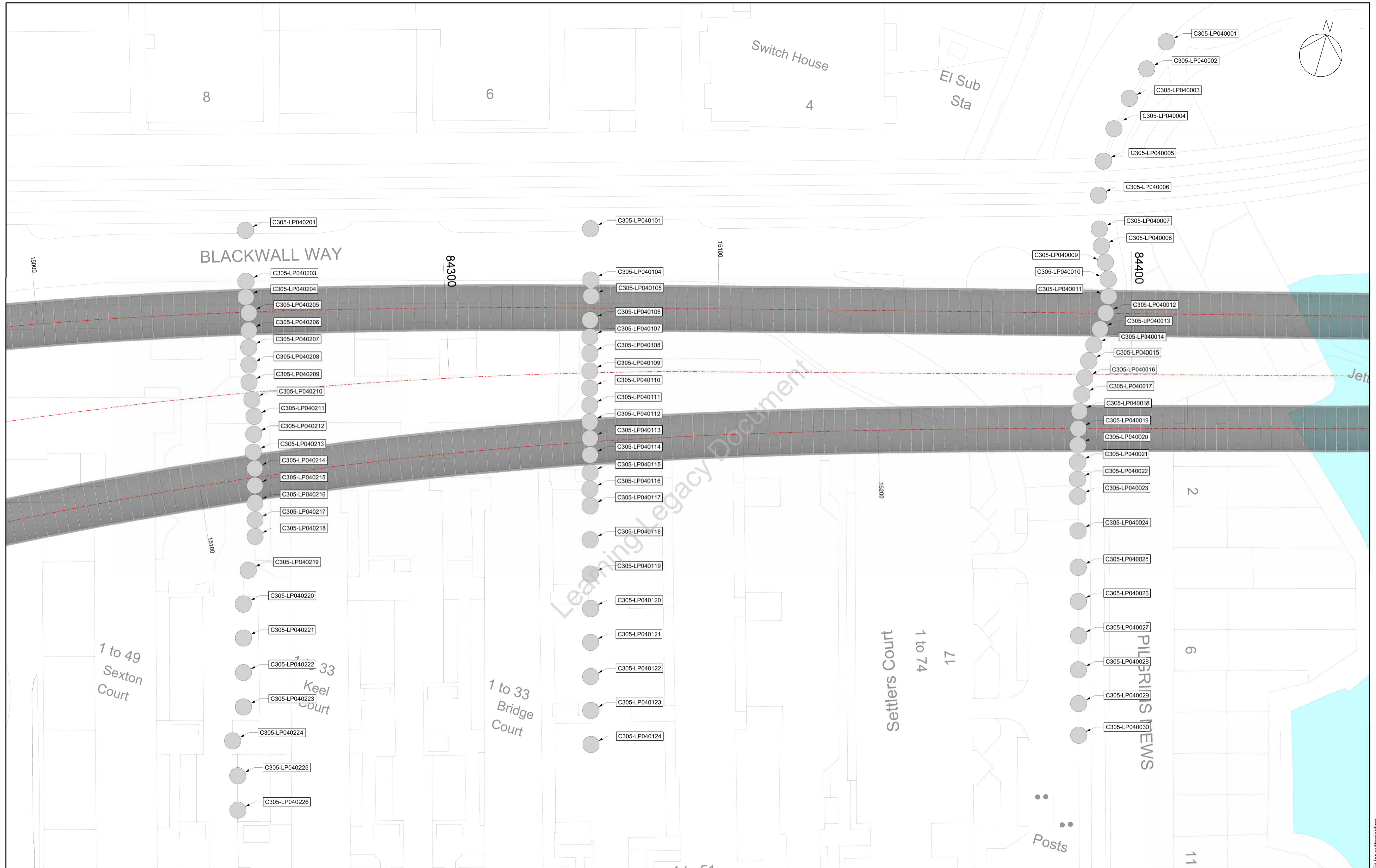
Rev.	Date	Description	By	Chkd	App	Auth
P01	13/08/2015	First Issue	MD	RC	RC	-
P02	08/10/2015		MD	RC	RC	-
P03	25/04/2016		MD	MD	MD	-

Notes

- Levelling Point



<p>Crossrail Limited 25 Canada Square Canary Wharf London E14 6LQ</p> <p>© Crossrail www.crossrail.co.uk</p>	<p>Contract: Tunnels East - Drive Y LIM to FAR & Drive Z SGJ to PML & Drive G</p> <p>Originator: Dragados Sisk Joint Venture</p> <p>Location: Crossrail Tunnels - Drive Y (Limmo Peninsula to Farringdon Stn)</p>	<p>Title: Instrumentation & Monitoring Installation Report for Lower Lea Crossing Bridge Area and Abutment Wall (Drive Y)</p> <p>C305-DSJ-C2-RGN-CRG03-502092</p>	<p>By: M.DAVIS</p> <p>CHK: M.DAVIS</p> <p>App: M.DAVIS</p> <p>Auth: ...</p>	
	<p>Scale: 1:500 @ A1</p>	<p>Drawing and CAD file No: C305-DSJ-C2-DDA-CRT00_ST006_Z-08108</p>	<p>Rev: P03</p>	<p>Suitability: S4</p>
	<p>www.crossrail.co.uk</p>			
	<p>RESTRICTED</p>			

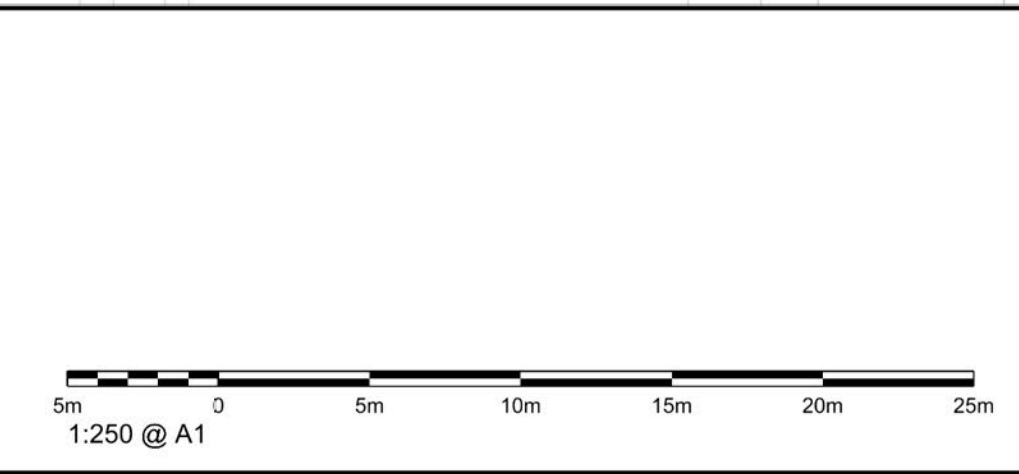


Rev.	Date	Description	By	Chkd	App	Auth
P01	23/04/2015	First Issue	MD	RC	RC	-
P02	25/08/2015	---	MD	RC	RC	-
P03	14/01/2016	---	MD	MD	MD	-

Notes

- Levelling Point

Learning Legacy Document



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)

Crossrail
 Crossrail Limited
 25 Canada Square
 Canary Wharf
 London
 E14 5LQ

Title: Instrumentation & Monitoring
 Installation Report for I&M Studs Installation
 East India to Canary Wharf (84400-84350)
 C305-DSJ-C-GMS-CR143-50011

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_1-08137
 Rev: P03
 Stability: S4

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Fit for authorisation
RESTRICTED



Rev.	Date	Description	By	Chkd	App	Auth
P01	22/01/2015	First Issue	AH	AH	RC	-
P02	18/03/2015	---	MD	AH	RC	-

Notes

○ Levelling Socket



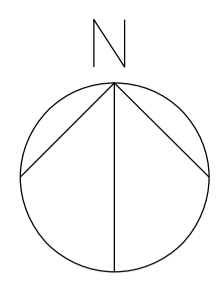
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Canary Wharf
London
E14 5LQ

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Contract: Tunnels East - Drive Y LIM to FAR & Drive Z SGJ to PML & Drive G		By: M.DAVIS	
Originator: Dragados Sisk Joint Venture		CHK: A.HAWES	
Location: Crossrail Tunnels - Drive Y (Limmo Peninsula to Farringdon Stn)		App: R.CULLEN	
Title: Instrumentation & Monitoring Installation Report for I&M MS Sockets Pilgrims Mews (84400-84500) C305-DSJ-C2-GMS-CRG03-50017		Auth: ---	
Scale: 1:200 @ A1	Drawing and CAD file No: C305-DSJ-C2-DDA-CRT00_ST006_Z-08100	Rev: P02	Suitability: S4

S:PDY/S

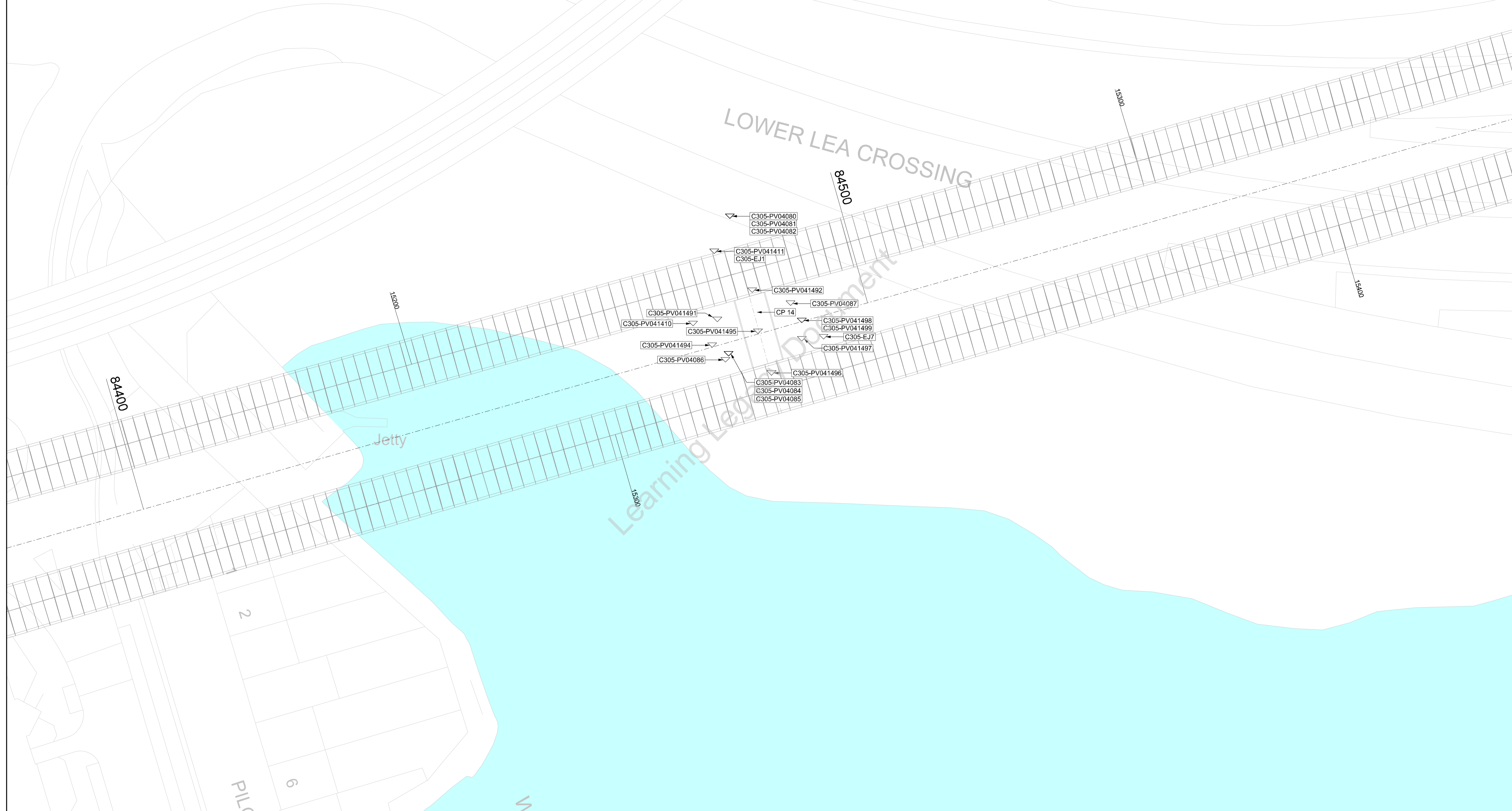
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OUTH ROAD

CCLW
Bow Creek

LOWER LEA CROSSING

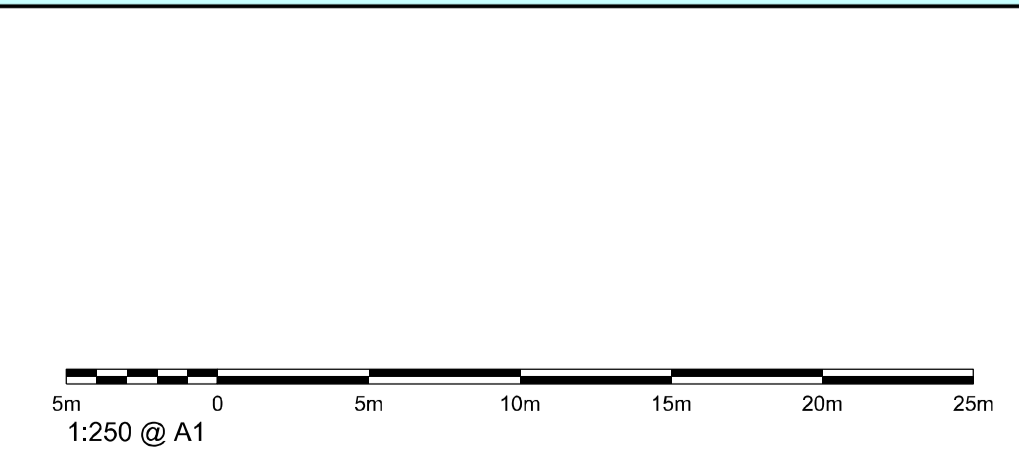
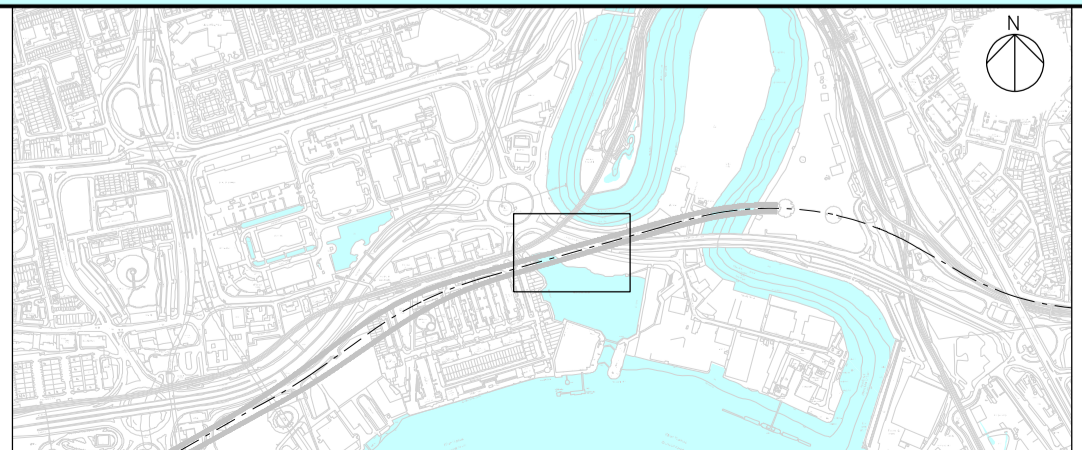


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Rev.	Date	Description	By	Chkd	App	Auth
P01	18/04/2016	First Issue	MD	MD	MD	-

Notes

▽ Vibrating Wire Piezometer



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London
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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 CP13,
CP14 & CP5 Piezometers (Drive Y)
C305-DSJ-C2-RGN-CRG03-50407

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_1-08285

Rev: P01
Suitability: S4

RESTRICTED
Fit for authorisation

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APPENDIX B:
SUMMARY OF INSTRUMENTATION INSTALLED ON SITE

IRS Installation Record Sheets - Levelling Points

Sensor Type	Sensor ID	Sub-Area	Installation Date	Status	Location SENSOR (m)			Commissioning Readings (mATD))			
					Eastings X (m)	Northings Y (m)	Elevation Z (mATD)	Average	16/10/2012	16/10/2012	16/10/2012
Levelling Point	C305-LP040001	Pilgrim Mews	14/09/2012	Installed	89282.327	35459.406	106.124	106.0492	106.0490	106.0495	106.0491
Levelling Point	C305-LP040002	Pilgrim Mews	14/09/2012	Installed	89280.678	35454.784	106.054	105.9939	105.9933	105.9943	105.9941
Levelling Point	C305-LP040003	Pilgrim Mews	14/09/2012	Installed	89279.409	35449.920	105.988	105.9256	105.9255	105.9260	105.9253
Levelling Point	C305-LP040004	Pilgrim Mews	14/09/2012	Installed	89278.502	35445.003	105.910	105.8475	105.8481	105.8473	105.8471
Levelling Point	C305-LP040005	Pilgrim Mews	14/09/2012	Installed	89278.370	35439.988	105.859	105.8257	105.8260	105.8251	105.8260
Levelling Point	C305-LP040006	Pilgrim Mews	14/09/2012	Installed	89279.086	35435.003	105.877	105.8206	105.8212	105.8205	105.8201
Levelling Point	C305-LP040007	Pilgrim Mews	14/09/2012	Installed	89280.567	35430.269	106.171	106.1097	106.1095	106.1099	106.1097
Levelling Point	C305-LP040008	Pilgrim Mews	14/09/2012	Installed	89281.557	35427.950	106.237	106.1716	106.1710	106.1717	106.1721
Levelling Point	C305-LP040009	Pilgrim Mews	14/09/2012	Installed	89282.800	35425.836	106.286	106.2311	106.2306	106.2315	106.2312
Levelling Point	C305-LP040010	Pilgrim Mews	14/09/2012	Installed	89283.855	35423.589	106.340	106.2766	106.2770	106.2761	106.2767
Levelling Point	C305-LP040011	Pilgrim Mews	14/09/2012	Installed	89284.610	35421.163	106.350	106.3006	106.3001	106.3008	106.3009
Levelling Point	C305-LP040012	Pilgrim Mews	14/09/2012	Installed	89284.900	35418.709	106.380	106.3287	106.3291	106.3283	106.3287
Levelling Point	C305-LP040013	Pilgrim Mews	14/09/2012	Installed	89284.745	35416.195	106.419	106.3491	106.3485	106.3495	106.3493
Levelling Point	C305-LP040014	Pilgrim Mews	14/09/2012	Installed	89284.524	35413.708	106.416	106.3761	106.3764	106.3759	106.3760
Levelling Point	C305-LP040015	Pilgrim Mews	14/09/2012	Installed	89284.471	35411.270	106.394	106.3586	106.3584	106.3590	106.3584
Levelling Point	C305-LP040016	Pilgrim Mews	14/09/2012	Installed	89284.600	35408.730	106.380	106.3520	106.3516	106.3524	106.3520
Levelling Point	C305-LP040017	Pilgrim Mews	14/09/2012	Installed	89284.866	35406.255	106.296	106.2426	106.2429	106.2421	106.2428
Levelling Point	C305-LP040018	Pilgrim Mews	14/09/2012	Installed	89285.217	35403.755	106.443	106.3882	106.3876	106.3882	106.3888
Levelling Point	C305-LP040019	Pilgrim Mews	14/09/2012	Installed	89285.785	35401.289	106.495	106.4570	106.4572	106.4564	106.4574
Levelling Point	C305-LP040020	Pilgrim Mews	14/09/2012	Installed	89286.381	35398.950	106.473	106.4913	106.4907	106.4918	106.4914
Levelling Point	C305-LP040021	Pilgrim Mews	14/09/2012	Installed	89287.068	35396.533	106.492	106.5322	106.5326	106.5316	106.5324
Levelling Point	C305-LP040022	Pilgrim Mews	14/09/2012	Installed	89287.763	35394.131	106.532	106.5720	106.5716	106.5722	106.5722
Levelling Point	C305-LP040023	Pilgrim Mews	14/09/2012	Installed	89288.500	35391.758	106.590	106.6222	106.6217	106.6228	106.6221
Levelling Point	C305-LP040024	Pilgrim Mews	14/09/2012	Installed	89289.953	35386.892	106.772	106.7151	106.7154	106.7149	106.7150
Levelling Point	C305-LP040025	Pilgrim Mews	14/09/2012	Installed	89291.483	35381.748	106.858	106.8008	106.8002	106.8012	106.8010
Levelling Point	C305-LP040026	Pilgrim Mews	14/09/2012	Installed	89292.918	35376.952	106.948	106.8908	106.8906	106.8914	106.8904
Levelling Point	C305-LP040027	Pilgrim Mews	14/09/2012	Installed	89294.338	35372.173	107.039	106.9818	106.9815	106.9823	106.9816
Levelling Point	C305-LP040028	Pilgrim Mews	14/09/2012	Installed	89295.735	35367.357	107.107	107.0502	107.0497	107.0507	107.0502
Levelling Point	C305-LP040029	Pilgrim Mews	14/09/2012	Installed	89297.143	35362.603	107.194	107.1381	107.1386	107.1377	107.1380
Levelling Point	C305-LP040030	Pilgrim Mews	14/09/2012	Installed	89298.460	35358.137	107.276	107.2194	107.2192	107.2198	107.2192

IRS Installation Record Sheets											
Sensor Type	Sensor ID	Date Installation	Sub-area	Status	SENSOR Location - GPS reading (m)			Commissioning Readings (m)			
					Eastings X	Northings Y	Elevation Z (mATD)	AVERAGE	18-07-12	18-07-12	18-07-12
Leveling points	C305-LP045401	27-06-12	MS, Phase 3 – Section A	Installed	89368.438	35481.769	106.230	106.1711	106.1709	106.1715	106.1709
Leveling points	C305-LP045402	27-06-12	MS, Phase 3 – Section A	Installed	89373.295	35480.427	106.283	106.214	106.2146	106.2138	106.2136
Leveling points	C305-LP045403	27-06-12	MS, Phase 3 – Section A	Installed	89378.106	35479.131	106.351	106.270	106.2698	106.2691	106.2696
Leveling points	C305-LP045404	27-06-12	MS, Phase 3 – Section A	Installed	89382.986	35477.934	106.390	106.313	106.3132	106.3127	106.3134
Leveling points	C305-LP045405	27-06-12	MS, Phase 3 – Section A	Installed	89387.933	35476.836	106.451	106.382	106.3821	106.3825	106.3820
Leveling points	C305-LP045406	27-06-12	MS, Phase 3 – Section A	Installed	89392.855	35475.817	106.524	106.449	106.4491	106.4496	106.4492
Leveling points	C305-LP045407	27-06-12	MS, Phase 3 – Section A	Installed	89397.769	35474.887	106.601	106.508	106.5069	106.5079	106.5077
Leveling points	C305-LP045408	27-06-12	MS, Phase 3 – Section A	Installed	89402.757	35474.018	106.644	106.579	106.5786	106.5795	106.5789
Leveling points	C305-LP045409	27-06-12	MS, Phase 3 – Section A	Installed	89407.741	35473.248	106.722	106.654	106.6546	106.6536	106.6541
Leveling points	C305-LP045410	27-06-12	MS, Phase 3 – Section A	Installed	89412.748	35472.532	106.833	106.743	106.7432	106.7429	106.7429
Leveling points	C305-LP045411	27-06-12	MS, Phase 3 – Section A	Installed	89417.718	35471.926	106.919	106.843	106.8436	106.8429	106.8428
Leveling points	C305-LP045412	27-06-12	MS, Phase 3 – Section A	Installed	89422.779	35471.380	107.047	106.968	106.9676	106.9683	106.9675
Leveling points	C305-LP045413	27-06-12	MS, Phase 3 – Section A	Installed	89427.827	35470.915	107.174	107.100	107.1002	107.0997	107.1001
Leveling points	C305-LP045414	27-06-12	MS, Phase 3 – Section A	Installed	89432.742	35470.510	107.313	107.241	107.2416	107.2410	107.2413
Leveling points	C305-LP045415	27-06-12	MS, Phase 3 – Section A	Installed	89437.841	35470.211	107.482	107.407	107.4064	107.4071	107.4075
Leveling points	C305-LP045416	27-06-12	MS, Phase 3 – Section A	Installed	89442.795	35469.964	107.655	107.580	107.5794	107.5797	107.5797
Leveling points	C305-LP045417	27-06-12	MS, Phase 3 – Section A	Installed	89447.973	35469.863	107.841	107.772	107.7719	107.7712	107.7717
Leveling points	C305-LP045418	27-06-12	MS, Phase 3 – Section A	Installed	89452.991	35469.783	108.035	107.961	107.9617	107.9613	107.9612
Leveling points	C305-LP045419	27-06-12	MS, Phase 3 – Section A	Installed	89458.040	35469.801	108.185	108.115	108.1143	108.1149	108.1146
Leveling points	C305-LP045420	27-06-12	MS, Phase 3 – Section A	Installed	89463.050	35469.912	108.280	108.211	108.2111	108.2103	108.2104
Leveling points	C305-LP045421	27-06-12	MS, Phase 3 – Section A	Installed	89469.087	35470.164	108.382	108.312	108.3116	108.3109	108.3120
Leveling points	C305-LP045422	27-06-12	MS, Phase 3 – Section A	Installed	89470.554	35470.235	108.404	108.332	108.3327	108.3317	108.3325
Leveling points	C305-LP045423	27-06-12	MS, Phase 3 – Section A	Installed	89472.959	35470.427	108.430	108.363	108.3628	108.3640	108.3634
Leveling points	C305-LP045424	27-06-12	MS, Phase 3 – Section A	Installed	89475.649	35470.621	108.454	108.385	108.3844	108.3851	108.3849
Leveling points	C305-LP045425	27-06-12	MS, Phase 3 – Section A	Installed	89478.152	35470.857	108.470	108.405	108.4045	108.4051	108.4042
Leveling points	C305-LP045426	27-06-12	MS, Phase 3 – Section A	Installed	89480.692	35471.090	108.506	108.412	108.4127	108.4119	108.4126

IRS Installation Record Sheets											
Sensor Type	Sensor ID	Date Installation	Sub-area	Status	SENSOR Location - GPS reading (m)			Commissioning Readings (m)			
					Eastings X	Northings Y	Elevation Z (mATD)				
Leveling points	C305-LP045427	27-06-12	MS, Phase 3 – Section A	Installed	89483.266	35471.359	108.491	108.412	108.4115	108.4123	108.4125
Leveling points	C305-LP045428	27-06-12	MS, Phase 3 – Section A	Installed	89485.734	35471.654	108.499	108.407	108.4063	108.4074	108.4070
Leveling points	C305-LP045429	27-06-12	MS, Phase 3 – Section A	Installed	89488.209	35471.974	108.516	108.404	108.4046	108.4042	108.4044
Leveling points	C305-LP045430	27-06-12	MS, Phase 3 – Section A	Installed	89490.645	35472.319	108.490	108.395	108.3951	108.3941	108.3946
Leveling points	C305-LP045431	27-06-12	MS, Phase 3 – Section A	Installed	89493.127	35472.681	108.447	108.374	108.3741	108.3744	108.3744
Leveling points	C305-LP045432	27-06-12	MS, Phase 3 – Section A	Installed	89495.608	35473.054	108.421	108.347	108.3464	108.3467	108.3467
Leveling points	C305-LP045433	27-06-12	MS, Phase 3 – Section A	Installed	89498.161	35473.517	108.307	108.278	108.2781	108.2777	108.2776
Leveling points	C305-LP045434	27-06-12	MS, Phase 3 – Section A	Installed	89500.652	35473.962	108.329	108.250	108.2502	108.2509	108.2501
Leveling points	C305-LP045435	27-06-12	MS, Phase 3 – Section A	Installed	89503.132	35474.415	108.268	108.204	108.2031	108.2039	108.2041
Leveling points	C305-LP045436	27-06-12	MS, Phase 3 – Section A	Installed	89505.567	35474.917	108.235	108.143	108.1438	108.1427	108.1434
Leveling points	C305-LP045437	27-06-12	MS, Phase 3 – Section A	Installed	89508.053	35475.415	108.184	108.072	108.0729	108.0719	108.0724
Leveling points	C305-LP045438	27-06-12	MS, Phase 3 – Section A	Installed	89510.486	35475.914	108.127	108.016	108.0163	108.0156	108.0161
Leveling points	C305-LP045439	27-06-12	MS, Phase 3 – Section A	Installed	89512.982	35476.353	108.037	107.946	107.9457	107.9464	107.9459
Leveling points	C305-LP045440	27-06-12	MS, Phase 3 – Section A	Installed	89515.450	35476.805	107.952	107.876	107.8750	107.8760	107.8755
Leveling points	C305-LP045441	27-06-12	MS, Phase 3 – Section A	Installed	89517.937	35477.194	107.857	107.795	107.7950	107.7954	107.7955
Leveling points	C305-LP045442	27-06-12	MS, Phase 3 – Section A	Installed	89520.352	35477.552	107.709	107.708	107.7084	107.7077	107.7088
Leveling points	C305-LP045443	27-06-12	MS, Phase 3 – Section A	Installed	89522.867	35477.883	107.624	107.623	107.6234	107.6226	107.6236
Leveling points	C305-LP045444	27-06-12	MS, Phase 3 – Section A	Installed	89525.368	35478.159	107.520	107.520	107.5196	107.5202	107.5196
Leveling points	C305-LP045445	27-06-12	MS, Phase 3 – Section A	Installed	89527.815	35478.377	107.414	107.413	107.4123	107.4133	107.4125
Leveling points	C305-LP045446	27-06-12	MS, Phase 3 – Section A	Installed	89530.382	35478.597	107.296	107.295	107.2953	107.2955	107.2954
Leveling points	C305-LP045447	27-06-12	MS, Phase 3 – Section A	Installed	89532.943	35478.787	107.191	107.190	107.1909	107.1902	107.1898
Leveling points	C305-LP045448	27-06-12	MS, Phase 3 – Section A	Installed	89535.451	35478.909	107.068	107.067	107.0672	107.0668	107.0673
Leveling points	C305-LP045449	27-06-12	MS, Phase 3 – Section A	Installed	89538.246	35478.995	106.926	106.925	106.9251	106.9240	106.9244
Leveling points	C305-LP045450	27-06-12	MS, Phase 3 – Section A	Installed	89540.796	35479.069	106.795	106.795	106.7943	106.7954	106.7950
Leveling points	C305-LP045451	27-06-12	MS, Phase 3 – Section A	Installed	89543.324	35479.125	106.665	106.665	106.6649	106.6659	106.6654
Leveling points	C305-LP045452	27-06-12	MS, Phase 3 – Section A	Installed	89545.843	35479.127	106.521	106.521	106.5214	106.5206	106.5216
Leveling points	C305-LP045453	27-06-12	MS, Phase 3 – Section A	Installed	89548.334	35479.094	106.388	106.388	106.3870	106.3879	106.3876
Leveling points	C305-LP045454	27-06-12	MS, Phase 3 – Section A	Installed	89550.956	35478.985	106.239	106.244	106.2440	106.2433	106.2435
Leveling points	C305-LP045455	27-06-12	MS, Phase 3 – Section A	Installed	89555.863	35479.083	105.974	105.975	105.9744	105.9755	105.9751

IRS Installation Record Sheets											
Sensor Type	Sensor ID	Date Installation	Sub-area	Status	SENSOR Location - GPS reading (m)			Commissioning Readings (m)			
					Eastings X	Northings Y	Elevation Z (mATD)				
								AVERAGE	18-07-12	18-07-12	18-07-12
Leveling points	C305-LP045501	27-06-12	MS, Phase 3 – Section B	Installed	89329.411	35474.925	105.970	105.8768	105.8771	105.8762	105.8771
Leveling points	C305-LP045502	27-06-12	MS, Phase 3 – Section B	Installed	89333.832	35472.623	106.035	105.9313	105.9311	105.9314	105.9314
Leveling points	C305-LP045503	27-06-12	MS, Phase 3 – Section B	Installed	89338.963	35469.891	106.092	105.9901	105.9900	105.9905	105.9898
Leveling points	C305-LP045504	27-06-12	MS, Phase 3 – Section B	Installed	89342.970	35467.827	106.173	106.0664	106.0659	106.0666	106.0667
Leveling points	C305-LP045505	27-06-12	MS, Phase 3 – Section B	Installed	89347.149	35465.652	106.250	106.1343	106.1341	106.1349	106.1339
Leveling points	C305-LP045506	27-06-12	MS, Phase 3 – Section B	Installed	89351.630	35463.474	106.288	106.1971	106.1970	106.1975	106.1968
Leveling points	C305-LP045507	27-06-12	MS, Phase 3 – Section B	Installed	89356.220	35461.562	106.345	106.2731	106.2737	106.2729	106.2727
Leveling points	C305-LP045508	27-06-12	MS, Phase 3 – Section B	Installed	89360.858	35459.672	106.410	106.3324	106.3330	106.3323	106.3319
Leveling points	C305-LP045509	27-06-12	MS, Phase 3 – Section B	Installed	89365.482	35457.732	106.490	106.4159	106.4161	106.4154	106.4162
Leveling points	C305-LP045510	27-06-12	MS, Phase 3 – Section B	Installed	89370.095	35455.800	106.588	106.5067	106.5066	106.5072	106.5063
Leveling points	C305-LP045511	27-06-12	MS, Phase 3 – Section B	Installed	89374.741	35453.921	106.674	106.5914	106.5911	106.5919	106.5912
Leveling points	C305-LP045512	27-06-12	MS, Phase 3 – Section B	Installed	89379.403	35452.058	106.760	106.6817	106.6821	106.6813	106.6817
Leveling points	C305-LP045513	27-06-12	MS, Phase 3 – Section B	Installed	89384.081	35450.297	106.837	106.7619	106.7616	106.7622	106.7619
Leveling points	C305-LP045514	27-06-12	MS, Phase 3 – Section B	Installed	89388.726	35448.618	106.940	106.8595	106.8589	106.8600	106.8596
Leveling points	C305-LP045515	27-06-12	MS, Phase 3 – Section B	Installed	89391.092	35447.772	106.988	106.9084	106.9089	106.9080	106.9083
Leveling points	C305-LP045516	27-06-12	MS, Phase 3 – Section B	Installed	89393.450	35446.957	107.046	106.9616	106.9614	106.9619	106.9615
Leveling points	C305-LP045517	27-06-12	MS, Phase 3 – Section B	Installed	89395.820	35446.118	107.087	107.0134	107.0135	107.0133	107.0134
Leveling points	C305-LP045518	27-06-12	MS, Phase 3 – Section B	Installed	89398.176	35445.315	107.157	107.0835	107.0838	107.0833	107.0834
Leveling points	C305-LP045519	27-06-12	MS, Phase 3 – Section B	Installed	89400.529	35444.526	107.216	107.1386	107.1381	107.1390	107.1387
Leveling points	C305-LP045520	27-06-12	MS, Phase 3 – Section B	Installed	89402.902	35443.743	107.275	107.1999	107.2002	107.1997	107.1998
Leveling points	C305-LP045521	27-06-12	MS, Phase 3 – Section B	Installed	89405.253	35443.025	107.343	107.2626	107.2630	107.2624	107.2624
Leveling points	C305-LP045522	27-06-12	MS, Phase 3 – Section B	Installed	89407.615	35442.241	107.413	107.3339	107.3344	107.3334	107.3339
Leveling points	C305-LP045523	27-06-12	MS, Phase 3 – Section B	Installed	89410.002	35441.527	107.464	107.4008	107.4005	107.4012	107.4007
Leveling points	C305-LP045524	27-06-12	MS, Phase 3 – Section B	Installed	89412.386	35440.800	107.559	107.4804	107.4808	107.4798	107.4806
Leveling points	C305-LP045525	27-06-12	MS, Phase 3 – Section B	Installed	89414.764	35440.089	107.627	107.5545	107.5539	107.5549	107.5547
Leveling points	C305-LP045526	27-06-12	MS, Phase 3 – Section B	Installed	89417.166	35439.424	107.709	107.6346	107.6347	107.6343	107.6348
Leveling points	C305-LP045527	27-06-12	MS, Phase 3 – Section B	Installed	89419.545	35438.726	107.785	107.7065	107.7070	107.7059	107.7066
Leveling points	C305-LP045528	27-06-12	MS, Phase 3 – Section B	Installed	89424.379	35437.403	107.959	107.8799	107.8793	107.8800	107.8804

IRS Installation Record Sheets											
Sensor Type	Sensor ID	Date Installation	Sub-area	Status	SENSOR Location - GPS reading (m)			Commissioning Readings (m)			
					Eastings X	Northings Y	Elevation Z (mATD)				
Leveling points	C305-LP045529	27-06-12	MS, Phase 3 – Section B	Installed	89429.202	35436.150	108.110	108.0292	108.0288	108.0295	108.0293
Leveling points	C305-LP045530	27-06-12	MS, Phase 3 – Section B	Installed	89434.023	35434.967	108.245	108.1630	108.1624	108.1632	108.1634
Leveling points	C305-LP045531	27-06-12	MS, Phase 3 – Section B	Installed	89438.954	35433.790	108.361	108.2820	108.2823	108.2816	108.2821
Leveling points	C305-LP045532	27-06-12	MS, Phase 3 – Section B	Installed	89443.718	35432.733	108.431	108.3560	108.3558	108.3561	108.3561
Leveling points	C305-LP045533	27-06-12	MS, Phase 3 – Section B	Installed	89448.604	35431.655	108.501	108.4170	108.4165	108.4171	108.4174
Leveling points	C305-LP045534	27-06-12	MS, Phase 3 – Section B	Installed	89453.545	35430.697	108.418	108.3430	108.3436	108.3427	108.3427
Leveling points	C305-LP045535	27-06-12	MS, Phase 3 – Section B	Installed	89458.379	35429.783	108.545	108.4590	108.4587	108.4591	108.4592
Leveling points	C305-LP045536	27-06-12	MS, Phase 3 – Section B	Installed	89463.281	35428.882	108.510	108.4330	108.4333	108.4325	108.4332
Leveling points	C305-LP045537	27-06-12	MS, Phase 3 – Section B	Installed	89468.220	35428.056	108.461	108.3880	108.3885	108.3876	108.3879
Leveling points	C305-LP045538	27-06-12	MS, Phase 3 – Section B	Installed	89473.134	35427.276	108.392	108.3170	108.3171	108.3169	108.3170
Leveling points	C305-LP045539	27-06-12	MS, Phase 3 – Section B	Installed	89478.071	35426.557	108.306	108.2340	108.2334	108.2342	108.2344
Leveling points	C305-LP045540	27-06-12	MS, Phase 3 – Section B	Installed	89483.005	35425.917	108.205	108.1230	108.1236	108.1226	108.1228
Leveling points	C305-LP045541	27-06-12	MS, Phase 3 – Section B	Installed	89487.914	35425.311	108.058	107.9880	107.9884	107.9879	107.9877
Leveling points	C305-LP045542	27-06-12	MS, Phase 3 – Section B	Installed	89492.882	35424.753	107.891	107.8190	107.8188	107.8191	107.8191
Leveling points	C305-LP045543	27-06-12	MS, Phase 3 – Section B	Installed	89497.753	35424.253	107.705	107.6340	107.6345	107.6334	107.6341
Leveling points	C305-LP045544	27-06-12	MS, Phase 3 – Section B	Installed	89502.741	35423.815	107.506	107.4230	107.4232	107.4226	107.4232
Leveling points	C305-LP045545	27-06-12	MS, Phase 3 – Section B	Installed	89507.757	35423.409	107.267	107.1850	107.1851	107.1849	107.1850
Leveling points	C305-LP045546	27-06-12	MS, Phase 3 – Section B	Installed	89512.777	35423.094	107.001	106.9180	106.9185	106.9175	106.9180
Leveling points	C305-LP045547	27-06-12	MS, Phase 3 – Section B	Installed	89517.752	35422.810	106.711	106.6430	106.6431	106.6426	106.6433
Leveling points	C305-LP045548	27-06-12	MS, Phase 3 – Section B	Installed	89522.700	35422.602	106.434	106.3450	106.3453	106.3449	106.3448
Leveling points	C305-LP045549	27-06-12	MS, Phase 3 – Section B	Installed	89527.620	35422.459	106.132	106.0470	106.0474	106.0469	106.0467
Leveling points	C305-LP045550	27-06-12	MS, Phase 3 – Section B	Installed	89532.613	35422.375	105.845	105.7590	105.7584	105.7592	105.7594
Leveling points	C305-LP045551	27-06-12	MS, Phase 3 – Section B	Installed	89537.557	35422.392	105.584	105.4780	105.4785	105.4775	105.4780
Leveling points	C305-LP045552	27-06-12	MS, Phase 3 – Section B	Installed	89542.583	35422.354	105.282	105.1930	105.1924	105.1934	105.1932
Leveling points	C305-LP045553	27-06-12	MS, Phase 3 – Section B	Installed	89547.583	35422.368	104.999	104.9060	104.9066	104.9057	104.9057

IRS Installation Record Sheets-Sockets

Sensor Type	Sensor ID	Date Installation	Status	SENSOR Location - GPS reading (m)			Commissioning Readings (m)			
				Eastings X	Northings Y	Elevation Z	AVERAGE	10/10/2012	11/10/2012	11/10/2012
Socket	C305-LB040001	19/09/2012	Installed	89321.9495	35334.8596	109.3834	108.7446	108.7443	108.7447	108.7448
Socket	C305-LB040002	19/09/2012	Installed	89316.8275	35344.8166	109.4651	108.8264	108.8265	108.8268	108.8259
Socket	C305-LB040003	19/09/2012	Installed	89313.4189	35356.3281	109.4644	108.8272	108.8269	108.8272	108.8274
Socket	C305-LB040004	19/09/2012	Installed	89309.1156	35370.7495	109.4798	108.8418	108.8417	108.8422	108.8416
Socket	C305-LB040005	19/09/2012	Installed	89303.359	35390.9527	109.4783	108.8385	108.8389	108.8384	108.8381
Socket	C305-LB040006	19/09/2012	Installed	89299.9467	35402.4602	109.4689	108.8291	108.8295	108.8293	108.8286
Socket	C305-LB040007	19/09/2012	Installed	89300.325	35408.4426	109.471	108.8347	108.8349	108.8348	108.8345

Note: For Sockets - the difference between the Elevation Z reading and Commissioning reading results from the use of a GPS staff and a manual level respectively.

IRS Installation Record Sheets – Vibrating Wire Piezometer												
Sensor Type	Sensor ID	Sensor Serial Number	Sensor Depth (mbgl)	Date Installation	Status	SENSOR Location - GPS reading (m)			Commissioning Readings (mATD)			
						Eastings X (m)	Northings Y (m)	Elevation Z (mATD)	AVERAGE	26-03-13	26-03-13	26-03-13
Vibrating Wire Piezometer	C305-PV04080	1237112	31.20	25-03-13	Installed	89368.877	35450.176	106.248	96.354	96.364	96.355	96.344
									AVERAGE	26-03-13	26-03-13	26-03-13
Vibrating Wire Piezometer	C305-PV04081	136964	38.50	25-03-13	Installed	89368.877	35450.176	106.248	92.325	92.368	92.324	92.282
									AVERAGE	26-03-13	26-03-13	26-03-13
Vibrating Wire Piezometer	C305-PV04082	1237110	47.10	25-03-13	Installed	89368.877	35450.176	106.248	91.400	91.446	91.403	91.350
									AVERAGE	22-03-14	22-03-14	22-03-14
Vibrating Wire Piezometer	C305-PV04083	1321128	30.50	20-03-14	Installed	89368.708	35431.907	105.22	86.994	86.969	86.988	87.024
									AVERAGE	20-03-14	20-03-14	20-03-14
Vibrating Wire Piezometer	C305-PV04084	1310990	34.50	20-03-14	Installed	89368.708	35431.907	105.22	82.141	82.219	82.194	82.009
									AVERAGE	20-03-14	20-03-14	20-03-14
Vibrating Wire Piezometer	C305-PV04085	1321127	45.00	20-03-14	Installed	89368.708	35431.907	105.22	76.625	76.666	76.652	76.558
									AVERAGE	16-10-14	16-10-14	16-10-14
Vibrating Wire Piezometer	C305-PV04086	1215931	31.20	16-10-14	Installed	89368.291	35431.107	105.302	82.641	82.643	82.641	82.640
									AVERAGE	17-10-14	17-10-14	17-10-14
Vibrating Wire Piezometer	C305-PV04087	1416580	30.49	17-10-14	Installed	89376.939	35438.628	105.289	82.892	82.897	82.892	82.887
									AVERAGE	21-04-15	21-04-15	21-04-15
Vibrating Wire Piezometer	C305-PV041410	1237723	38.10	21-04-15	Installed	89363.985	35435.917	105.302	75.260	75.261	75.259	75.259
									AVERAGE	21-04-15	21-04-15	21-04-15
Vibrating Wire Piezometer	C305-PV041411	1312806	39.67	21-04-15	Installed	89366.808	35445.516	105.16	77.641	77.642	77.641	77.641
									AVERAGE	20-01-14	20-01-14	20-01-14
Vibrating Wire Piezometer	C305-EJ1	1312806	39.67	20-01-14	Installed	89366.808	35445.516	105.267	83.355	83.346	83.363	83.356
									AVERAGE	20-01-14	20-01-14	20-01-14
Vibrating Wire Piezometer	C305-EJ7	1237723	39.35	20-01-14	Installed	89381.323	35434.16	105.351	81.684	81.681	81.689	81.681
									AVERAGE	30-03-15	30-03-15	30-03-15
Vibrating Wire Piezometer	C305-PV041498	1321127	45.00	24-03-15	Installed	89378.432	35436.328	105.465	82.105	82.111	82.105	82.099
									AVERAGE	30-03-15	30-03-15	30-03-15
Vibrating Wire Piezometer	C305-PV041499	1300931	31.50	30-03-15	Installed	89378.432	35436.328	105.465	76.758	77.074	76.738	76.462
									AVERAGE	30-03-15	30-03-15	30-03-15
Vibrating Wire Piezometer	C305-PV041497	1310990	31.10	24-03-15	Installed	89378.438	35433.897	105.508	72.974	72.987	72.974	72.961
									AVERAGE	31-03-15	31-03-15	31-03-15
Vibrating Wire Piezometer	C305-PV041494	1323930	31.70	30-03-15	Installed	89366.53	35433.05	105.568	89.778	89.775	89.777	89.783
									AVERAGE	31-03-15	31-03-15	31-03-15
Vibrating Wire Piezometer	C305-PV041491	1404525	31.50	30-03-15	Installed	89367.213	35436.469	105.576	91.563	91.572	91.562	91.554
									AVERAGE	31-03-15	31-03-15	31-03-15
Vibrating Wire Piezometer	C305-PV041496	1323928	28.70	30-03-15	Installed	89374.41	35429.358	105.27	99.901	99.901	99.901	99.900
									AVERAGE	30-03-15	30-03-15	30-03-15
Vibrating Wire Piezometer	C305-PV041492	1416580	29.00	24-03-15	Installed	89371.85	35440.35	105.928	87.775	87.784	87.775	87.766

IRS Installation Record Sheets – Vibrating Wire Piezometer												
Sensor Type	Sensor ID	Sensor Serial Number	Sensor Depth (mbgl)	Date Installation	Status	SENSOR Location - GPS reading (m)			Commissioning Readings (mATD)			
						Eastings X (m)	Northings Y (m)	Elevation Z (mATD)	AVERAGE	31-03-15	31-03-15	31-03-15
Vibrating Wire Piezometer	C305-PV041495	1312812	29.00	30-03-15	Installed	89372.607	35434.884	105.563	76.337	76.337	76.336	76.338

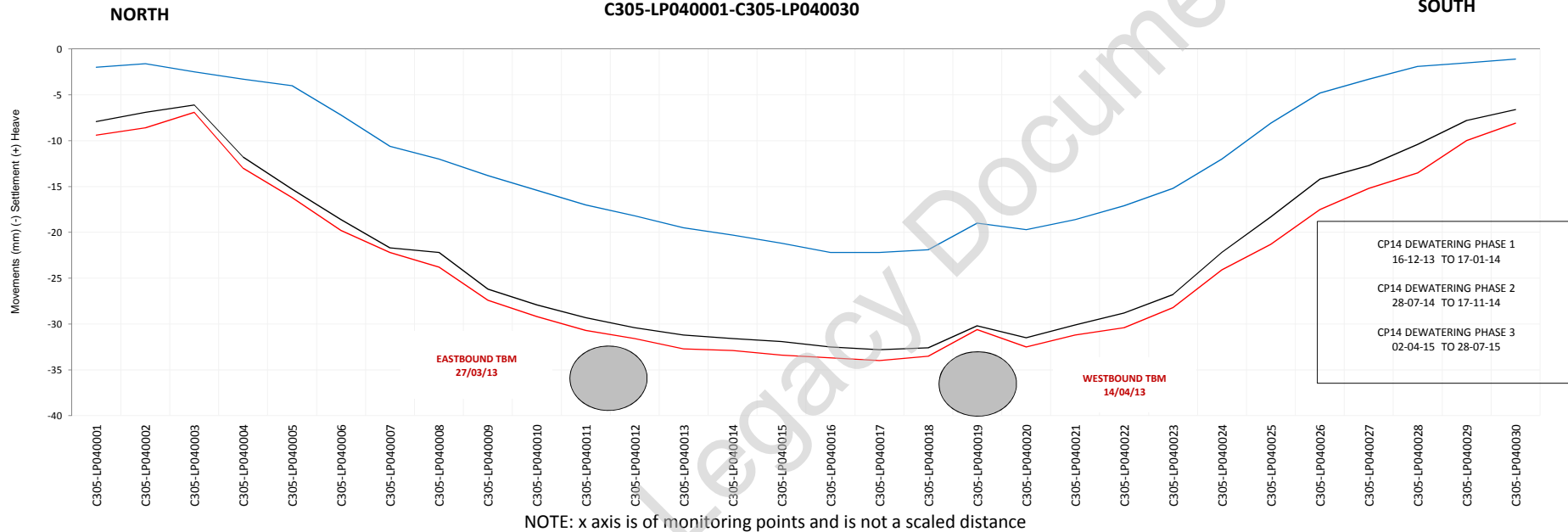
Note: All elevations or levels presented in this document are metres above tunnel datum (mATD).

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APPENDIX C:
DEFLECTION RATIO

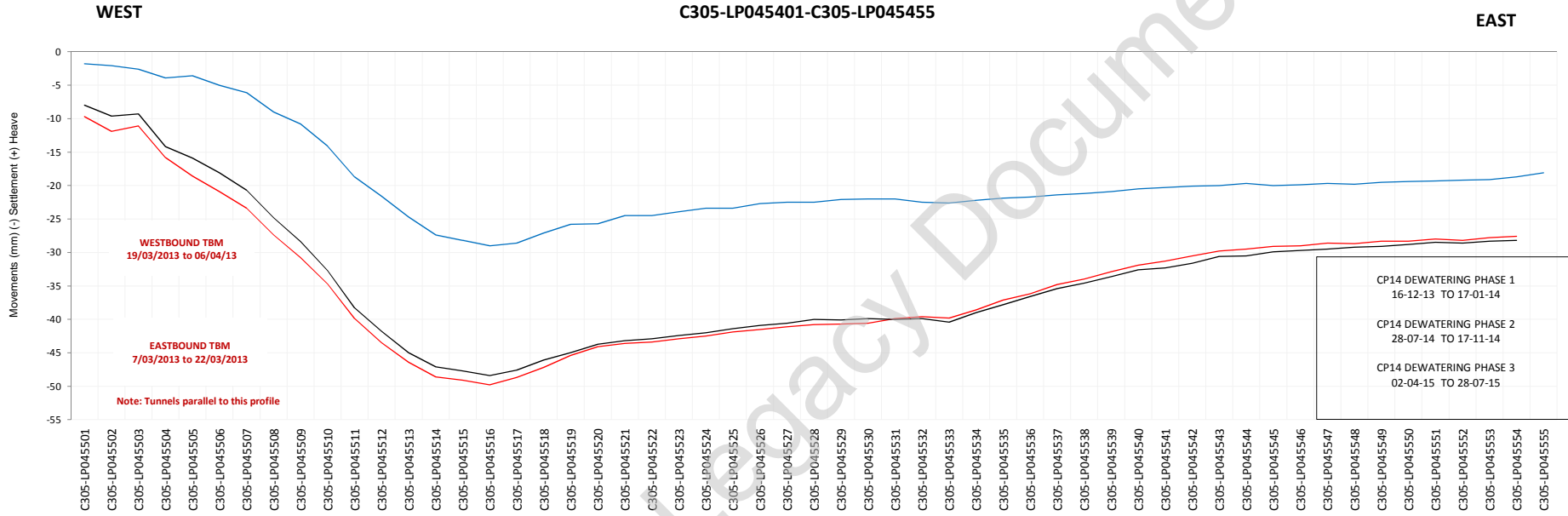
**AREA 4 Pilgrims Mews PROFILE
C305-LP040001-C305-LP040030**



TRANSECT	ALERT VALUE	MAX DEFLECTION RATIO		
		After TBMs	After CP14 Dewatering	Long Term
Pilgrims Mews	1/2600	1/3370	1/3409	1/4166

- 22/04/2013 AFTER TBMs TRANSIT
- 10/08/2015 AFTER CP14 DEWATERING
- 10/05/2016 LONG TERM

**AREA 4 Lower Lea Crossing (North Side) PROFILE
C305-LP045401-C305-LP045455**

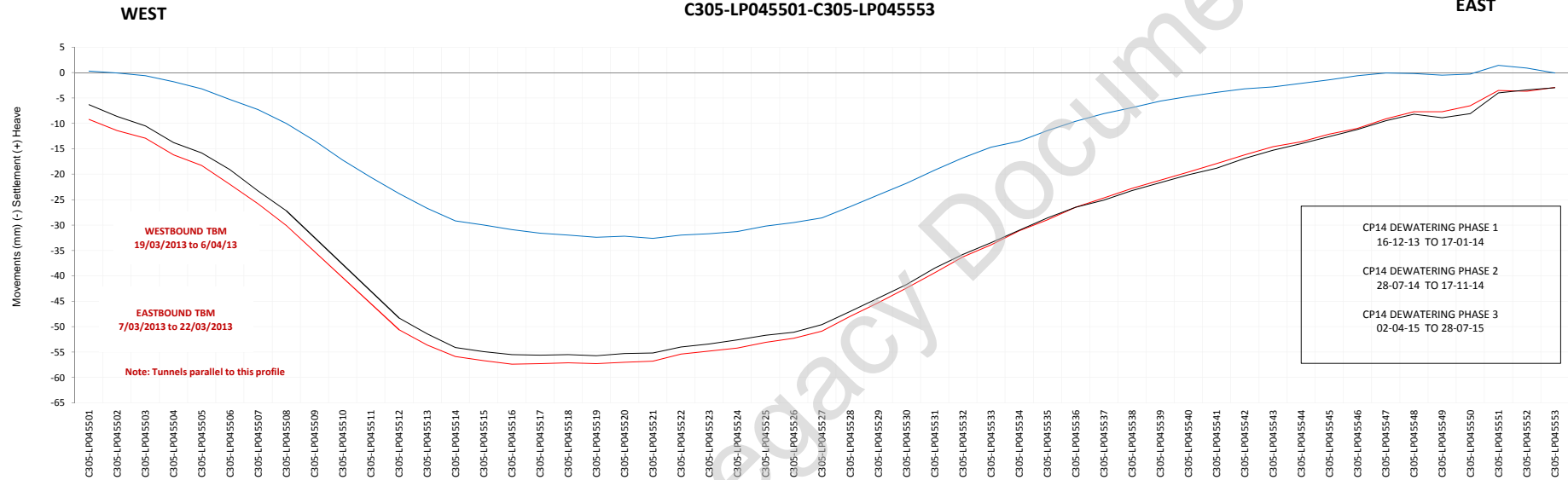


NOTE: x axis is of monitoring points and is not a scaled distance

TRANSECT	ALERT VALUE	MAX DEFLECTION RATIO		
		After TBMs	After CP14 Dewatering	Long Term
Lower Lea Crossing (North Side)	1/2000	1/9983	1/4113	1/3974

- 15/04/2013 AFTER TBMs TRANSIT
- 10/08/2015 AFTER CP14 DEWATERING
- 10/05/2016 LONG TERM

**AREA 4 Lower Lea Crossing (South Side) PROFILE
C305-LP045501-C305-LP045553**



NOTE: x axis is of monitoring points and is not a scaled distance

TRANSECT	ALERT VALUE	MAX DEFLECTION RATIO		
		After TBMs	After CP14 Dewatering	Long Term
Lower Lea Crossing (South Side)	1/2800	1/13112	1/8516	1/7136

- 15/04/2013 AFTER TBMs TRANSIT
- 10/08/2015 AFTER CP14 DEWATERING
- 10/05/2016 LONG TERM