



C305– Eastern Running Tunnels

I&M Close Out Report for 3D Prisms Poplar Dock & Crane Rails (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"/>

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C305 Crossrail Eastern Running Tunnels				
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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 summarize 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 cross passage excavation or 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

The instrumentation included within this report is situated within Area 4, Limmo Shaft to Canary Wharf Station, along project chainage 83500 to 83700. The prisms were installed onto the hard-standing dock structure situated adjacent to Poplar Dock.

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-CRG03-50021	I&M C305 TBM Poplar Dock & Crane Rails (83700-83500)	Main Method statement	11-3D Prisms
C305-DSJ-C2-RGN-CRG03-50211	Installation Report for I&M of Poplar Dock & Crane Rails (83700-83500) C305-DSJ-C2-GMS-CRG3-50021	Installation report	-

4. SUMMARY OF INSTALLED INSTRUMENTATION ON SITE

The total number of instruments installed, as per method statement and C122 drawings, was:

- 11 – 3D prisms

Detailed information of the installed instrumentation is reported in Appendix B. The average commissioning readings included in Appendix B have been used to calculate the relative movements provided in the graphs of this report.

5. CONSTRUCTION ACTIVITY

TBM PASSAGE

DRIVE Y	RINGS	PROJECT CHAINAGE	DATES
Eastbound	744 – 818	83560 – 83677	28/04/2013 to 03/05/2013
Westbound	736 – 812	83559 – 83679	24/05/2013 to 27/05/2013

No stoppage periods

DEWATERING

Cross passage 13	26 th November 2013 to 3 rd August 2015
Cross passage 14	16 th December 2013 to 17 th January 2014 28 th July 2014 to 27 th July 2015
Limmo	4 th November 2013 (still on)
Canary Wharf	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. 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

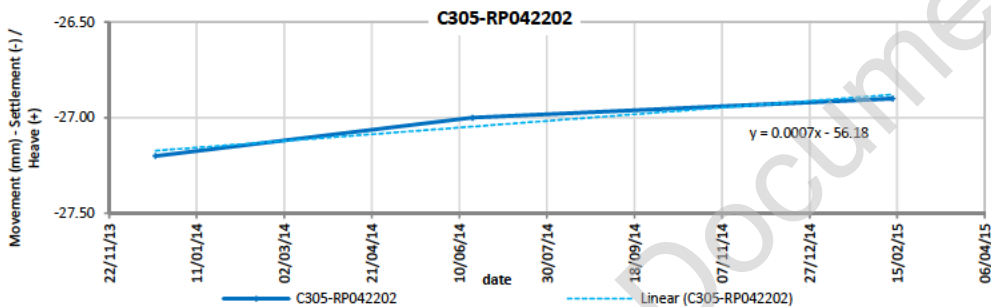
Y (dependent variable) = vertical movement

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/yr 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/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 for the prism C305-RP042202 and its projection included in this Close Out Report.

	Registered movement (mm)			RATE mm/year
	18/12/2013	17/06/2014	12/02/2015	
C305-RP042202	-27.20	-27.00	-26.90	0.256



CALCULATION - C305-RP042202

X_i	Y_i	$X_i - \bar{X}_i$	$Y_i - \bar{Y}_i$	$(X_i - \bar{X}_i)^2$	$(X_i - \bar{X}_i) \cdot (Y_i - \bar{Y}_i)$
18/12/2013	-27.20	-200.69	-0.17	40275.94	33.448
17/06/2014	-27.00	-19.67	0.03	387.10	-0.656
12/02/2015	-26.90	220.36	0.13	48560.04	29.382

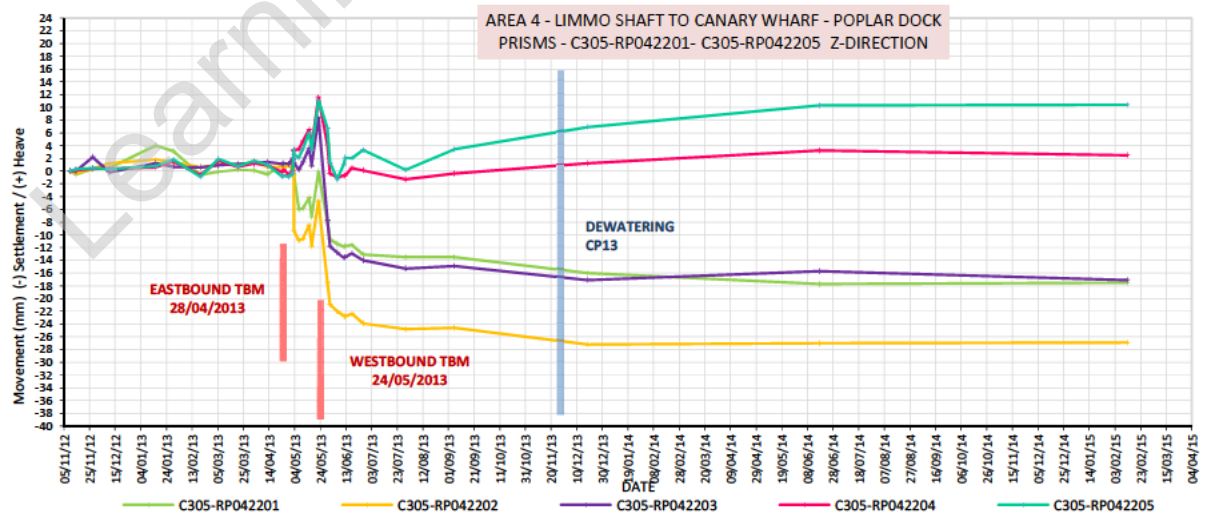
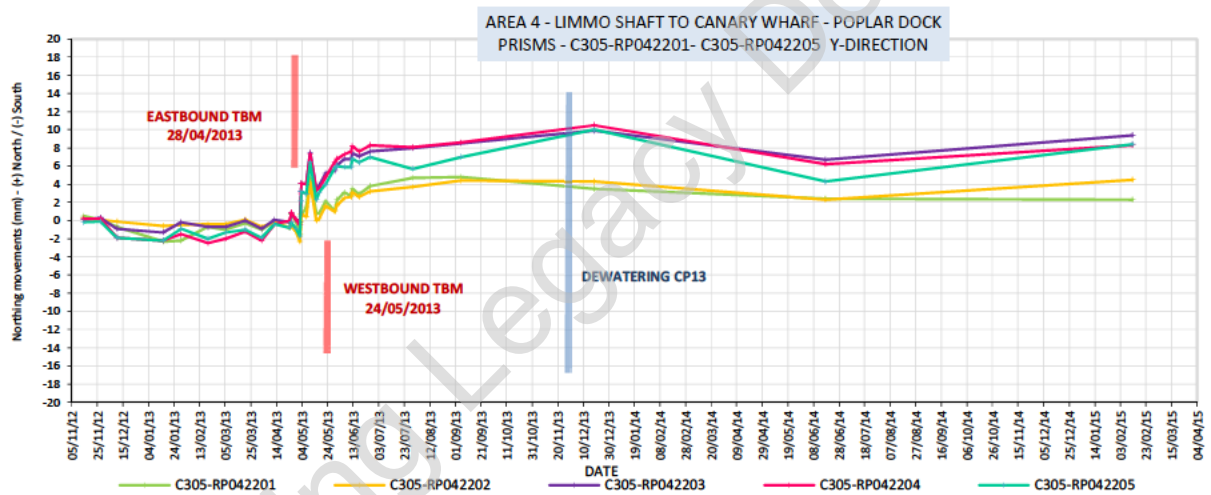
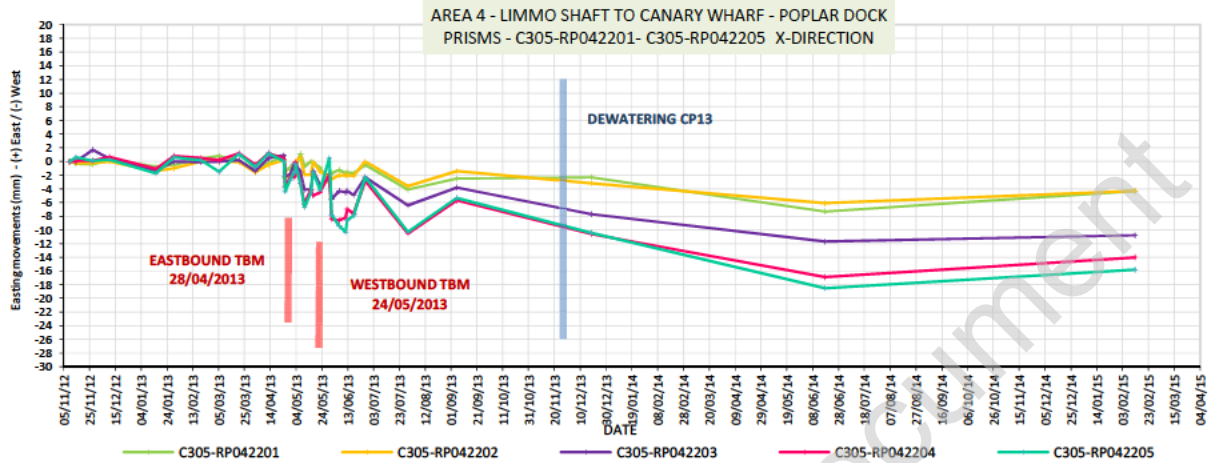
\bar{X}_i	41827.19	
\bar{Y}_i	-27.03	
$\sum_{i=1}^n (X_i - \bar{X}_i)^2$	89223.07	(2)
$\sum_{i=1}^n (X_i - \bar{X}_i) \cdot (Y_i - \bar{Y}_i)$	62.174	(1)
m (SLOPE)	(1)/(2)	0.0007
Rate (mm/year)	m * 365	0.256

7. SUMMARY OF THE DATA

Note: For the following data plots #N/A refers to instances where readings were not taken for that sensor (e.g. damaged sensor, not access, etc).

3D PRISMS

C305-RP042201 – C305-RP042205



As can be observed in the graph above, X axis shows a lateral movement of +4 mm followed by a -6 mm movement after the Eastbound TBM transit and +4 mm followed by -8 mm after the Westbound TBM transit.

In Y axis there is a negative lateral movement of -2 mm followed by +6 mm after the Eastbound TBM transit and +6 mm after the Westbound TBM transit.

In Z direction two different movements are observed. The prisms C305-RP042201 and C305-RP042202 have a settlement of -10 mm whereas the rest of the prisms have a heave of +4 mm after the Eastbound TBM transit. After the Westbound TBM transit the prisms have a heave of +6 mm followed by a settlement of -18 mm.

The effect of the dewatering in the Cross Passage 13 can be slightly observed in the graphic above. The last three readings from December 2013 to February 2015 show stability and they were used to calculate the annual projection.

The table below shows the annual rate for each 3D prism.

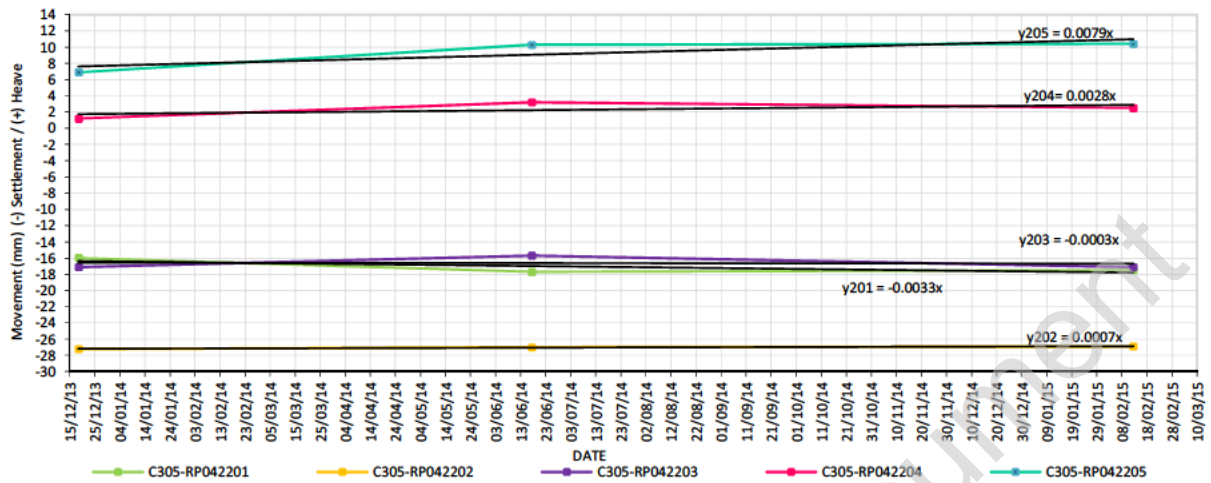
	Registered movement (mm)			Rate (mm/year)
	18/12/2013	17/06/2014	12/02/2015	
C305-RP042201	-16.00	-17.70	-17.50	-1.205
C305-RP042202	-27.20	-27.00	-26.90	0.256
C305-RP042203	-17.10	-15.70	-17.10	-0.110
C305-RP042204	1.20	3.20	2.50	1.022
C305-RP042205	6.90	10.30	10.40	2.884
	Rate less than -2.5 mm/year		% less 2 mm/ year	100.00%
	Rate greater than -3.5 mm/year		% less 3 mm/ year	100.00%

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

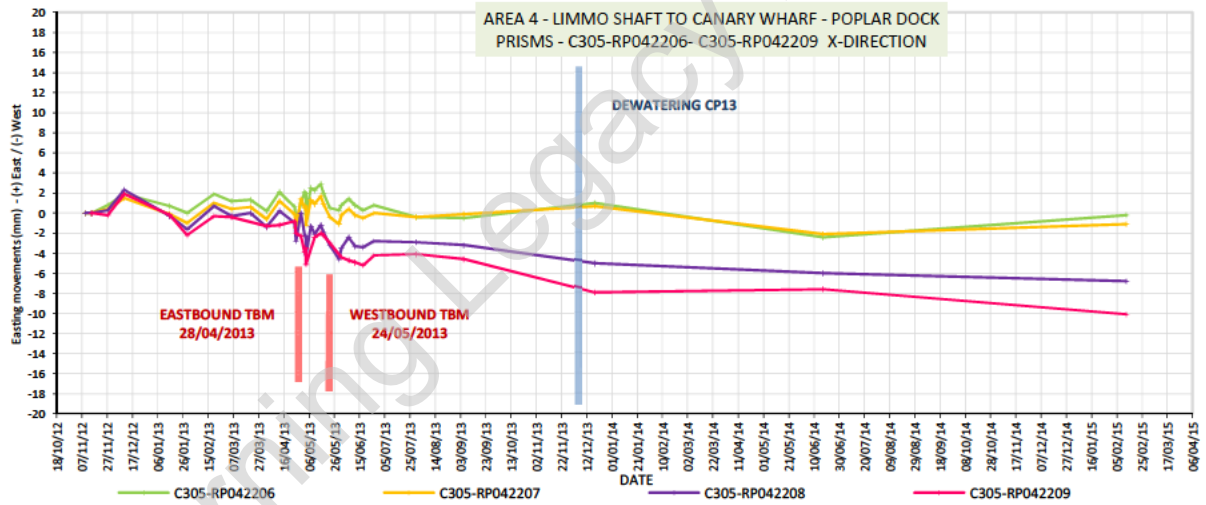
The percentage of the prisms with a settlement rate less than 2 mm/year is 100%.

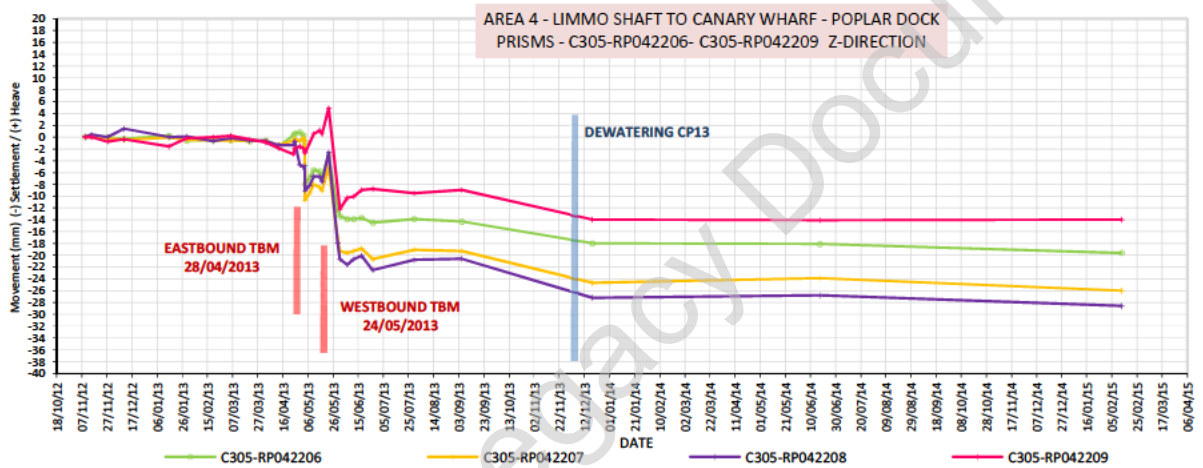
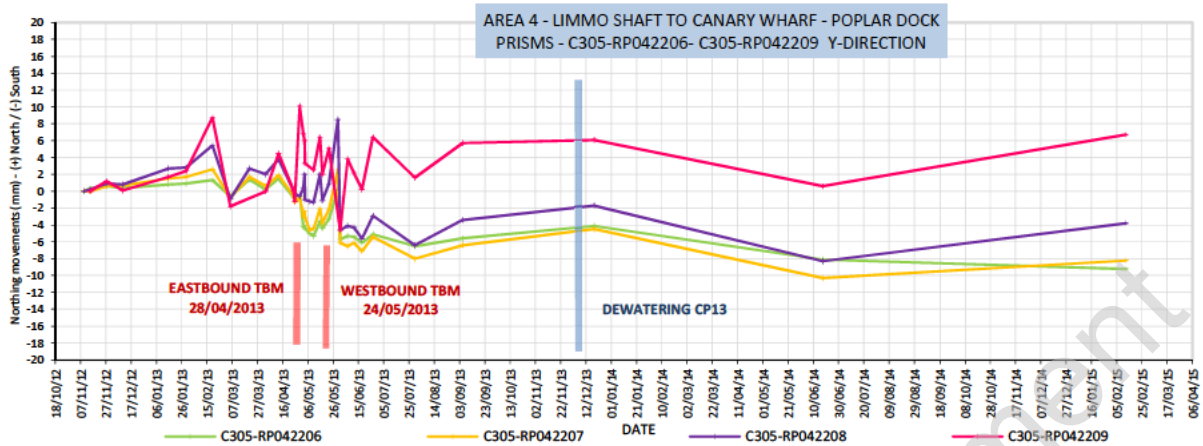
The next plot shows the trend line adjustment for each 3D prism.

AREA 4 - LIMMO SHAFT TO CANARY WHARF - POPLAR DOCK
 PRISMS - C305-RP042201-C305-RP042205 Z-DIRECTION (SLOPE - LINEAR TREND LINE)



C305-RP042206 – C305-RP042209





As can be observed in the graph above X axis shows a maximum lateral movement of -4 mm in the prism C305-RP042209 after the Eastbound TBM transit and -2 mm after the Westbound TBM transit.

In Y axis there is a positive lateral movement of +10 mm in the prism C305-RP042209 after the Eastbound TBM transit and +6 mm in the prism C305-RP042208 after the Westbound TBM transit.

In Z direction there is a settlement of -8 mm in the prism C305-RP042208 after the Eastbound TBM transit and -19 mm in the same prism after the Westbound TBM transit.

The effect of the dewatering in the Cross Passage 13 can be observed in the graphic above. The last three readings from December 2013 to February 2015 show stability and they were used to calculate the annual projection.

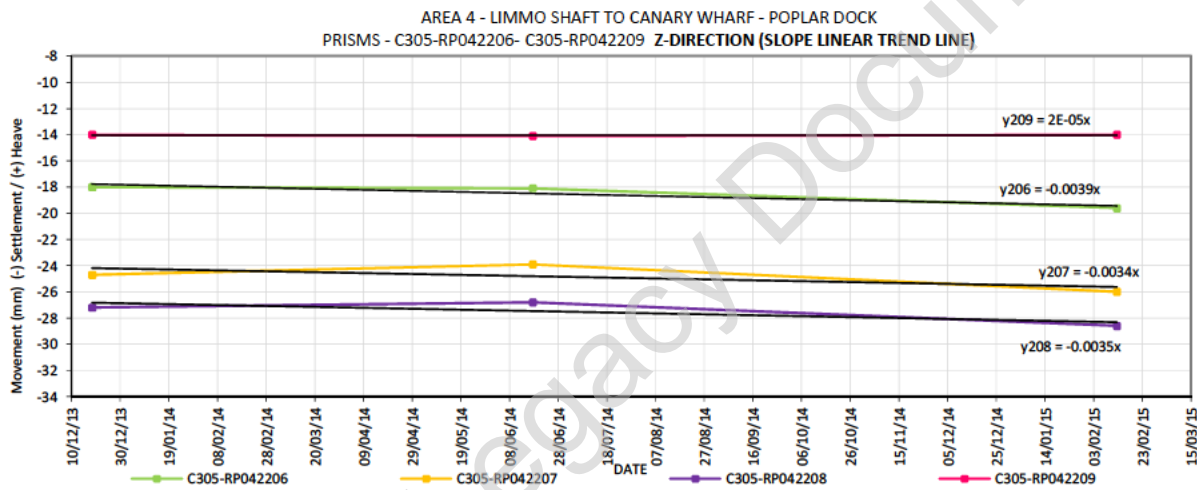
The table below shows the annual rate for each 3D prism.

	Registered movement (mm)			Rate (mm/year)
	18/12/2013	17/06/2014	12/02/2015	
C305-RP042206	-18.00	-18.10	-19.60	-1.424
C305-RP042207	-24.70	-23.90	-26.00	-1.241
C305-RP042208	-27.20	-26.80	-28.60	-1.278
C305-RP042209	-14.00	-14.10	-14.00	0.007
	Rate less than -2.5 mm/year		% less 2 mm/ year	100.00%
	Rate greater than -3.5 mm/year		% less 3 mm/ year	100.00%

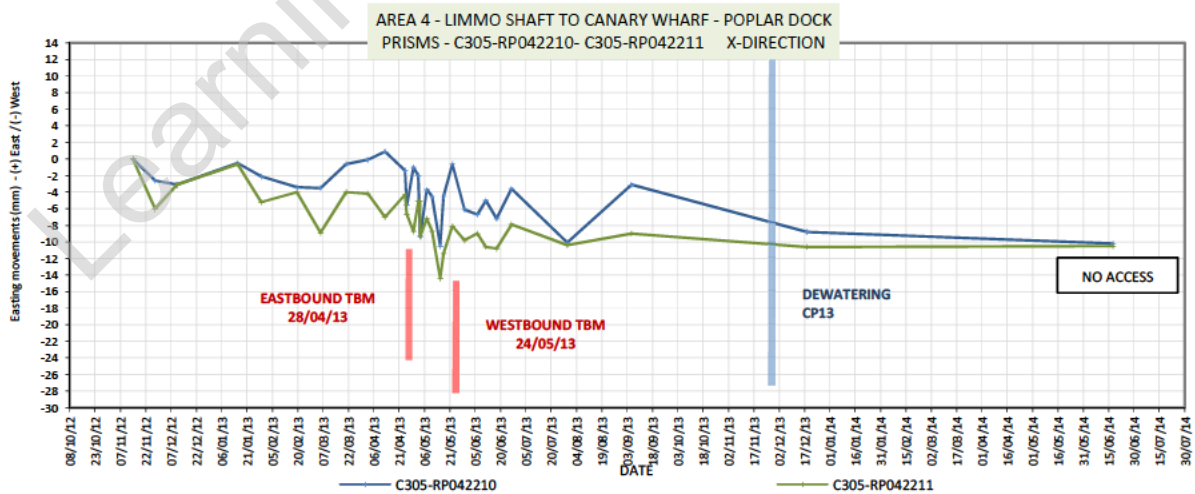
Note: All the movements are in mm. (-) Settlement / (+) Heave

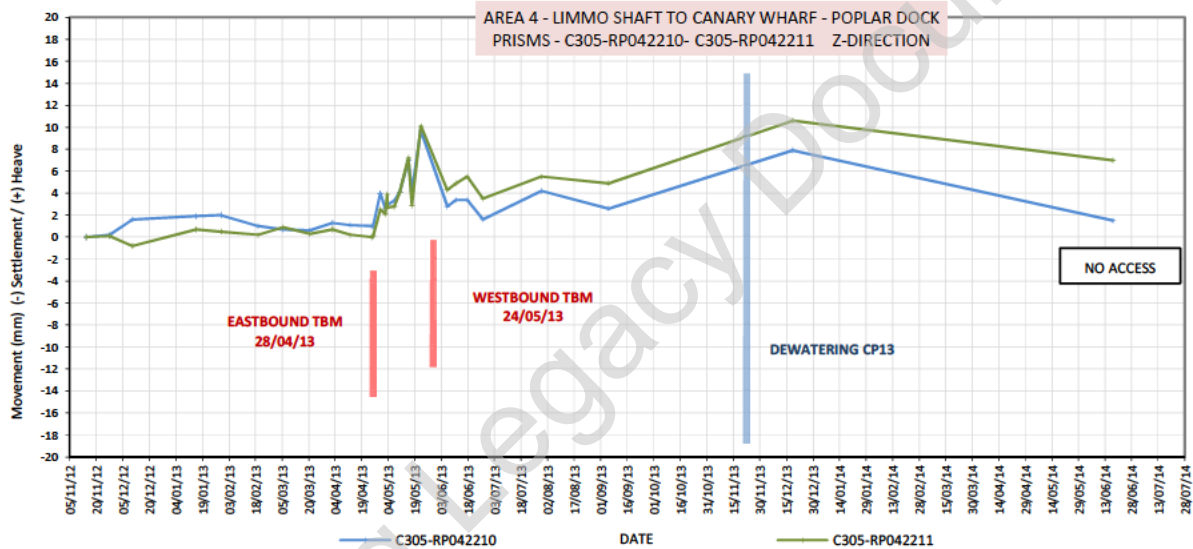
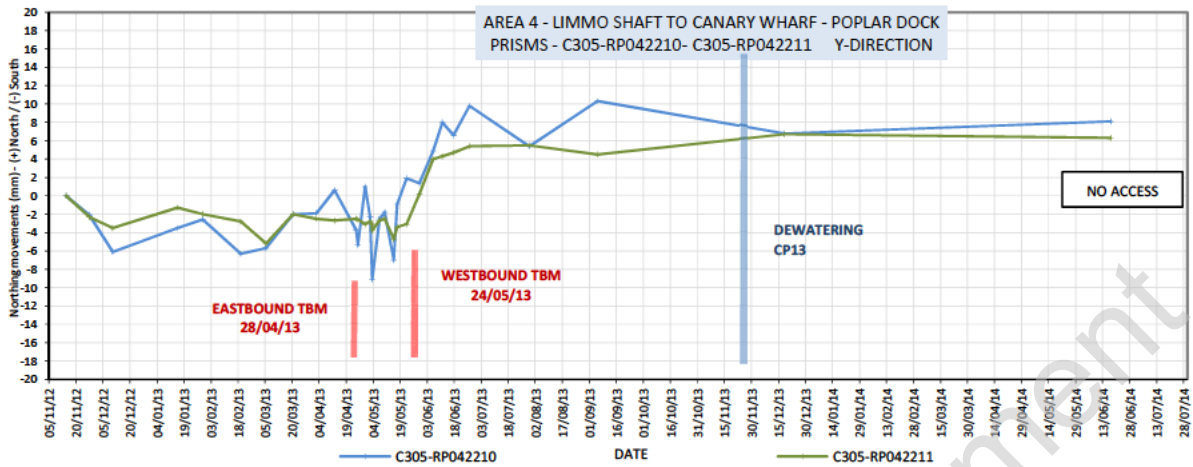
The percentage of the prisms with a settlement rate less than 2 mm/year is 100%.

The next plot shows the trend line adjustment for each 3D prism.



C305-RP042210 – C305-RP042211





As can be observed in the graph above X axis shows a maximum lateral movement of -6 mm after the Eastbound TBM transit and +9 mm in the prism C305-RP042210 after the Westbound TBM transit.

In Y axis prism C305-RP042210 shows spiky readings between +1 and -9 mm after the Eastbound TBM transit and a positive movement of +14 mm after the Westbound TBM transit.

In Z direction there is a heave of +4 mm for both prisms after the Eastbound TBM transit and a heave +7mm followed by a settlement of -7mm after the Westbound TBM transit.

The effect of the dewatering in the Cross Passage - 13 can be observed in the graphic above.

In February 2015 there was not access due to construction works in the area. The last reading was not taken for these two prisms and the annual projection was not calculated.

8. SUMMARY STATEMENT

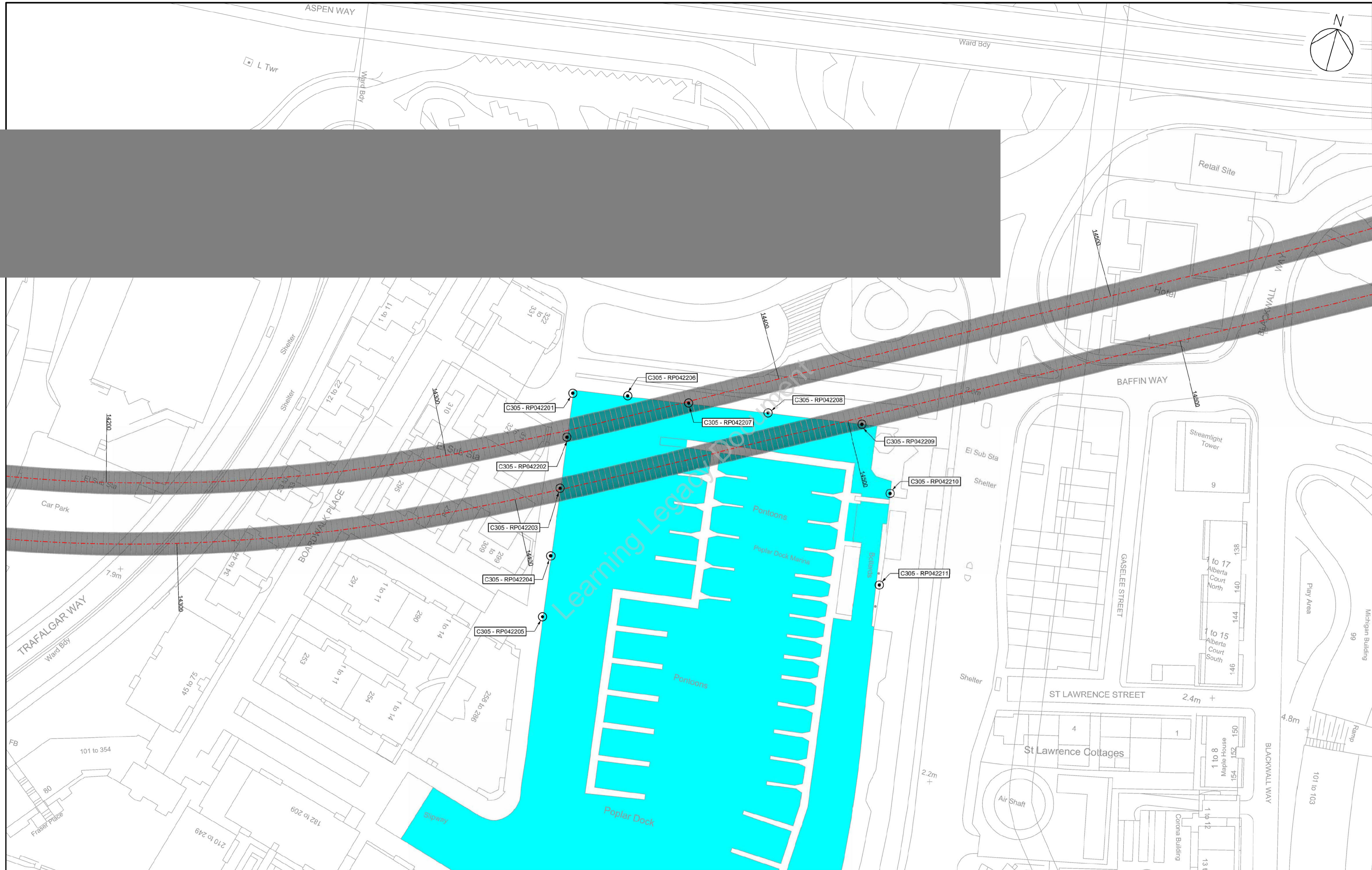
The monitoring data related to 3D prisms at Poplar Dock, presented in the close out report show the following:

- The effect of the dewatering system at CP13 being switched on is clearly illustrated in the graphs presented in section 7 above. However the effect of the dewatering is minimal.
- Post dewatering settlement rate is stable.
- Monitoring period post dewatering exceeds 12 months.
- Settlement rate has been demonstrated as less than 2 mm/year, acceptably low to cease monitoring and decommission.

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APPENDIX A: INSTRUMENT LOCATION



Rev	Date	Description	By	Chkd	App	Auth
P01	09/03/2015	First Issue	MD	AH	RC	-
P02	18/03/2015	---	MD	AH	RC	-

Notes

- 3D Prism



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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 Installation Report for I&M MS Poplar Dock & Crane Rails (83700-83500)
 C305-DSJ-C2-GMS-CRG03-50021
 Scale: 1:500 @ A1
 Drawing and CAD file No.: C305-DSJ-C2-DDA-CRT00_ST006_Z-08096
 Rev: P02
 Suitability: S4

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Fit for authorisation
RESTRICTED

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APPENDIX B: SUMMARY OF INSTRUMENTATION INSTALLED ON SITE

IRS Installation Record Sheets - 3D PRISMS

Sensor Type	Sensor ID	Date Installation	Status	SENSOR Location - GPS reading (m)			Commissioning Readings (m)			
				Eastings X	Northings Y	Elevation Z (mATD)		Eastings X	Northings Y	Elevation Z (mATD)
3D Prisms	C305-RP042201	10/10/2012	Installed	88568.807	35038.272	105.338	Baseline	88568.8074	35038.2723	105.3380
							08/11/2012	88568.8072	35038.2719	105.3377
							08/11/2012	88568.8076	35038.2729	105.3381
							09/11/2012	88568.8073	35038.2720	105.3382
3D Prisms	C305-RP042202	10/10/2012	Installed	88570.540	35025.398	105.351	Baseline	88570.5395	35025.3982	105.3512
							08/11/2012	88570.5395	35025.3986	105.3510
							08/11/2012	88570.5396	35025.3980	105.3511
							09/11/2012	88570.5393	35025.3981	105.3514
3D Prisms	C305-RP042203	10/10/2012	Installed	88572.534	35010.519	105.352	Baseline	88572.5341	35010.5189	105.3520
							08/11/2012	88572.5335	35010.5193	105.3518
							08/11/2012	88572.5342	35010.5192	105.3523
							09/11/2012	88572.5346	35010.5183	105.3520
3D Prisms	C305-RP042204	10/10/2012	Installed	88575.147	34990.698	105.361	Baseline	88575.1473	34990.6981	105.3611
							08/11/2012	88575.1475	34990.6985	105.3611
							08/11/2012	88575.1476	34990.6987	105.3609
							09/11/2012	88575.1469	34990.6970	105.3612
3D Prisms	C305-RP042205	10/10/2012	Installed	88577.549	34972.859	105.347	Baseline	88577.5493	34972.8585	105.3473
							08/11/2012	88577.5487	34972.8589	105.3474
							08/11/2012	88577.5498	34972.8587	105.3475
							09/11/2012	88577.5494	34972.8578	105.3471
3D Prisms	C305-RP042206	10/10/2012	Installed	88584.528	35041.759	105.334	Baseline	88584.5276	35041.7591	105.3339
							08/11/2012	88584.5272	35041.7596	105.3341
							08/11/2012	88584.5277	35041.7590	105.3339

Sensor Type	Sensor ID	Date Installation	Status	SENSOR Location - GPS reading (m)			Commissioning Readings (m)			
				Eastings X	Northings Y	Elevation Z (mATD)		Eastings X	Northings Y	Elevation Z (mATD)
							09/11/2012	88584.5280	35041.7587	105.3338
3D Prisms	C305-RP042207	10/10/2012	Installed	88602.308	35044.435	105.340	Baseline	88602.2082	35044.4353	105.3397
							08/11/2012	88602.2086	35044.4348	105.3401
							08/11/2012	88602.2082	35044.4356	105.3398
							09/11/2012	88602.2078	35044.4354	105.3392
3D Prisms	C305-RP042208	10/10/2012	Installed	88625.503	35047.786	105.342	Baseline	88625.5031	35047.7859	105.3418
							08/11/2012	88625.5029	35047.7858	105.3415
							08/11/2012	88625.5035	35047.7864	105.3418
							09/11/2012	88625.5030	35047.7854	105.3422
3D Prisms	C305-RP042209	10/10/2012	Installed	88652.837	35051.793	105.349	Baseline	88652.8381	35051.7830	105.3401
							08/11/2012	88652.8381	35051.7827	105.3407
							08/11/2012	88652.8371	35051.7841	105.3394
							09/11/2012	88652.8391	35051.7821	105.3402
3D Prisms	C305-RP042210	10/10/2012	Installed	88666.140	35034.443	105.435	Baseline	88666.1425	35034.4452	105.4350
							13/11/2012	88666.1419	35034.4445	105.4350
							13/11/2012	88666.1426	35034.4460	105.4339
							14/11/2012	88666.1431	35034.4451	105.4362
3D Prisms	C305-RP042211	10/10/2012	Installed	88670.141	35007.784	105.473	Baseline	88670.1469	35007.7858	105.4733
							13/11/2012	88670.1465	35007.7845	105.4734
							13/11/2012	88670.1472	35007.7850	105.4721
							14/11/2012	88670.1469	35007.7878	105.4744

Note: For 3D Prisms - the difference between Sensor location readings and Commissioning reading results from the use of a GPS staff and a manual level respectively.

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