



C300/410

Western Tunnels & Caverns Project

Final Monitoring Report

TBM DRIVES ~ from Paddington Station to Bond Street Station

CRL Document No. **C300-BFK-C4-RGN-CRT00_ST005-51015**

Contract MDL reference: C03.035

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		[REDACTED]	[REDACTED]	[REDACTED]	

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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: _____ Name: _____ Role: _____ Date: _____

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

2b. Review by Stakeholder (if required):

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

3. Acceptance by Crossrail:

	Crossrail Review and Acceptance Decal			
	This decal is to be used for submitted documents requiring acceptance by Crossrail.			
<input checked="" type="checkbox"/>	Code 1.	Accepted. Work May Proceed		
<input type="checkbox"/>	Code 2.	Not Accepted. Revise and resubmit. Work may proceed subject to incorporation of changes indicated		
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1. Purpose and Scope

The purpose of this document is to provide a summary of the observed movements relative to the TBM works between Paddington and Bond Street Stations in accordance with the requirements of the Instrumentation and Monitoring Specification KX10, Clauses KX10.2113 and KX10.2114.

KX10.2114 Close-Out Reports

Prior to the de-commissioning of any instrumentation, the *Contractor* shall produce a "close-out" report which summarises the data from the instrumentation the *Contractor* wishes to remove and relates it to the construction activities which produced any observed changes. The report shall demonstrate that the rate of change in the data has reached an acceptably small rate either in accordance with specified rates or, where no rate is specified, in relation to trigger values and an evaluation of any potential residual risks.

This report is one of a series of 5 which cover the TBM drives between Royal Oak Portal and Farringdon Station as listed in Table 1.

Report title: <i>Final and Close Out Monitoring</i>	Report Number: C300-BFK-C4-RGN-CRT00_ST005-	Eastbound Tunnel		Westbound Tunnel	
		Start Chainage	End Chainage	Start Chainage	End Chainage
Royal Oak Portal to Paddington Station (ROP to PAD)	51232	510	1312	510	1300
Paddington Station to Bond Street Station (PAD to BOS)	51015	1670	3561	1660	3568
Bond Street Station to Tottenham Court Road Station (BOS to TCR)	51016	4187	4672	4159	4679
Tottenham Court Road Station to Fisher Street Shaft & Crossover (TCR to FIS)	51129	5147	5792	5108	5856
Fisher Street Shaft & Crossover to Farringdon Station (FIS to FAR)	51130	6097	6860	6162	6945

Table 1 List of Final / Close Out Reports for TBM drives Royal Oak Portal to Farringdon.

1.1. Executive summary

This document includes settlement data from instruments on assets (BRE) and from general ground transects (PLP) for the TBM drives between Paddington Station and Bond Street Station.

A summary of the monitoring data is provided, with the influence of the two TBM drives identified. The rate of post-construction settlement is compared to the specified limit of 2mm/year and the absolute magnitude of settlement is compared to the trigger values given in the C122 I&M plan. Points where trigger levels have been exceeded are listed. Monitoring data from Cross Passage 2, Cross Passage 3, Cross Passage 4 is also presented.

Information about Thames Water assets is also provided, both within the report and in Appendix 3 (summary table). In general, no deflection amber trigger (average of 3 values) has been breached on Thames Water assets.

The transects from which data is presented are listed in Table 2. The locations of the instruments are plotted in Appendix 7 and those from which data is presented are identified. A summary of the final settlements recorded on all BRE and PLP is also given in Appendix 7. The maximum recorded settlement between Paddington and Bond Street Stations is just over -30mm.

The transects marked with "*" in Table 2 were de-scoped less than 1 year after the passage of the TBMs. This was agreed during dedicated meetings with CRL and C122 based on analysis of the monitoring data (trends and settlement values).

Data is presented from sub-surface instruments comprising "shallow datums" in and around Sussex Square, inclinometers and extensometers in Hyde Park and North Audley Street and piezometers in Hyde Park.

TBM progress information, supporting documents references, and a summary of claims for building damage (provided by CRL) are provided in Appendices 1, 2 and 4 respectively.

The data from LU assets is presented in Appendix 5. The slides reported in Appendix 5 have been presented to LU, CRL and C122 representatives during dedicated meetings at which further monitoring was de-scoped.

It should be noted that the data from all instruments is available on the UCIMS platform.

Sections
Conduit Place
Spring Street
Sussex Gardens
Bathurst Mews
Sussex Square
North Carriage Drive
Bayswater road
Hyde Park Sections
Park Lane*
Park Street*
North Audley Street*
Balderton Street*
Duke Street*

LU assets
LU03 – District and Circle Lines
LU05 – Central Line East of Lancaster Gate

Table 2 Sections from which data is presented

It should be noted that some transects include a large number of measuring points. In these cases, for the sake of clarity, only the points within the zone of influence of the TBMs have been included in the charts.

2. Summary of the observed settlements

2.1. Conduit Place PLPs

2.1.1. Data

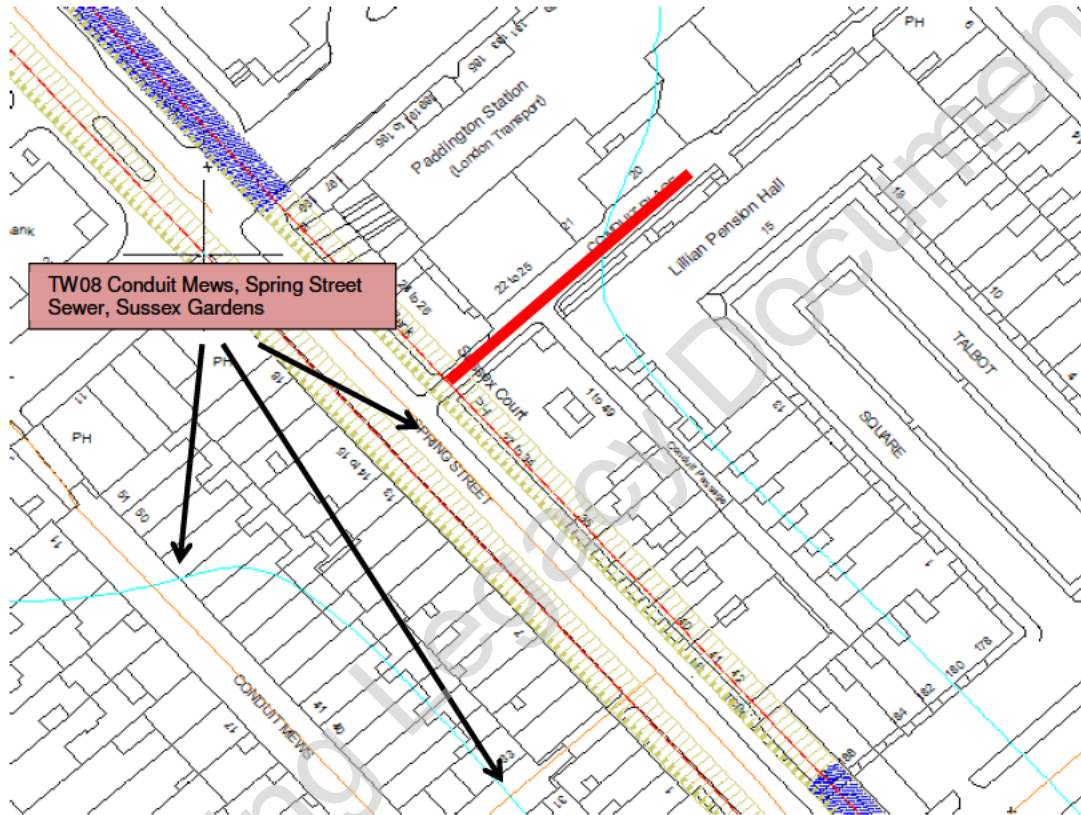


Figure 1: Location

PLPs - Conduit Place

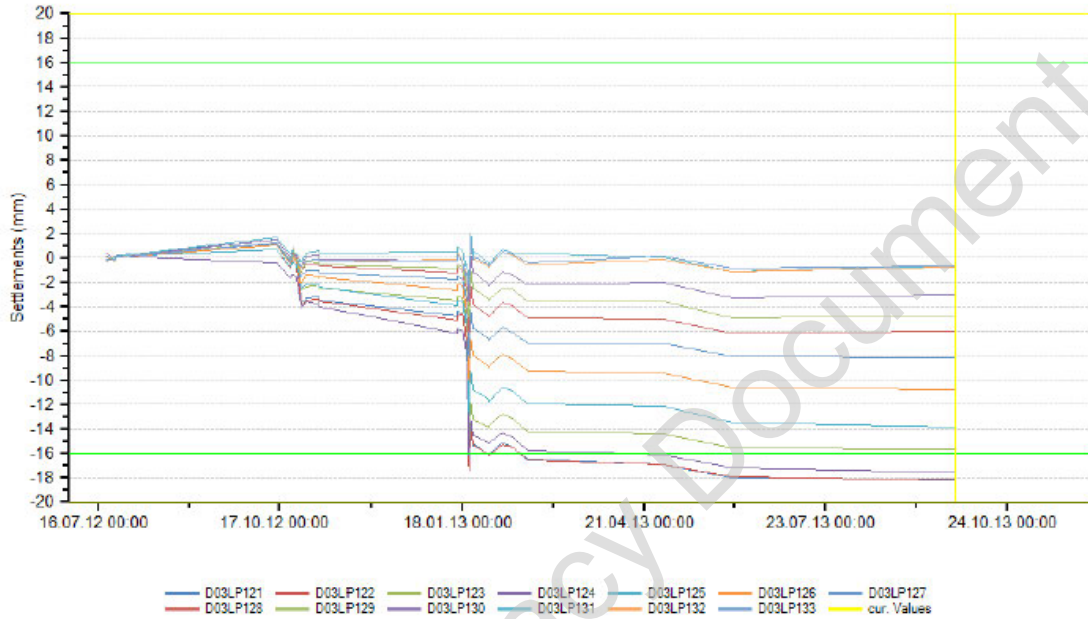


Figure 2: data time-plots: comparison against settlement triggers

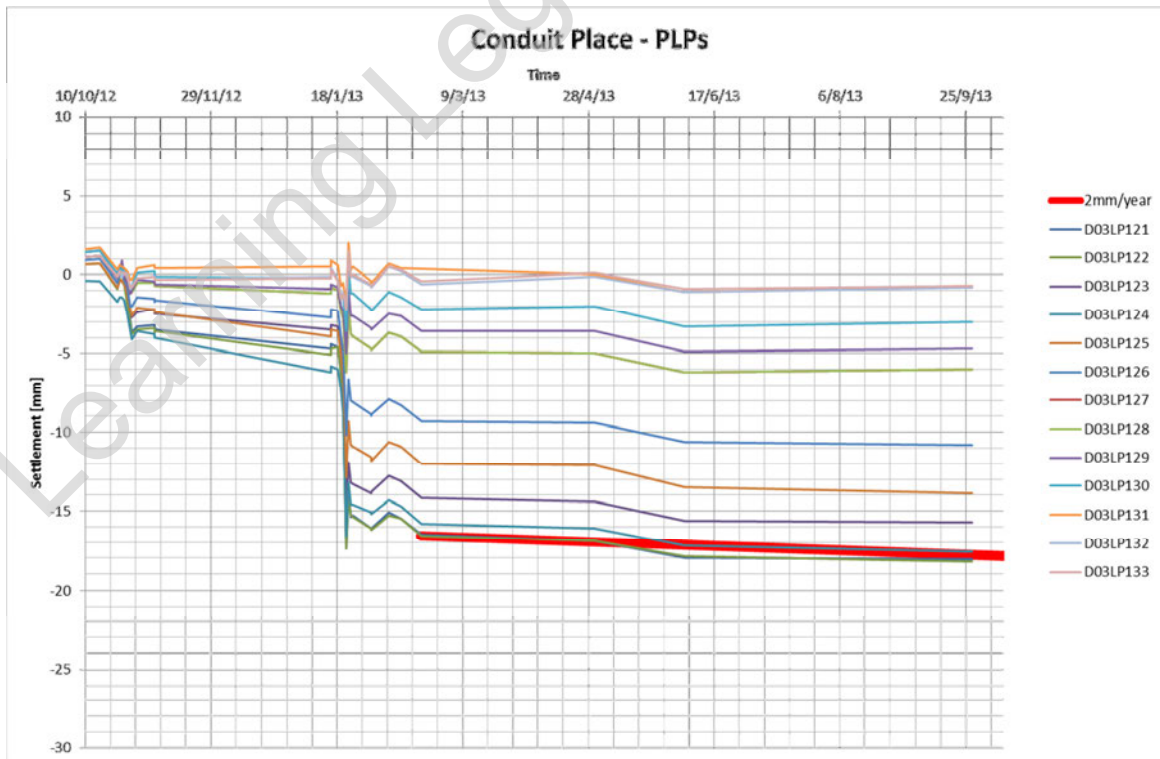


Figure 3: data time-plots - comparison against 2mm/year settlement rate (long-term)

Table 3: Achieved Triggers – settlements and deflection ratio

Point Code	Point type	Achieved Trigger
D03LP121	PLP	Green
D03LP122	PLP	Amber
D03LP123	PLP	Green
D03LP124	PLP	Green
Worst case deflection ratio (average of 3 values) [1/-]		Trigger
4,900		no

2.1.2. Comments

The PLPs in Conduit Place settled up to approx. 18mm due to the C300 running tunnels excavation. The effect of the WB and EB TBMs is clearly visible from the settlement time-plots. Three points breached green trigger and one point breached amber trigger. The long-term trend is approximately around 2mm/year, and appears to stabilise with the last readings.

The residual risk associated with long-term settlements is considered to be negligible.

2.2. Spring Street PLPs and BREs

2.2.1. Data

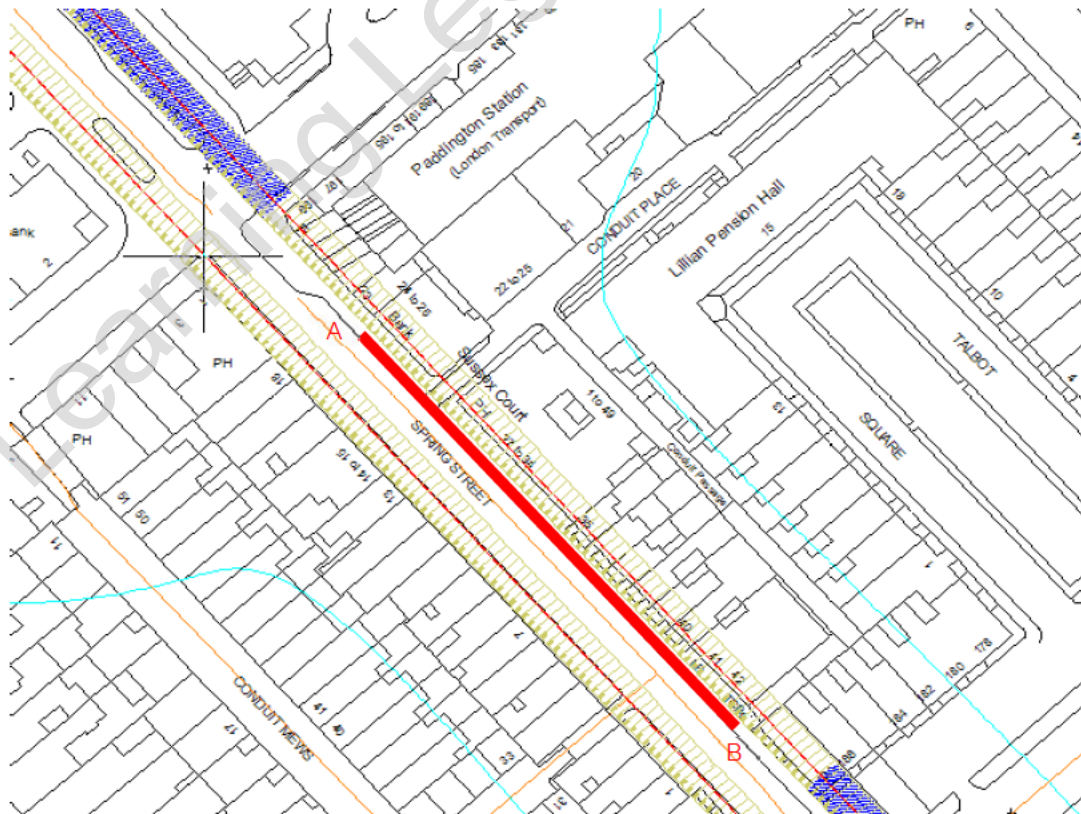


Figure 4: Location

PLPs - 19-34 Spring Street NW

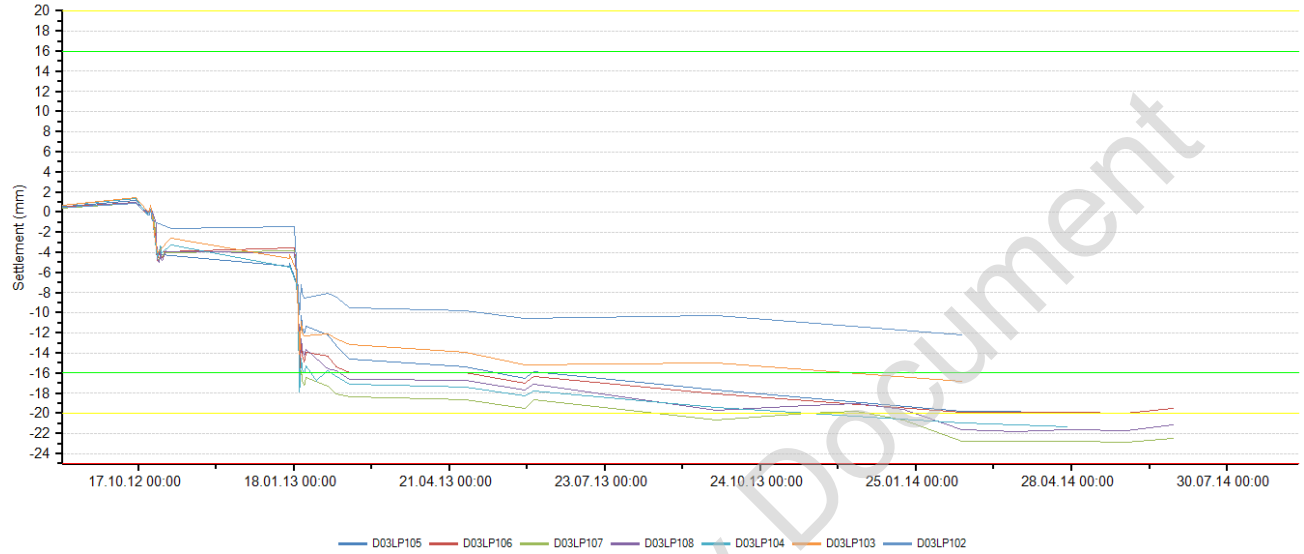


Figure 5: data time-plots: comparison against settlement triggers

PLPs - 35-42 Spring Street NW

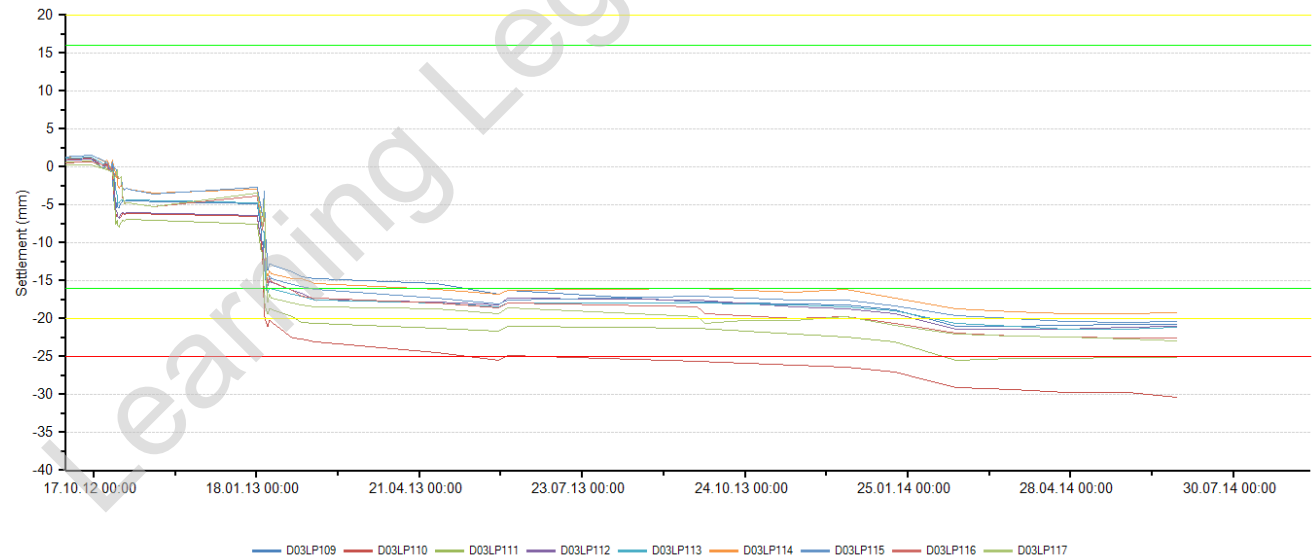


Figure 6: data time-plots: comparison against settlement triggers

BREs - 41-42 Spring Street NW

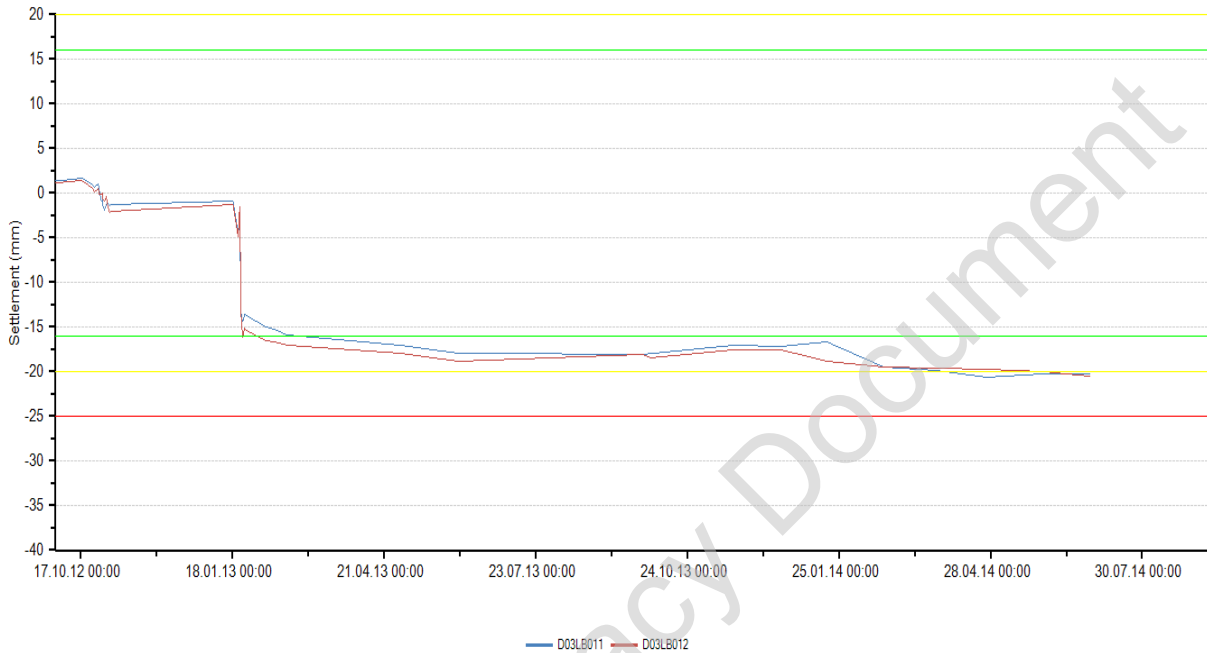


Figure 7: data time-plots - comparison against settlement triggers

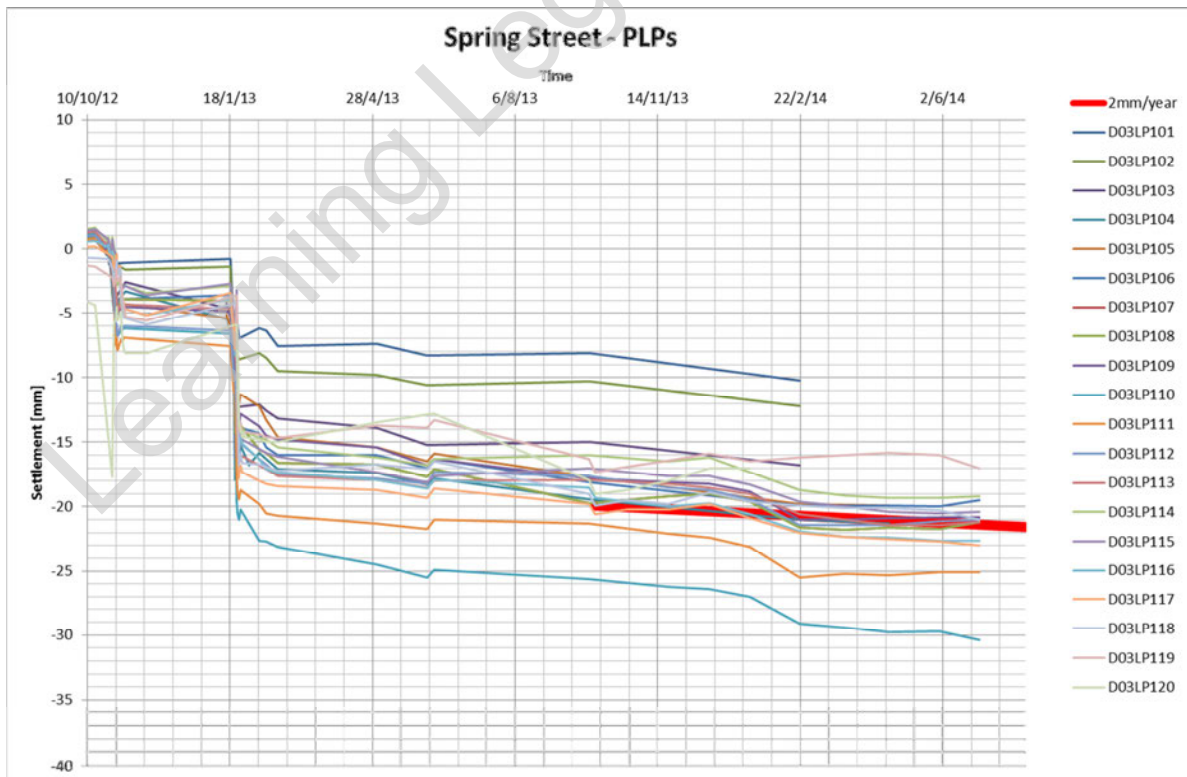


Figure 8: data time-plots - comparison against 2mm/year settlement rate (long-term)

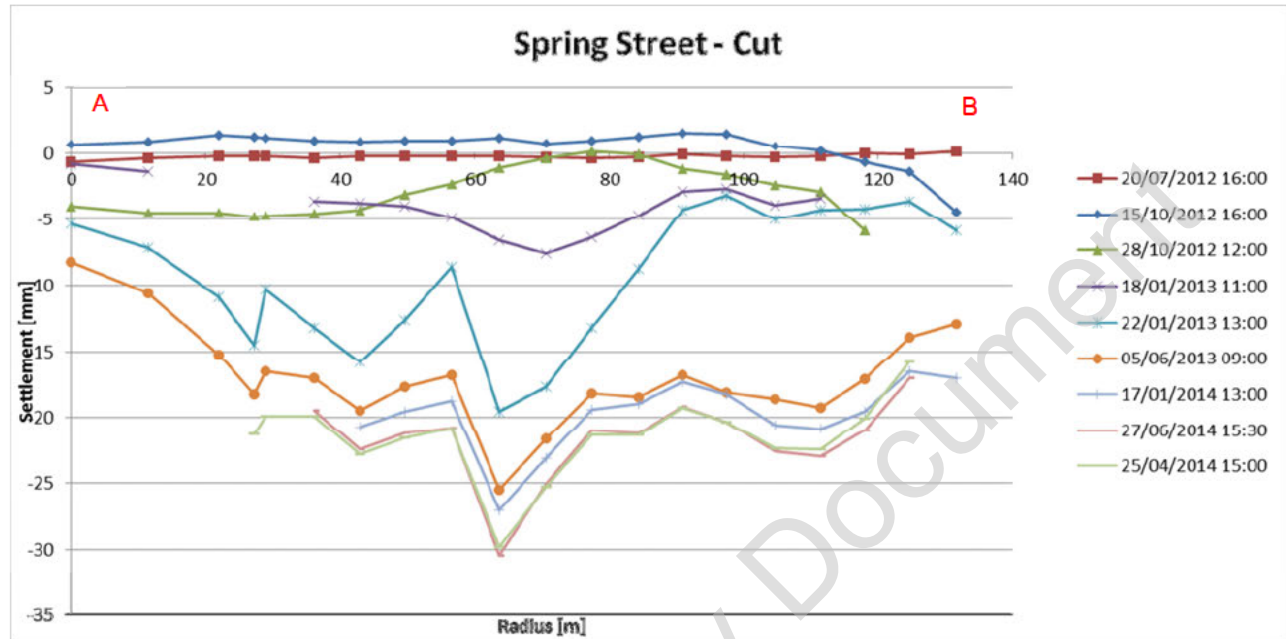


Figure 9: longitudinal cut along Spring Street.

Table 4: Achieved Triggers – settlements, slopes and deflection ratios

Point Code	Point type	Achieved Trigger
D09LP103	PLP	Green
D09LP104	PLP	Amber
D09LP105	PLP	Green
D09LP106	PLP	Green
D09LP107	PLP	Amber
D09LP108	PLP	Amber
D09LP109	PLP	Amber
D09LP110	PLP	Red
D09LP111	PLP	Red
D09LP112	PLP	Amber
D09LP113	PLP	Amber
D09LP114	PLP	Green
D09LP115	PLP	Amber
D09LP116	PLP	Amber
D09LP117	PLP	Amber
D09LP118	PLP	Amber
D09LP119	PLP	Green
D09LP120	PLP	Green
A04LP103	PLP	Green

Worst case deflection ratio (average of 3 values) [1/-]	Trigger
10,000	no
Worst case slope [1/-]	Trigger
2,400	no

2.2.2. Comments

The PLPs in Spring Street settled up to approx. 30mm and the BREs up to approx. 20mm due to the C300 running tunnels excavation. The effect of the WB and EB TBMs is clearly visible from the settlement time-plots. There has been a post-construction increase in settlement of up to 10mm on PLP and 5mm on BRE. The most recent readings show a stabilising trend.

2.3. Sussex Gardens PLPs

2.3.1. Data

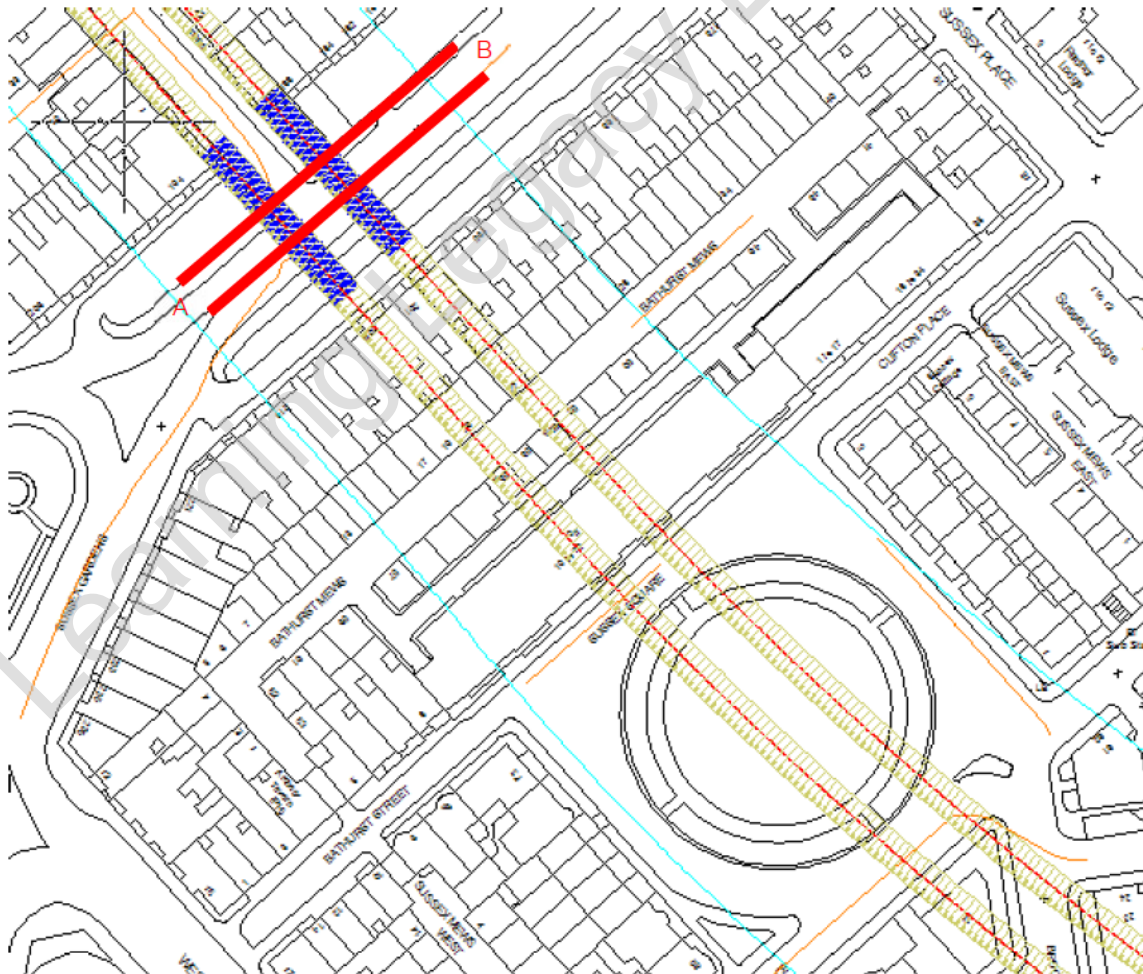


Figure 10: Location

**PLPs - Sussex Gardens West
Thames Water asset**

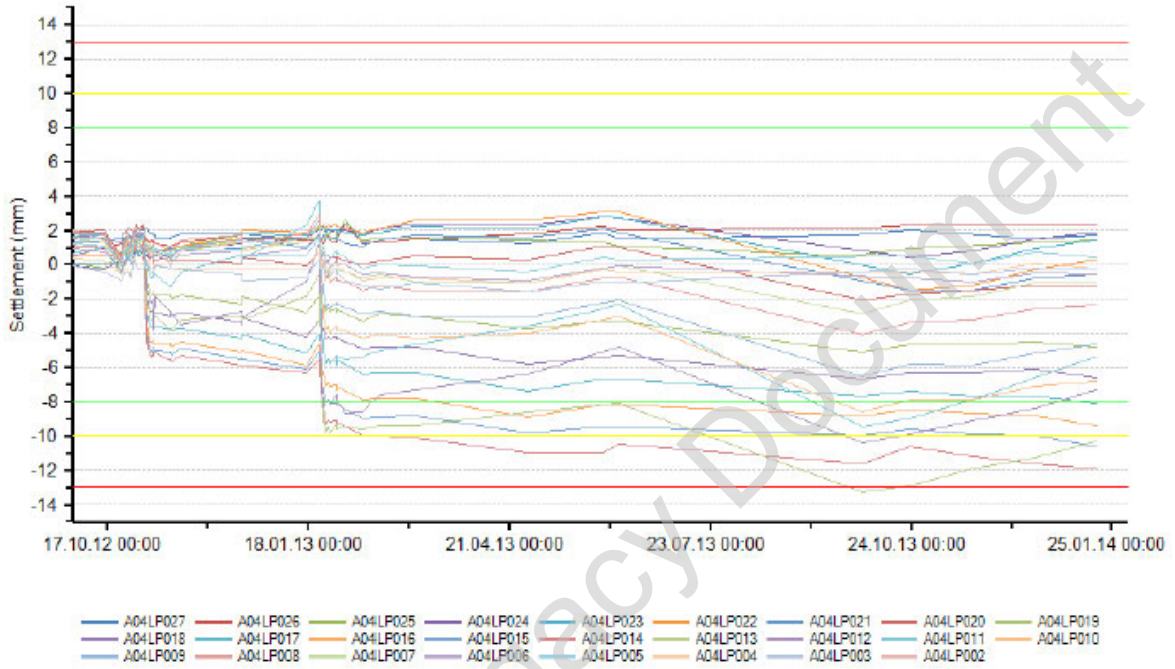


Figure 11: data time-plots - comparison against settlement triggers

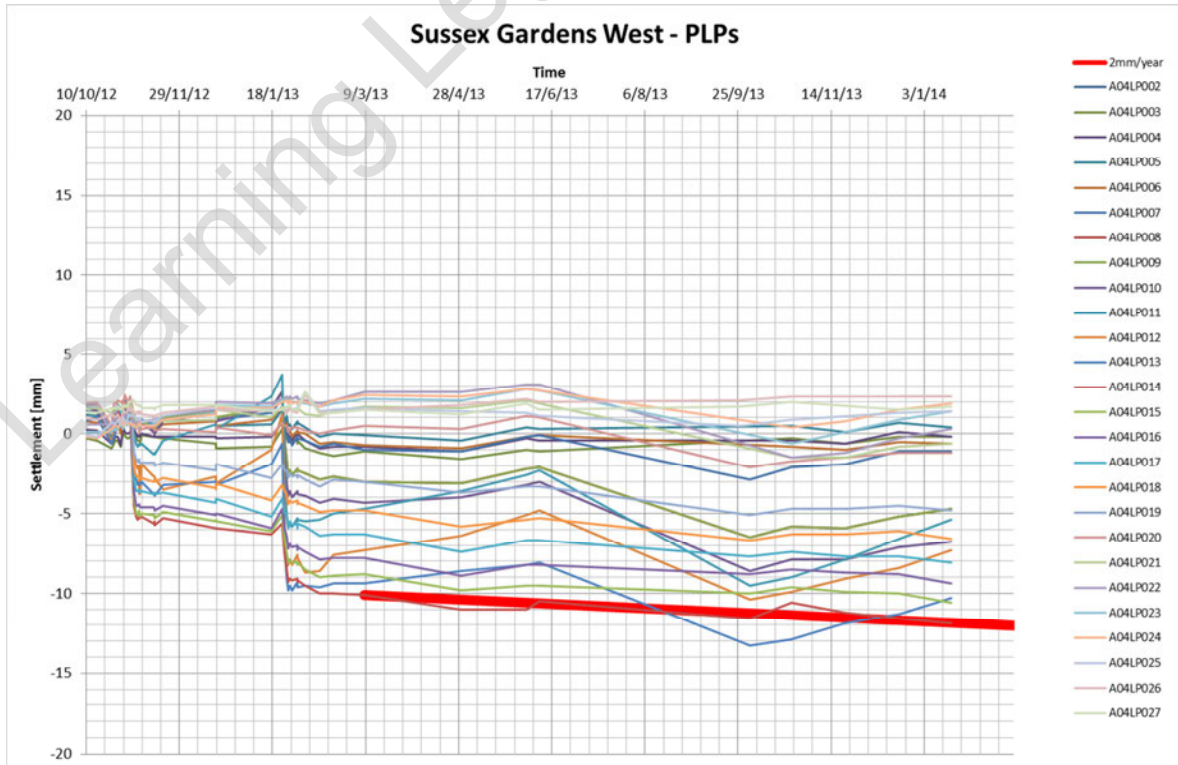


Figure 12: data time-plots - comparison against 2mm/year settlement rate (long-term)

PLPs at Sussex Gardens - Thames Water asset

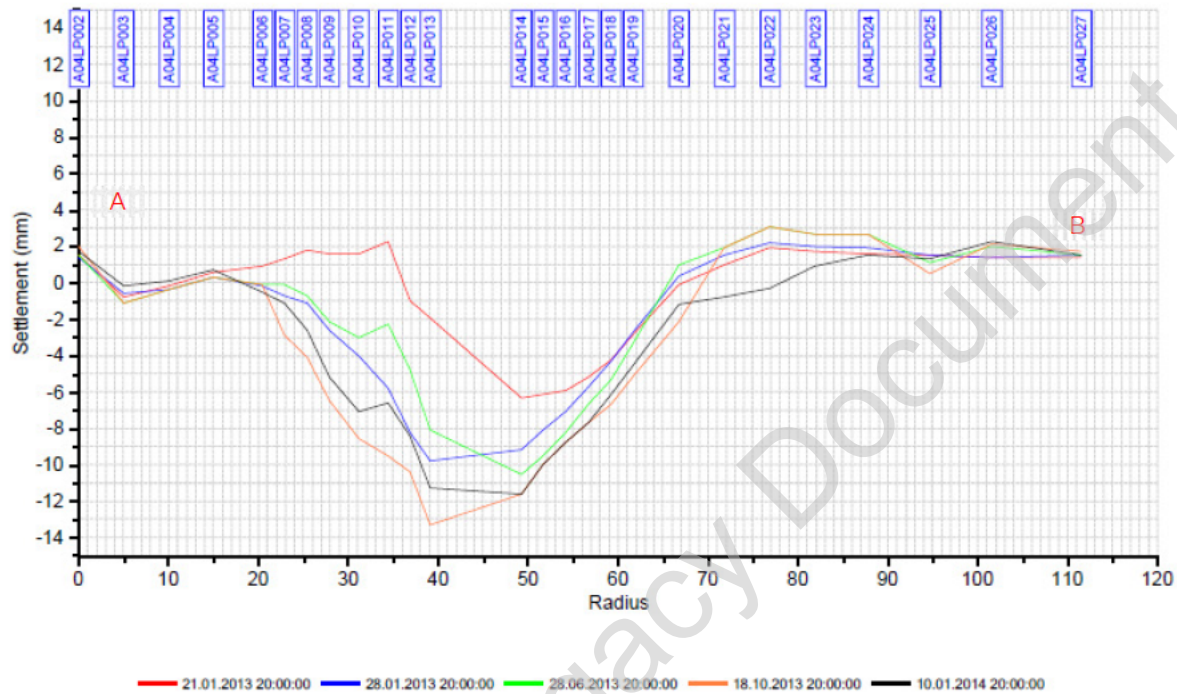


Figure 13: Sussex Gardens West cut

PLPs - Sussex Gardens East

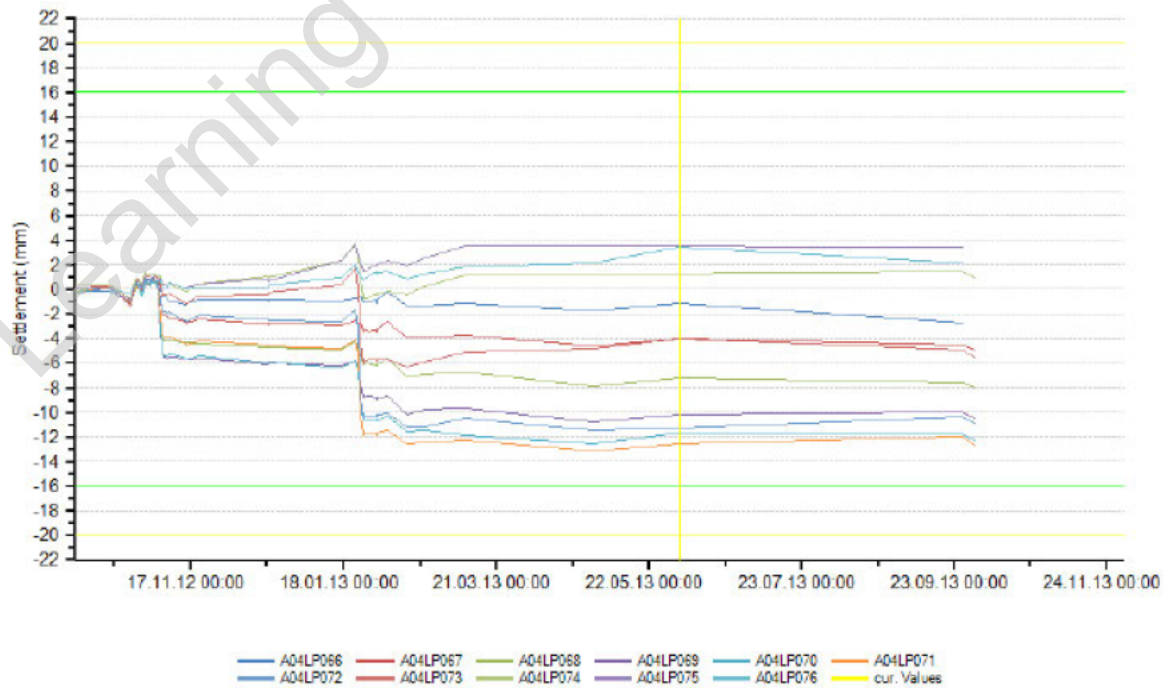


Figure 14: data time-plots - comparison against settlement triggers

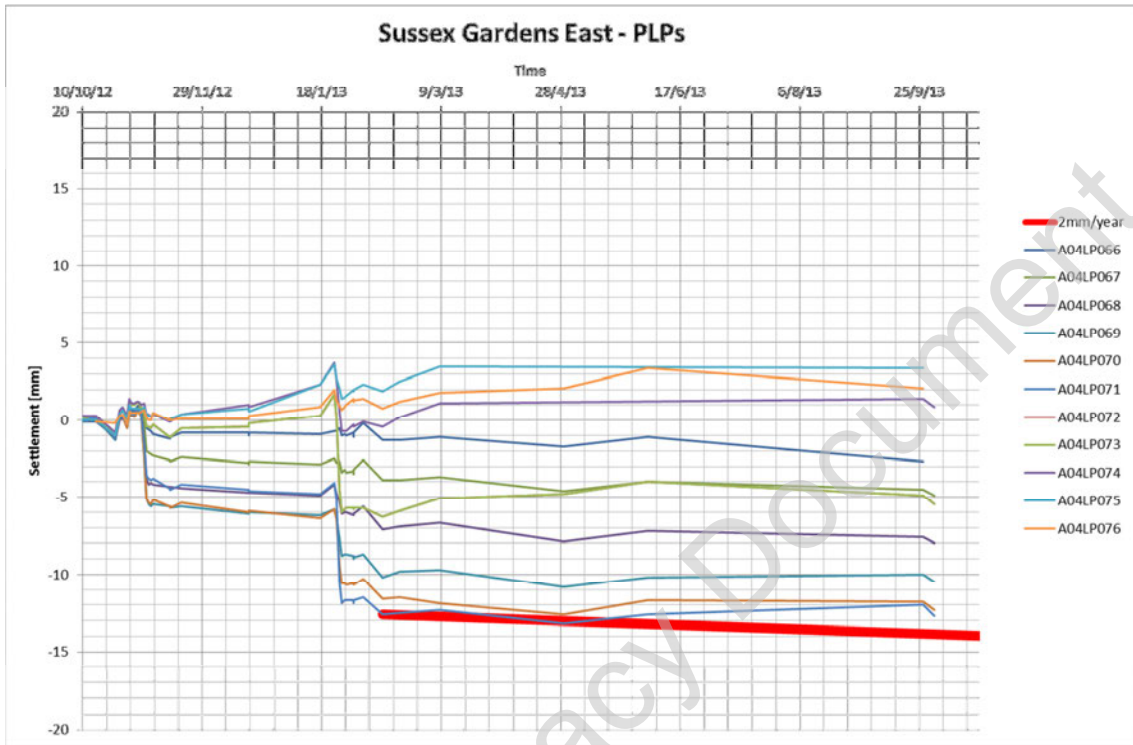


Figure 15: data time-plots - comparison against 2mm/year settlement rate (long-term)

Table 5: Achieved Triggers – settlements and deflection ratios

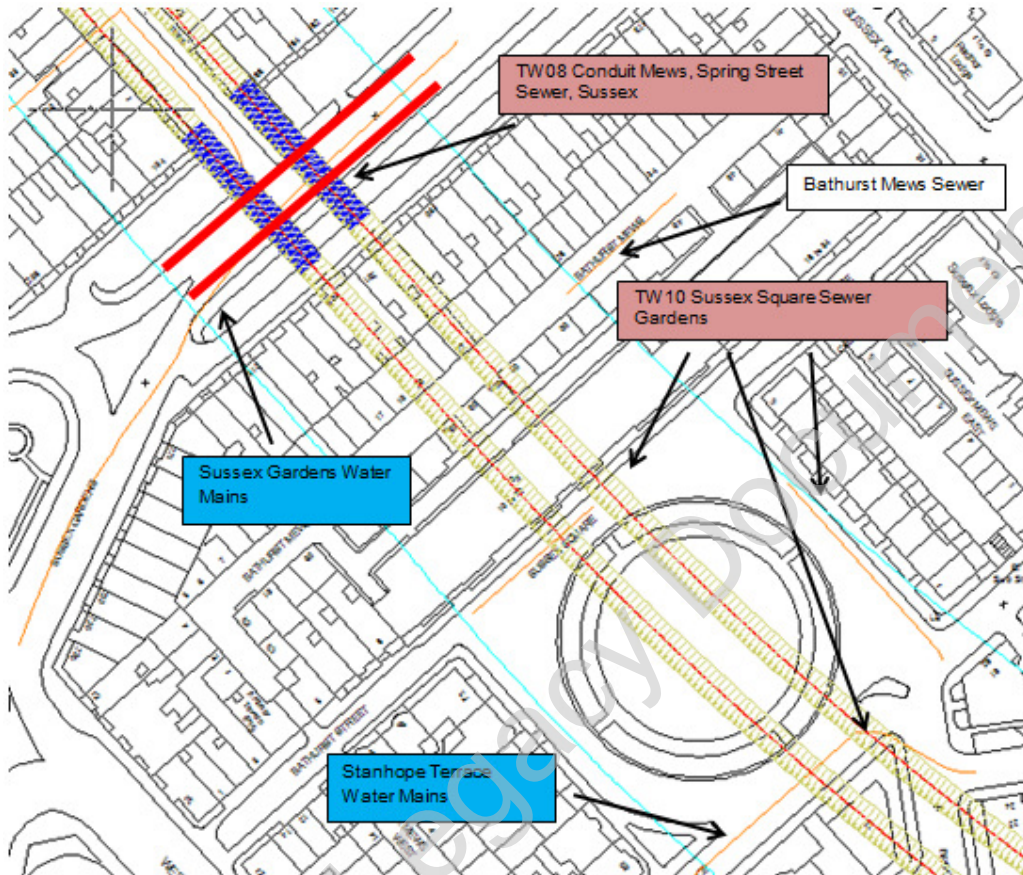
Point Code	Point type	Achieved Trigger
A04LP013	PLP	Green
A04LP014	PLP	Amber
A04LP015	PLP	Amber
A04LP016	PLP	Green
A04LP017	PLP	Green

Worst case deflection ratio (average of 3 values) [1/-]	Trigger
4.5 E+03	no

2.3.2. Thames Water Assets

NOTE: all the assets in Sussex Gardens have been replaced.

Asset Type	Location	Asset ID	Status
Water Main	Sussex Gardens	-	1 in 3200
Water Main	Sussex Gardens	-	1 in 3400
Water Main	Sussex Gardens	-	1 in 2700
Water Main	Sussex Gardens	-	1 in 2900



2.3.3. Comments

The PLPs in Sussex Gardens settled up to approx. 13mm due to the C300 running tunnels works. The effect of the WB and EB TBMs is clearly visible from the settlement time plots. Three points breached the green trigger and two points breached the amber trigger. The long-term behaviour shows stability over a period of 1 year.

The residual risk associated with long-term settlements is considered to be negligible.

2.4. Bathurst Mews BREs

2.4.1. Data

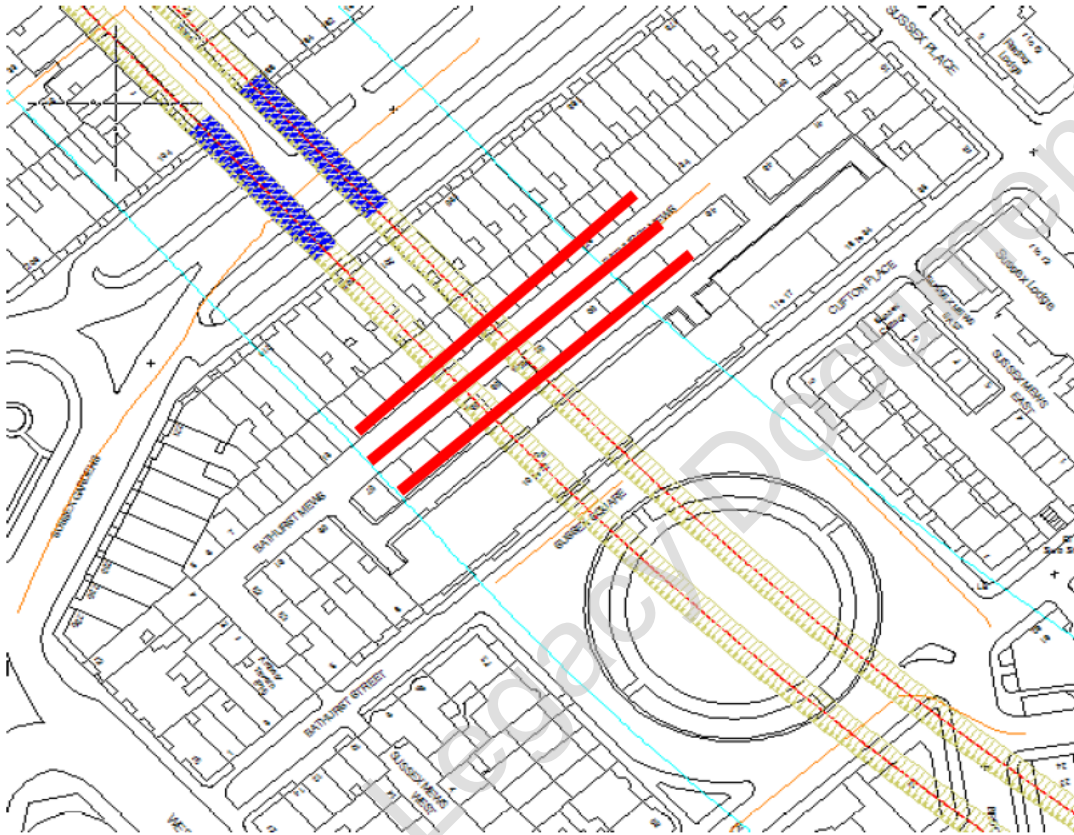


Figure 16: Location

BREs - Bathurst Mews West



Figure 17: data time-plots - comparison against settlement triggers

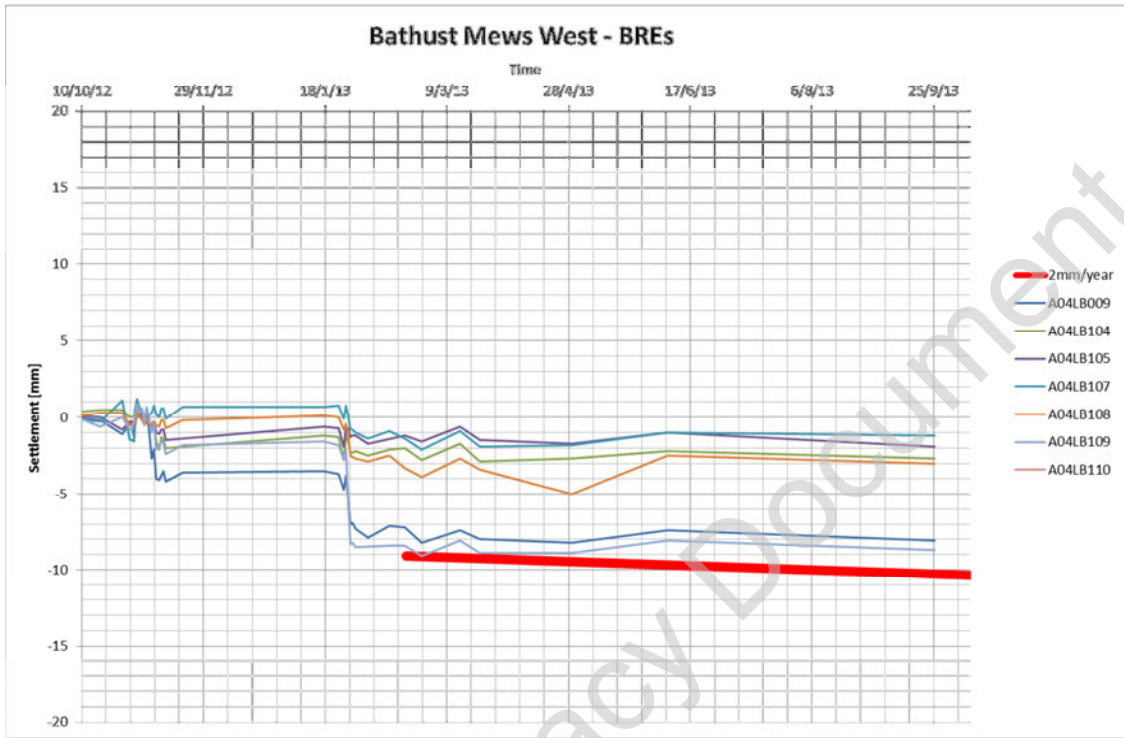


Figure 18: data time-plots - comparison against 2mm/year settlement rate (long-term)

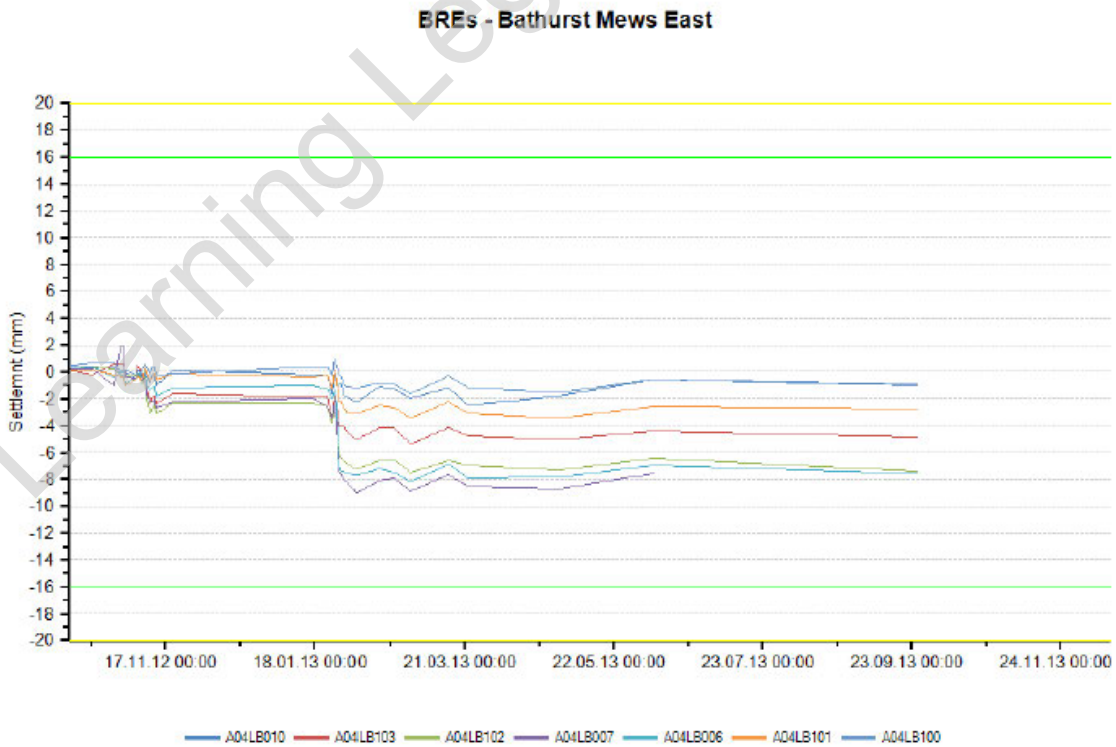


Figure 19: data time-plots - comparison against settlement triggers

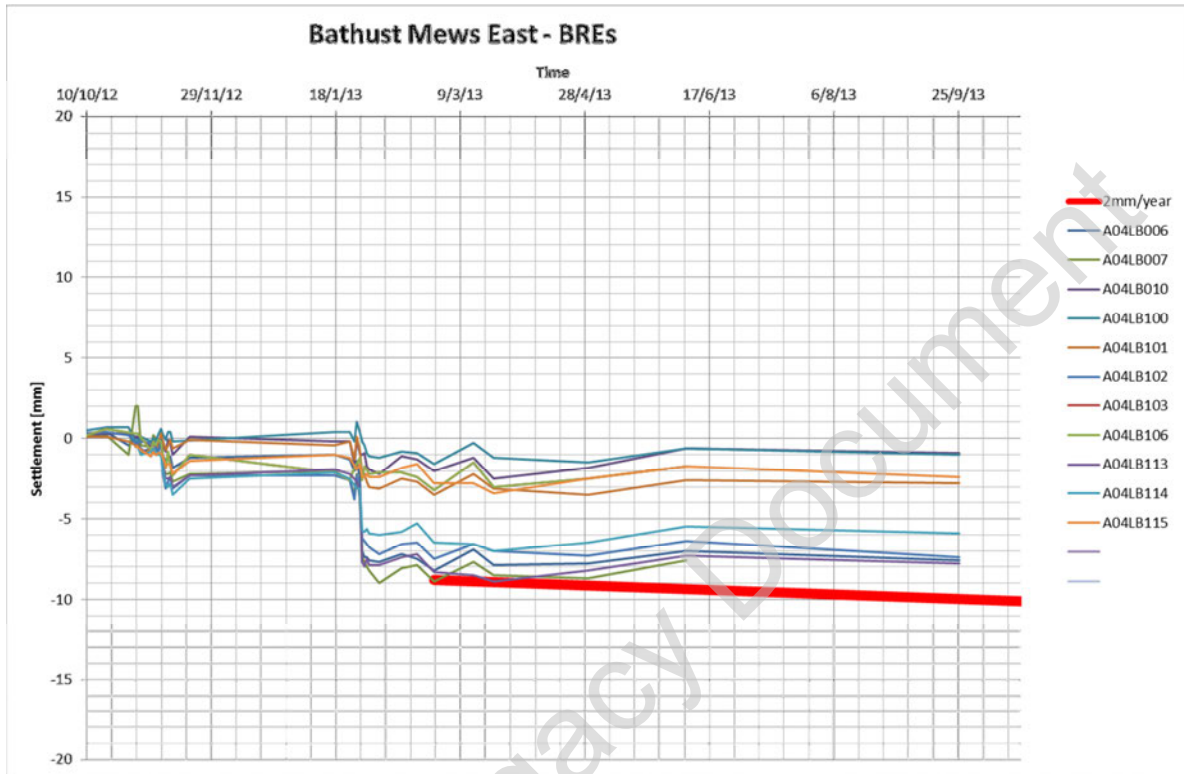


Figure 20: data time-plots - comparison against 2mm/year settlement rate (long-term)

2.4.2. Comments

The PLPs in Bathurst Mews settled up to approx. 8mm due to the C300 running tunnels works. The effect of the WB and EB TBMs is clearly visible from the settlement time plots. No triggers breached. The long-term behaviour shows no increase in settlement with stable reading over a period of over 7 months.

The residual risk associated with long-term settlements is considered to be negligible.

2.5. Sussex Square PLPs

2.5.1. Data

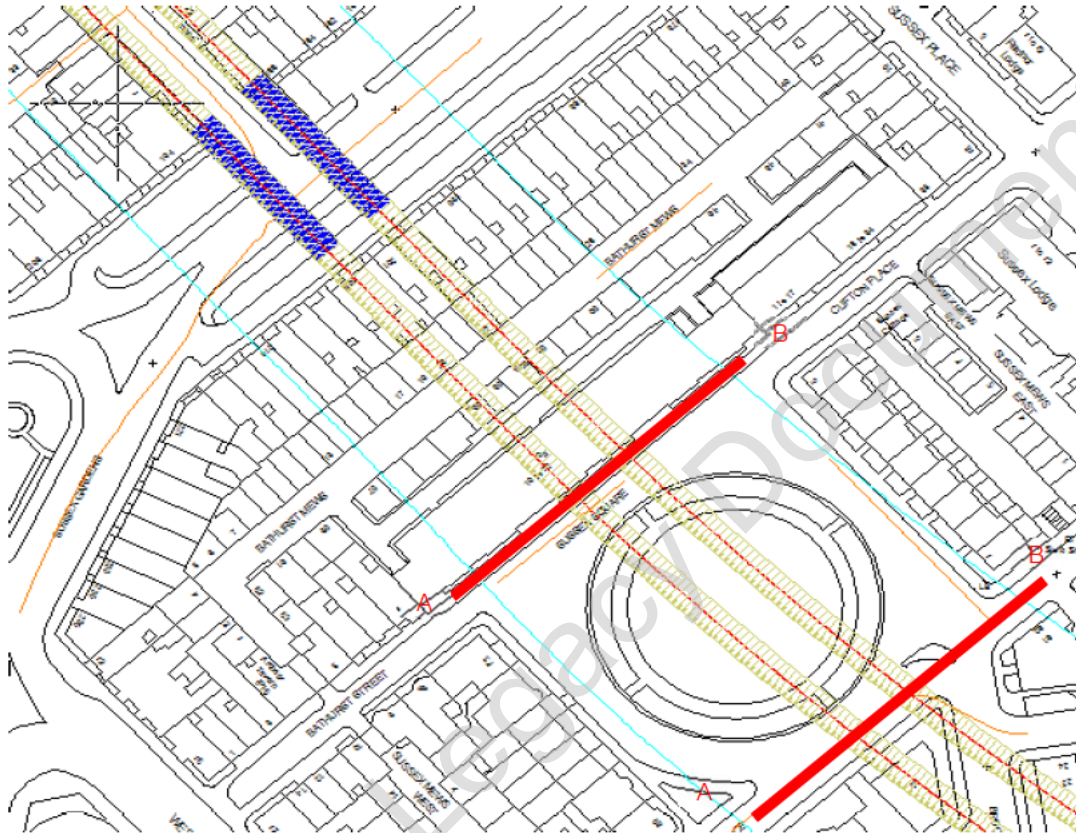


Figure 21: Location

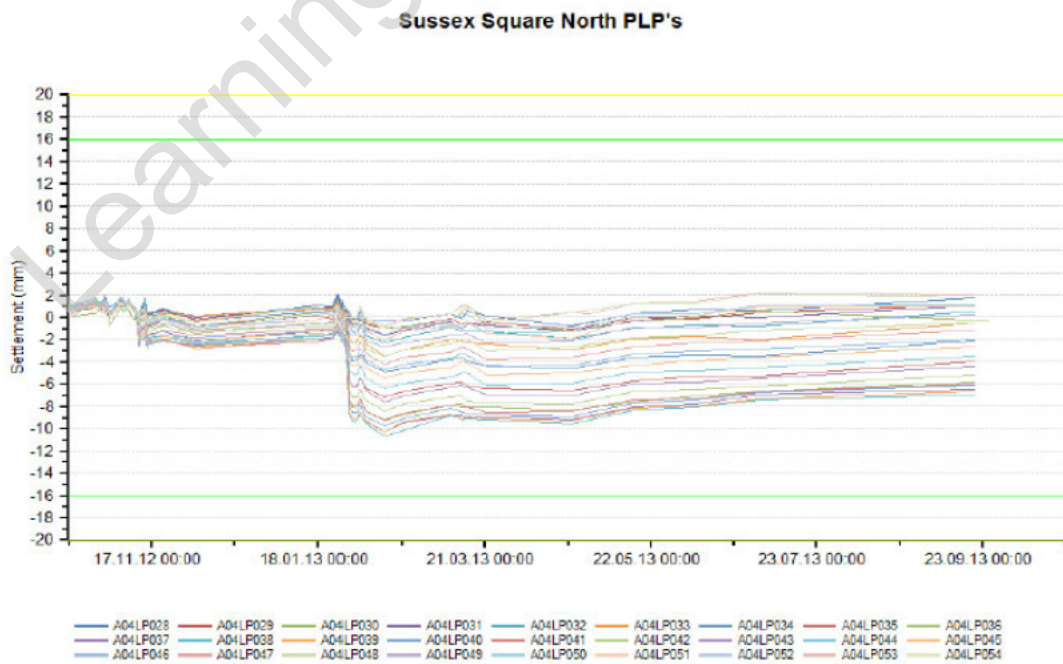


Figure 22: data time-plots - comparison against settlement triggers

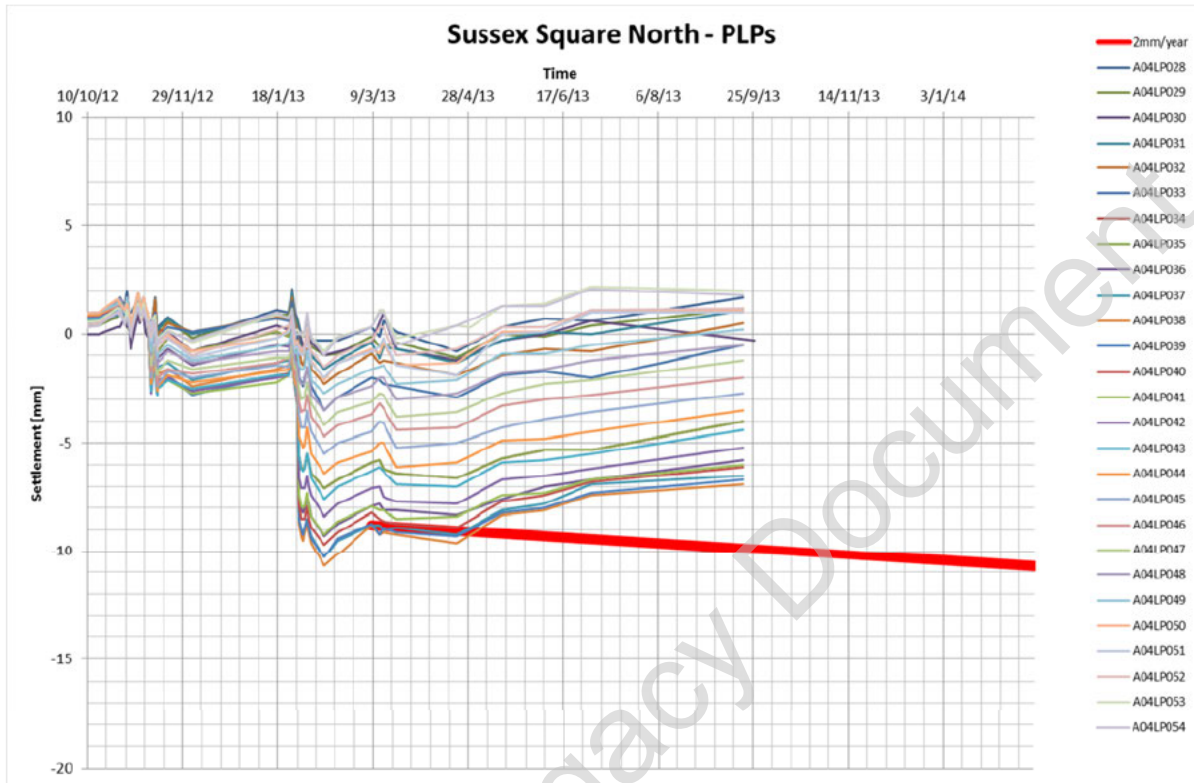


Figure 23: data time-plots - comparison against 2mm/year settlement rate (long-term)

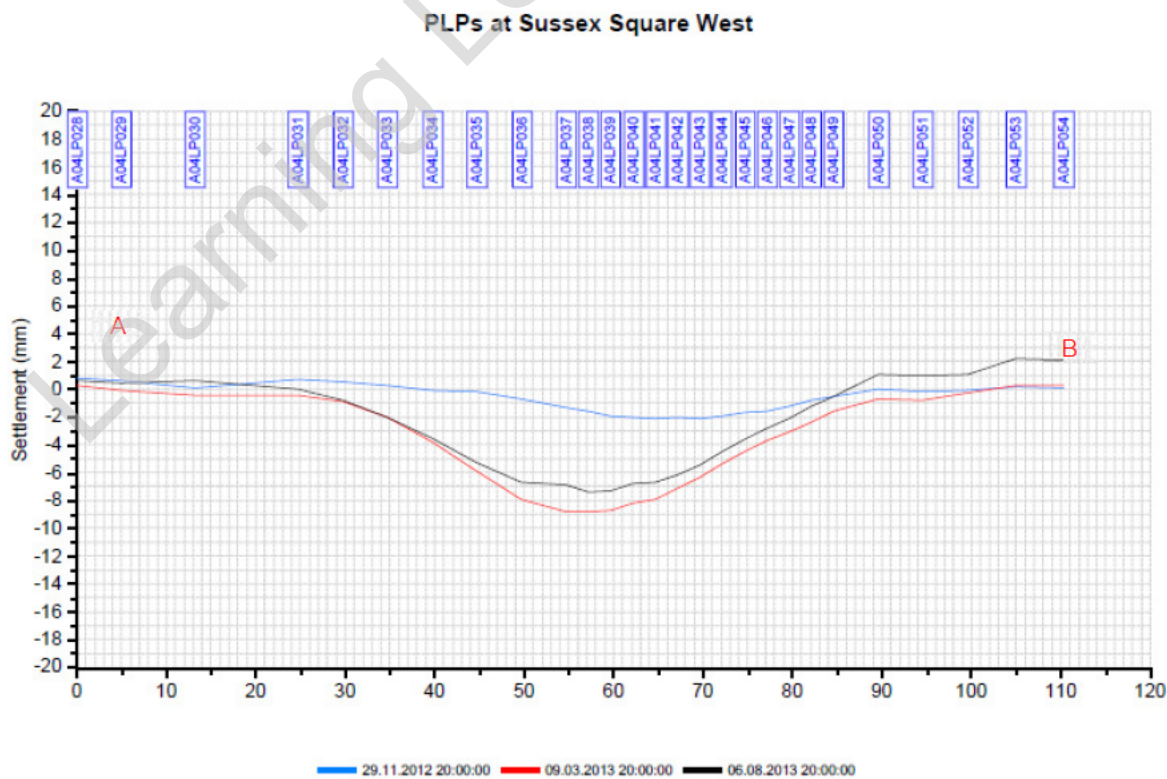


Figure 24: Sussex Square North cut

**Sussex Square PLPs South
Settlement**

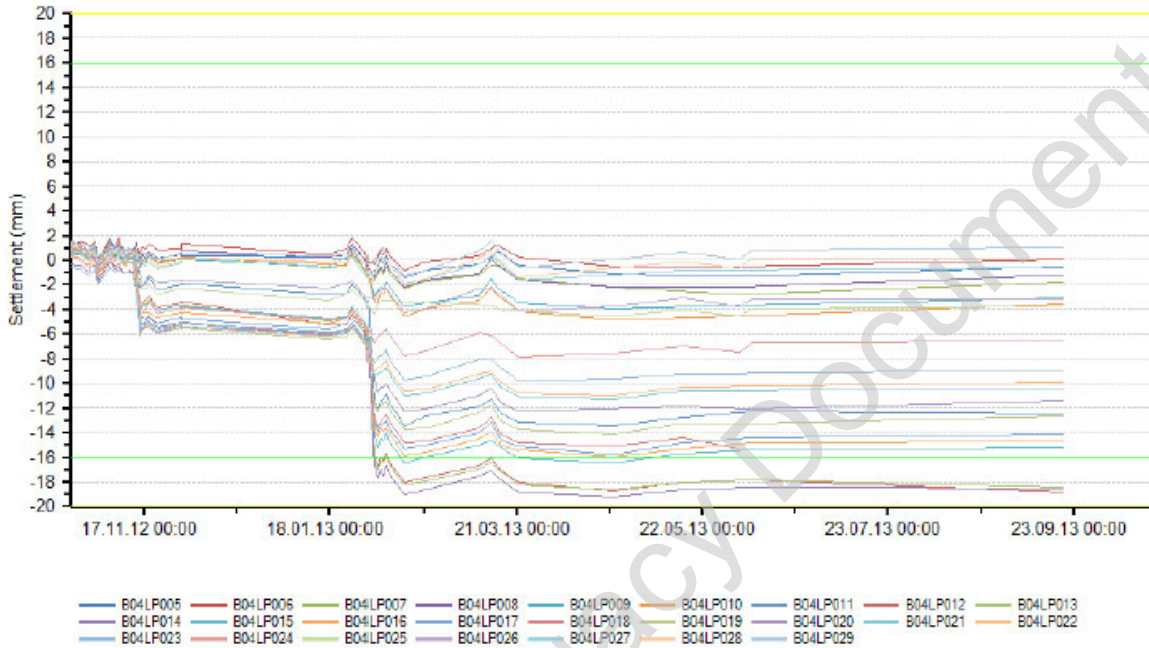


Figure 25: data time-plots - comparison against settlement triggers

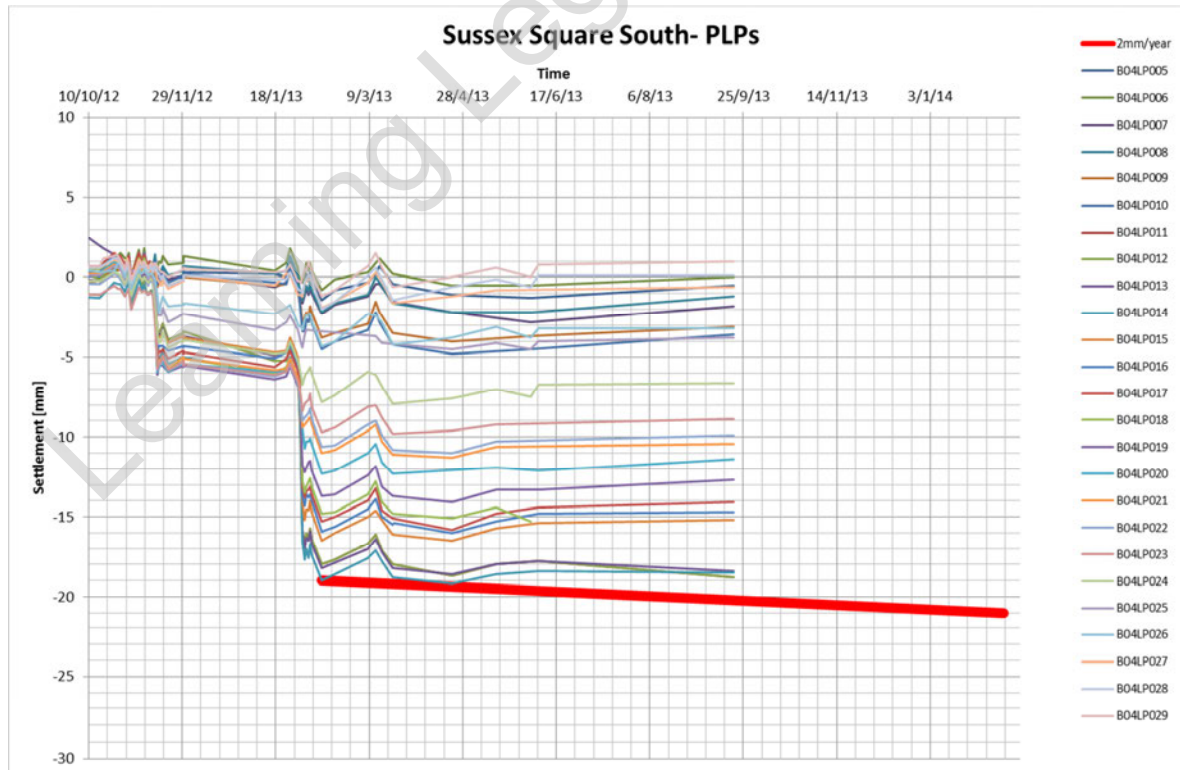


Figure 26: data time-plots - comparison against 2mm/year settlement rate (long-term)

PLPs at Sussex square South

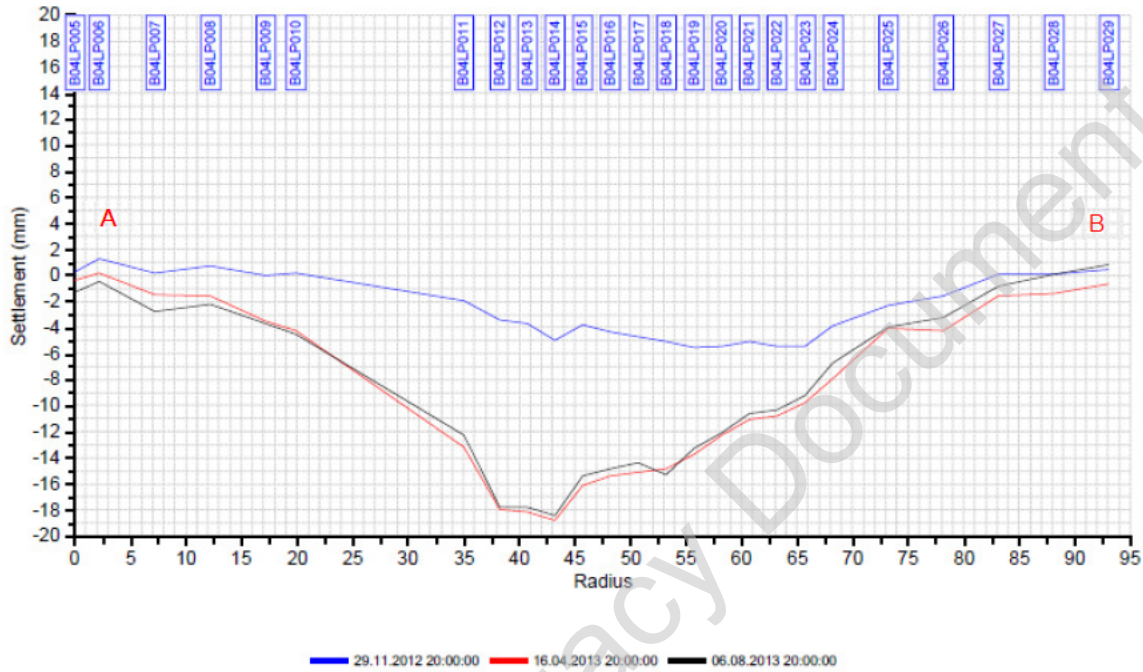


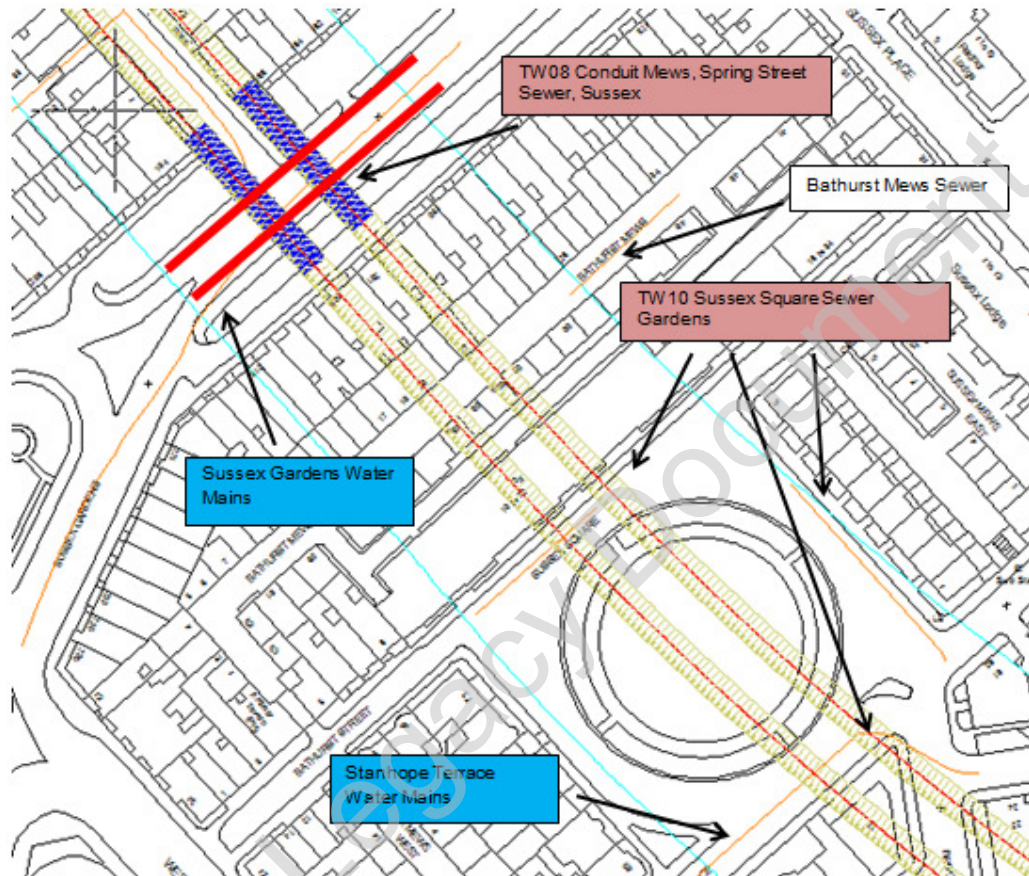
Figure 27: Sussex Square south cut

Table 6: Achieved Triggers – settlements and deflection ratios

Point Code	Point type	Achieved Trigger
B04LP013	PLP	Green
B04LP014	PLP	Green
B04LP015	PLP	Green

Worst case deflection ratio (average of 3 values) [1/-]	Trigger
5,300	no

2.5.2. Thames Water assets



2.5.3. Comments

The PLPs in Sussex Gardens settled up to approx. 20mm due to the C300 running tunnels works. The effect of the WB and EB TBMs is clearly visible from the settlement time plots. Three points breached the amber triggers. The long-term behaviour shows no increase in settlement with stable or decreasing readings over a period of over 7 months.

The residual risk associated with long-term settlements is considered to be negligible.

2.6. North Carriage Drive PLPs

2.6.1. Data

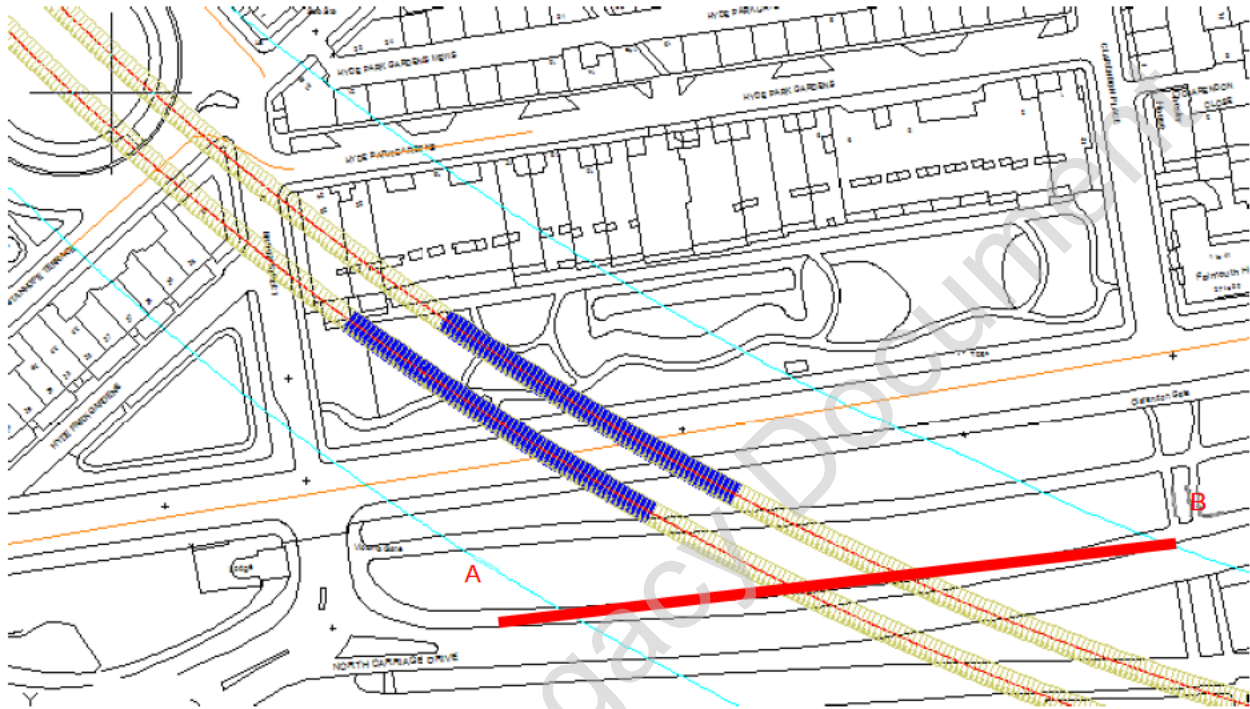


Figure 28: Location

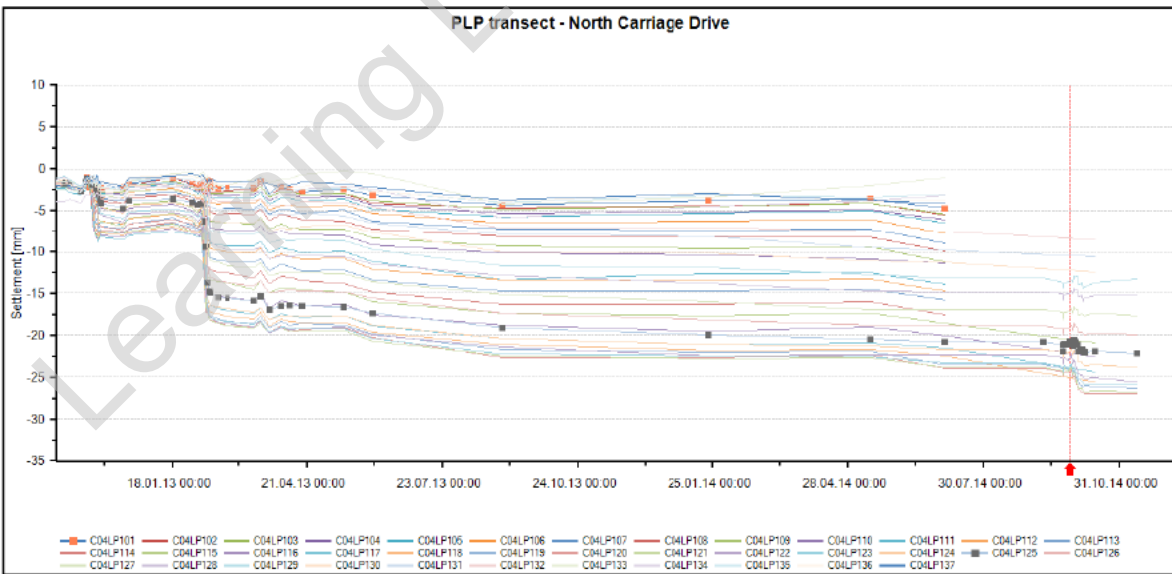


Figure 29: data time-plots - comparison against settlement triggers

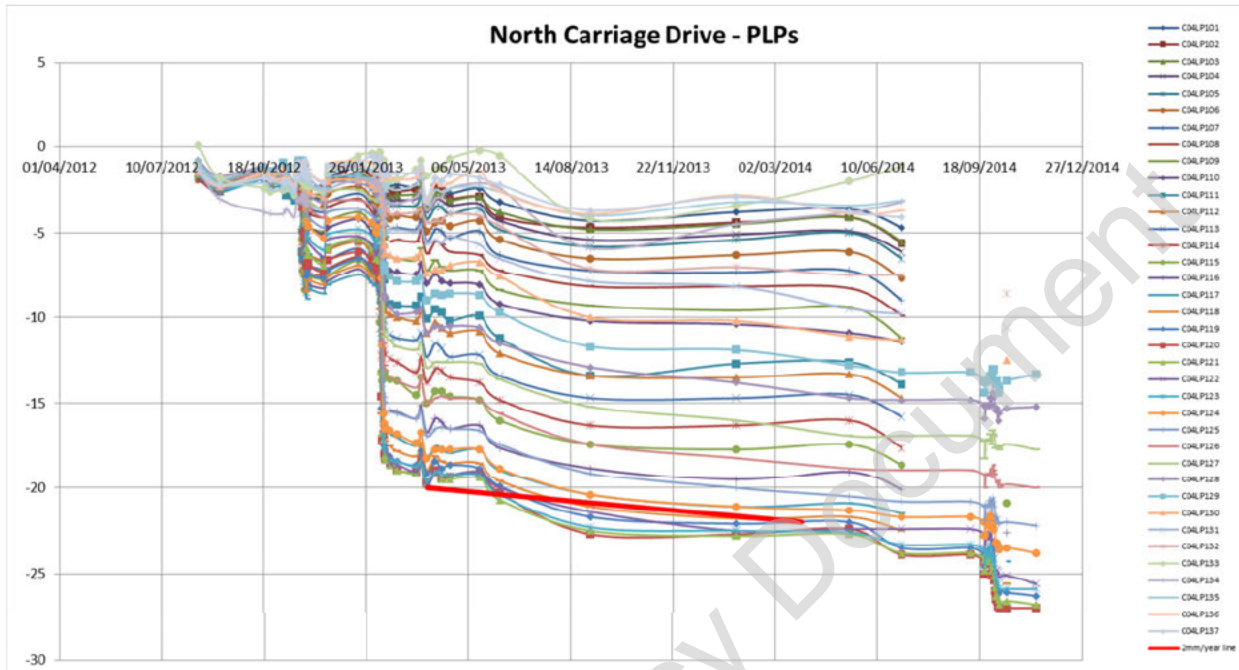


Figure 30: data time-plots - comparison against 2mm/year settlement rate (long-term)

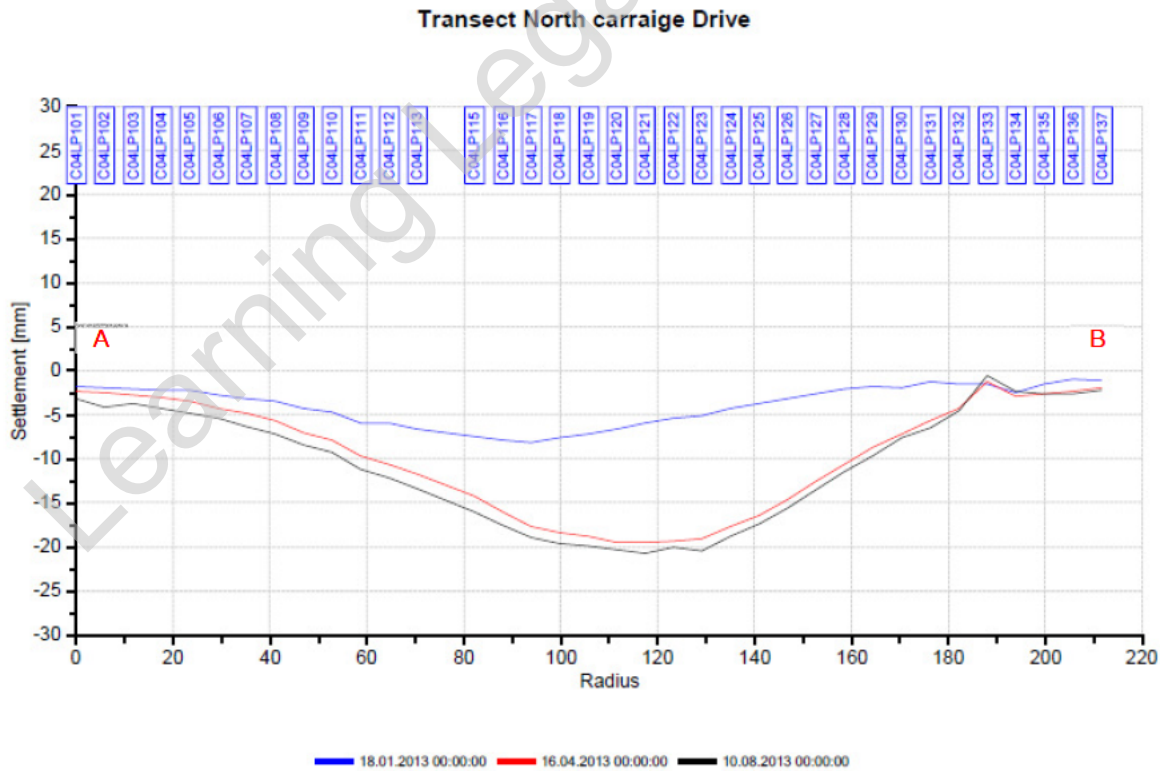


Figure 31: North Carriage Drive cut

Table 7: Achieved Triggers – settlements and deflection ratios

Point Code	Point type	Achieved Trigger
C04LP114	PLP	Green
C04LP115	PLP	Amber
C04LP116	PLP	Amber
C04LP117	PLP	Amber
C04LP118	PLP	Red
C04LP119	PLP	Red
C04LP120	PLP	Red
C04LP121	PLP	Red
C04LP122	PLP	Red
C04LP123	PLP	Amber
C04LP124	PLP	Amber
C04LP125	PLP	Amber
C04LP126	PLP	Green
C04LP127	PLP	Green
Worst case deflection ratio (average of 3 values) [1/-]		Trigger
6,800		no

2.6.2. Comments

The PLPs in North Carriage Drive settled up to approx. 23mm due to the C300 running tunnels works. The effect of the WB and EB TBMs is clearly visible from the settlement time plots. Eight points breached the amber triggers and four points breached the green trigger. The apparent on-going displacements that can be observed from the time-plots are most probably due to ambient temperature or variation in soil moisture deficit within Hyde Park (see Sections 2.8) since they apply to all the points of the transect and their increment is similar on all points.

Additional displacements were generated by the construction of Cross Passage 2 below this transect (refer to Section 2.14 for details).

2.7. Bayswater Road

2.7.1. Data

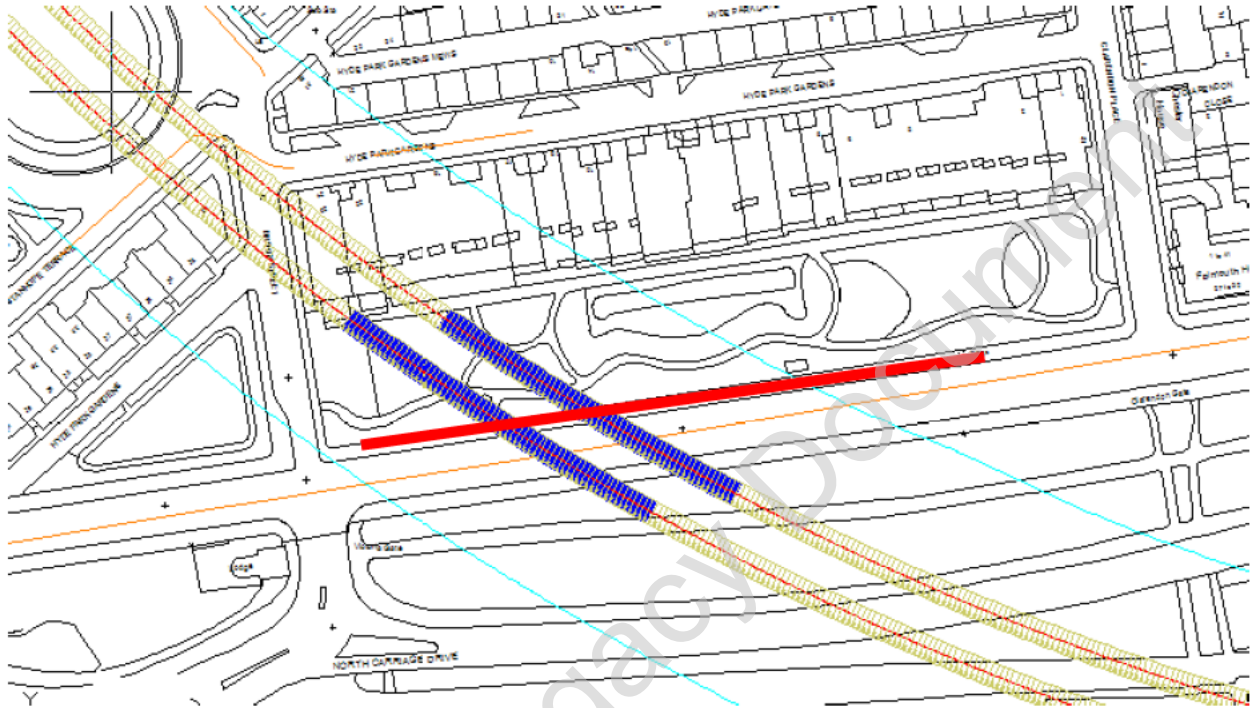


Figure 32: location

PLPs above Central Line - Lancaster Gate

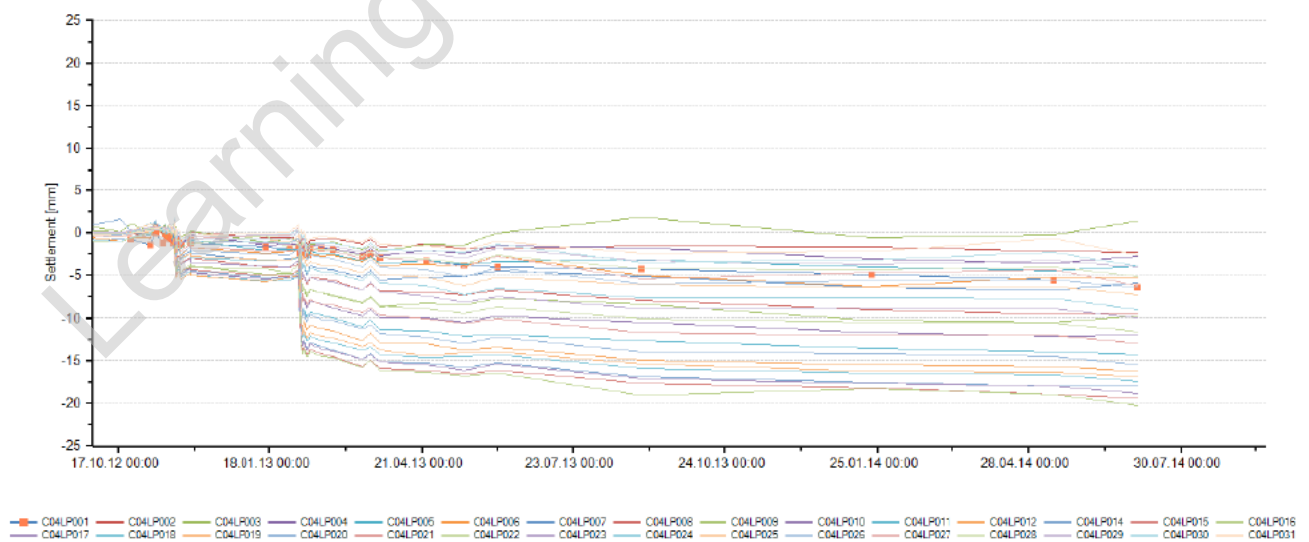


Figure 33: data time-plots - comparison against settlement triggers

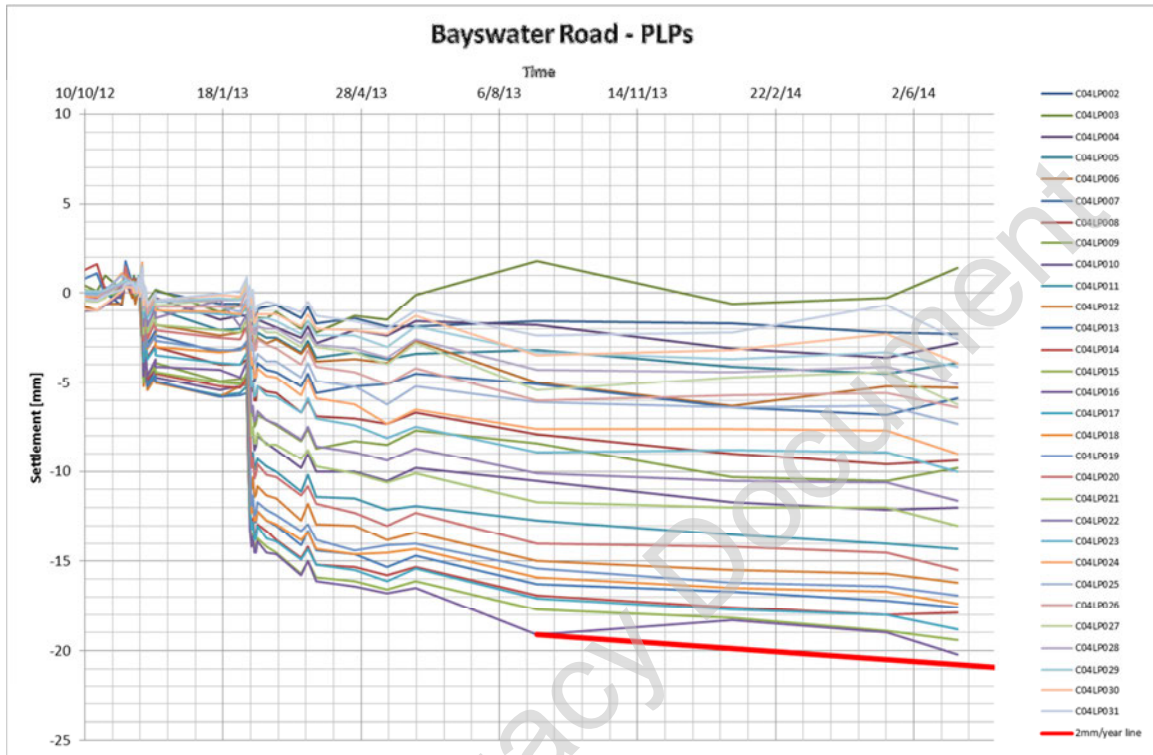


Figure 34: data time-plots - comparison against 2mm/year settlement rate (long-term)

Table 8: Achieved Triggers – settlements and deflection ratios

Point Code	Point type	Achieved Trigger
C04LP012	PLP	Green
C04LP013	PLP	Green
C04LP014	PLP	Green
C04LP015	PLP	Green
C04LP016	PLP	Amber
C04LP017	PLP	Green
C04LP018	PLP	Green
C04LP019	PLP	Green

Worst case deflection ratio (average of 3 values) [1/-]	Trigger
5,300	no

2.7.2. Thames Water Assets

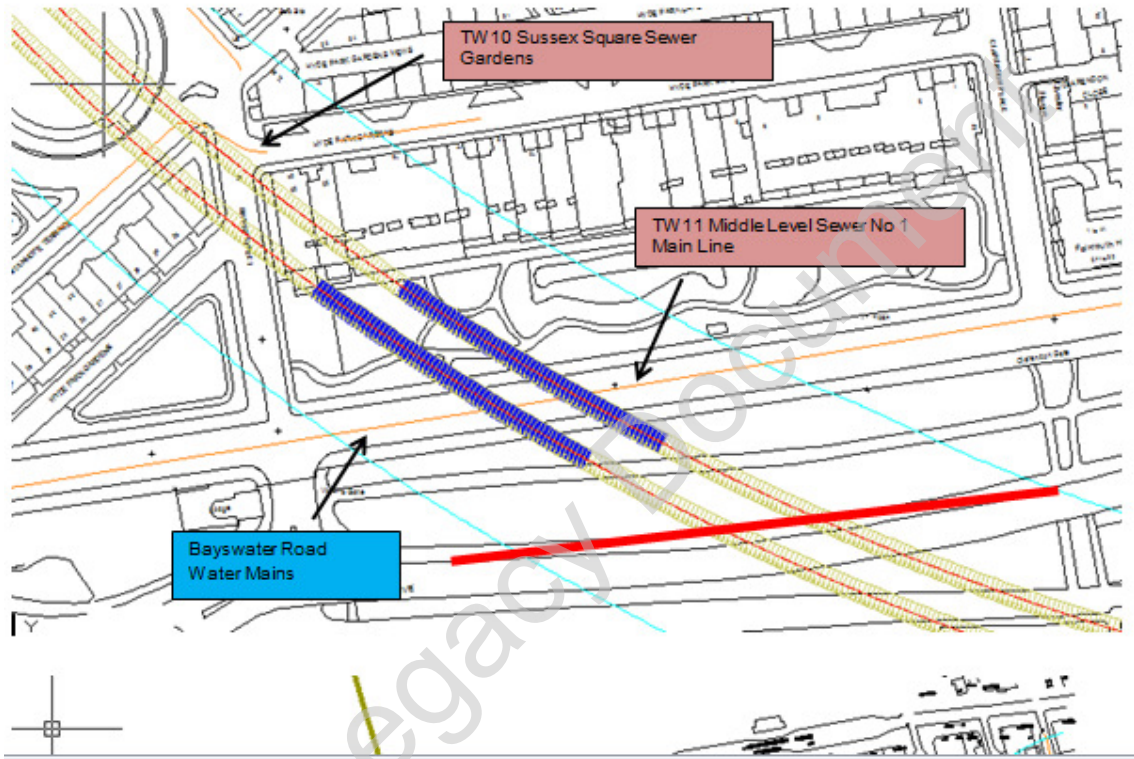


Figure 35: Location

2.7.3. Comments

The PLPs in Bayswater Road settled up to approx. 20mm due to the C300 running tunnels works. The effect of the WB and EB TBMs is clearly visible from the settlement time plots. Seven points breached the green trigger and one point breached the amber trigger. The long-term settlement behaviour connected with C300 works is stable.

The residual risk associated with long-term settlements is considered to be negligible.

2.8. Hyde Park Sections

2.8.1. Data

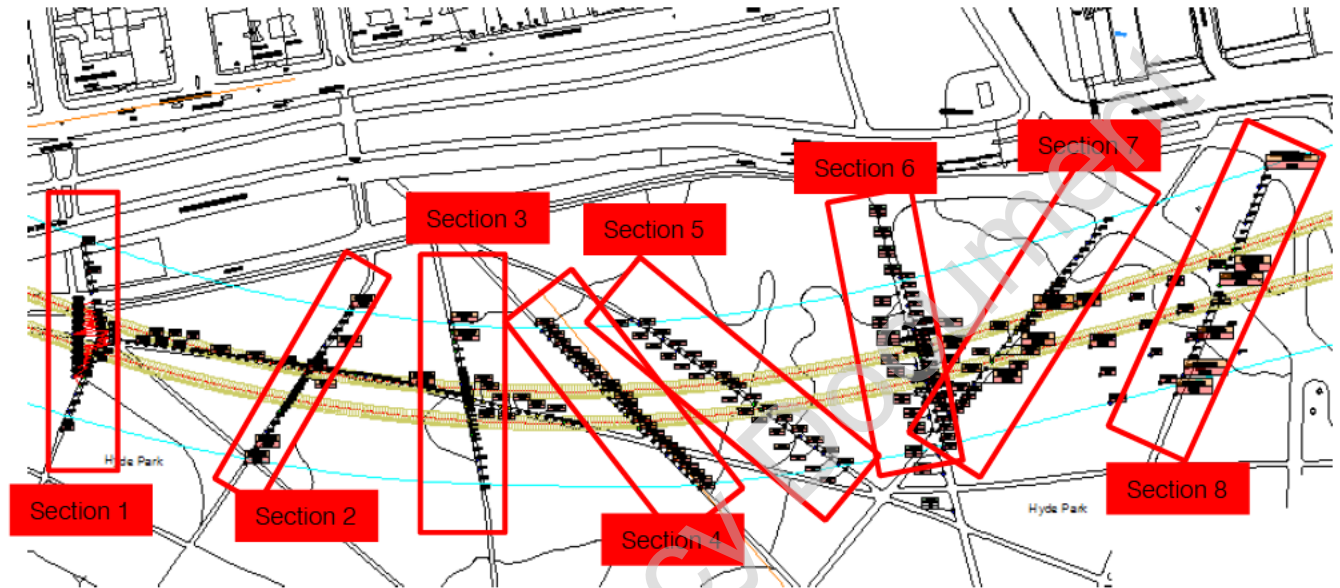


Figure 36: Location

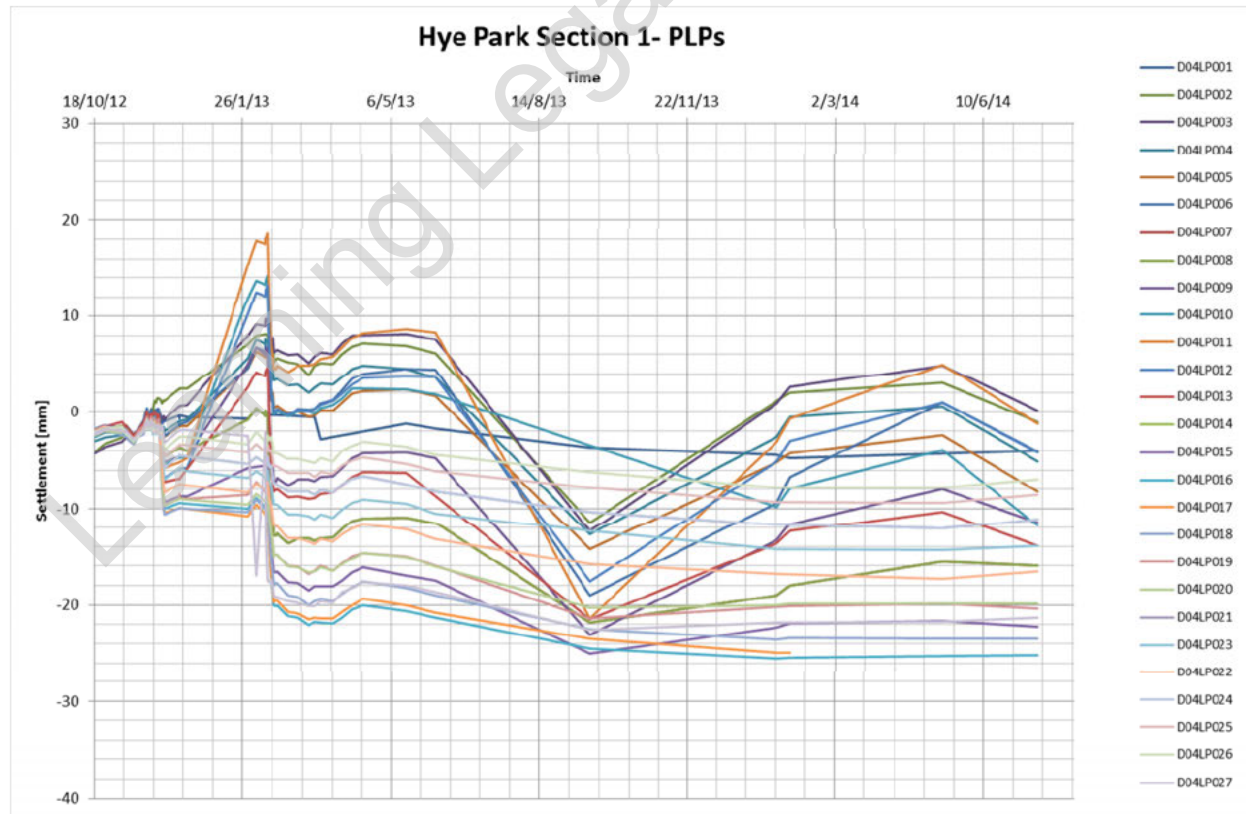


Figure 37: Hyde Park Section 1

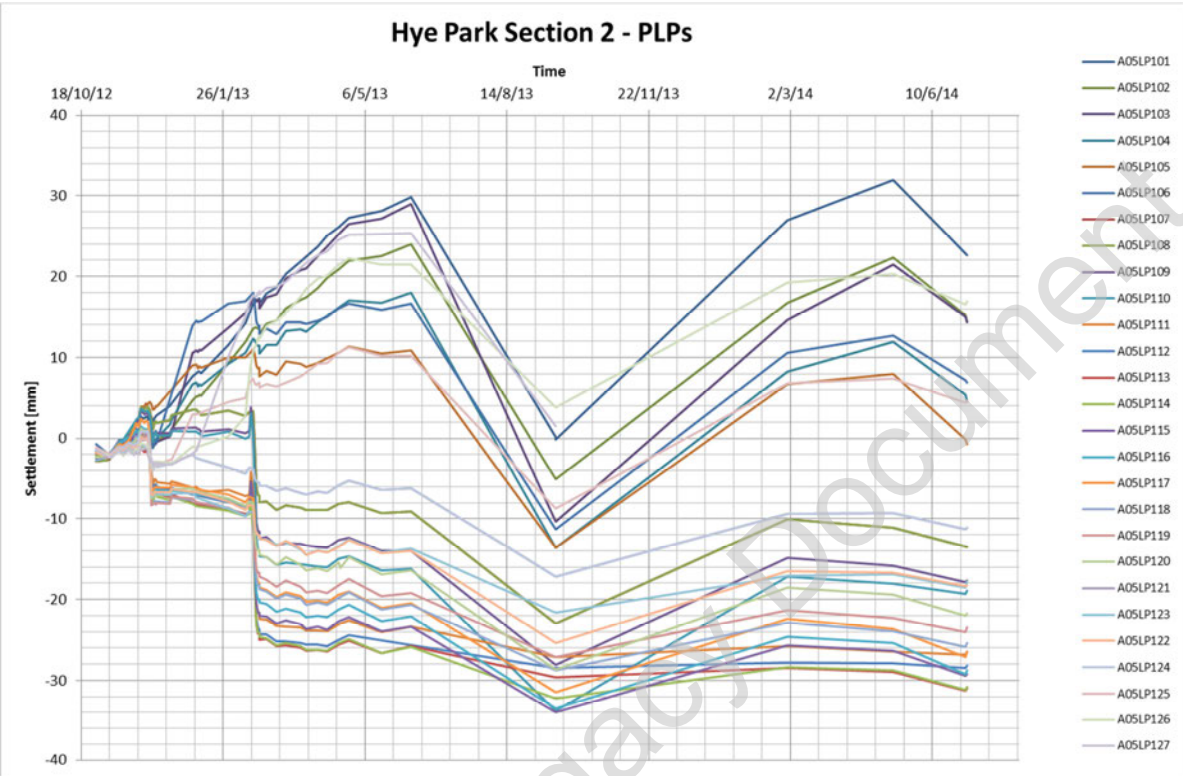


Figure 38: Hyde Park Section 2

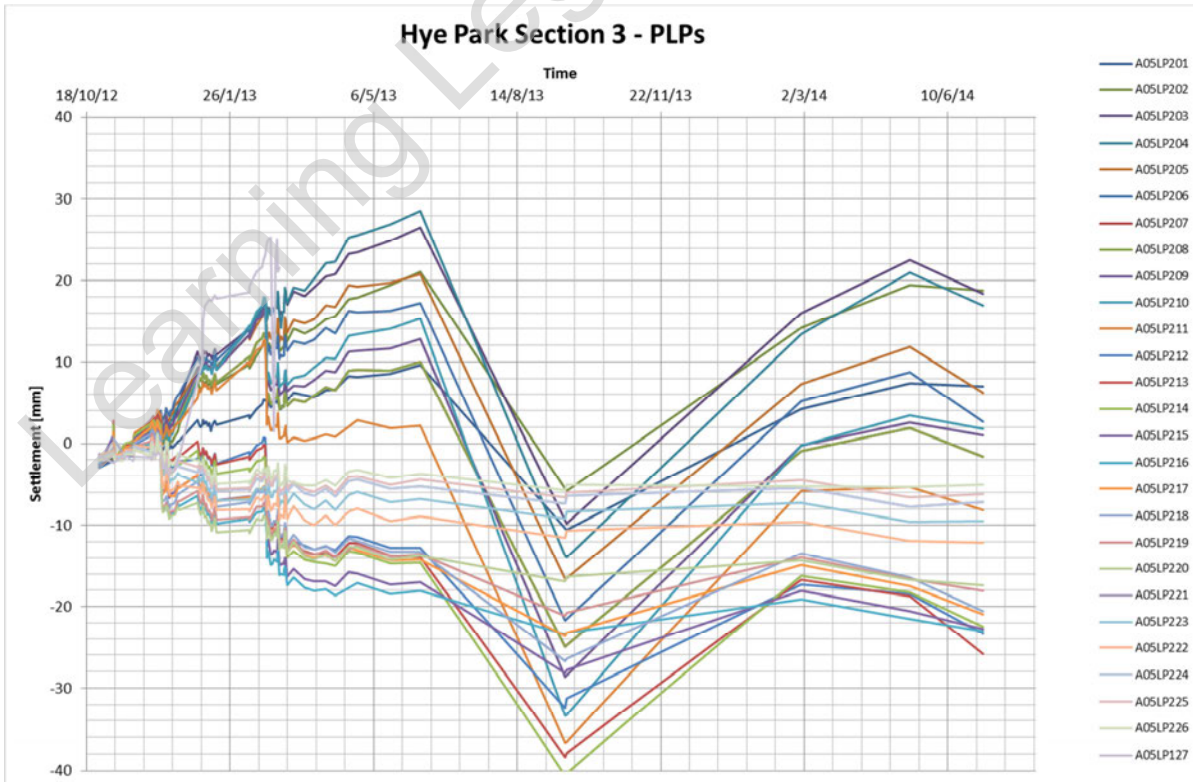


Figure 39: Hyde Park Section 3

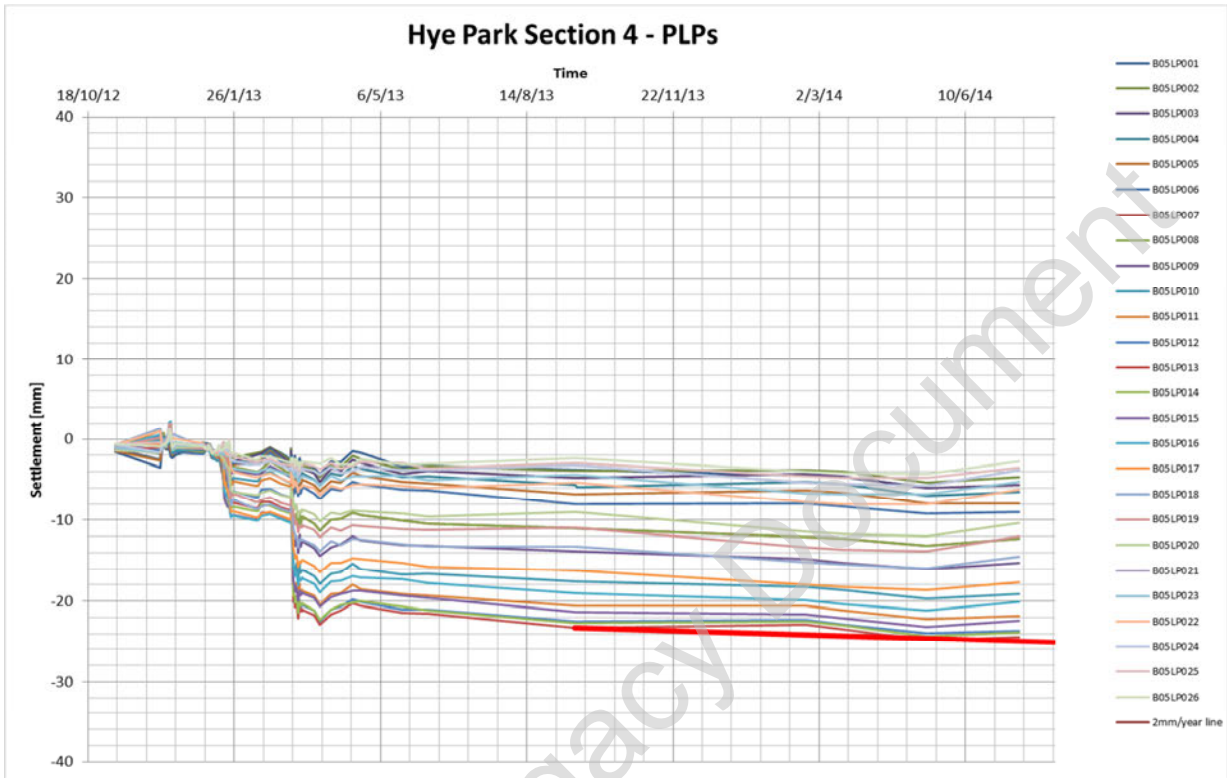


Figure 40: Hye Park Section 4

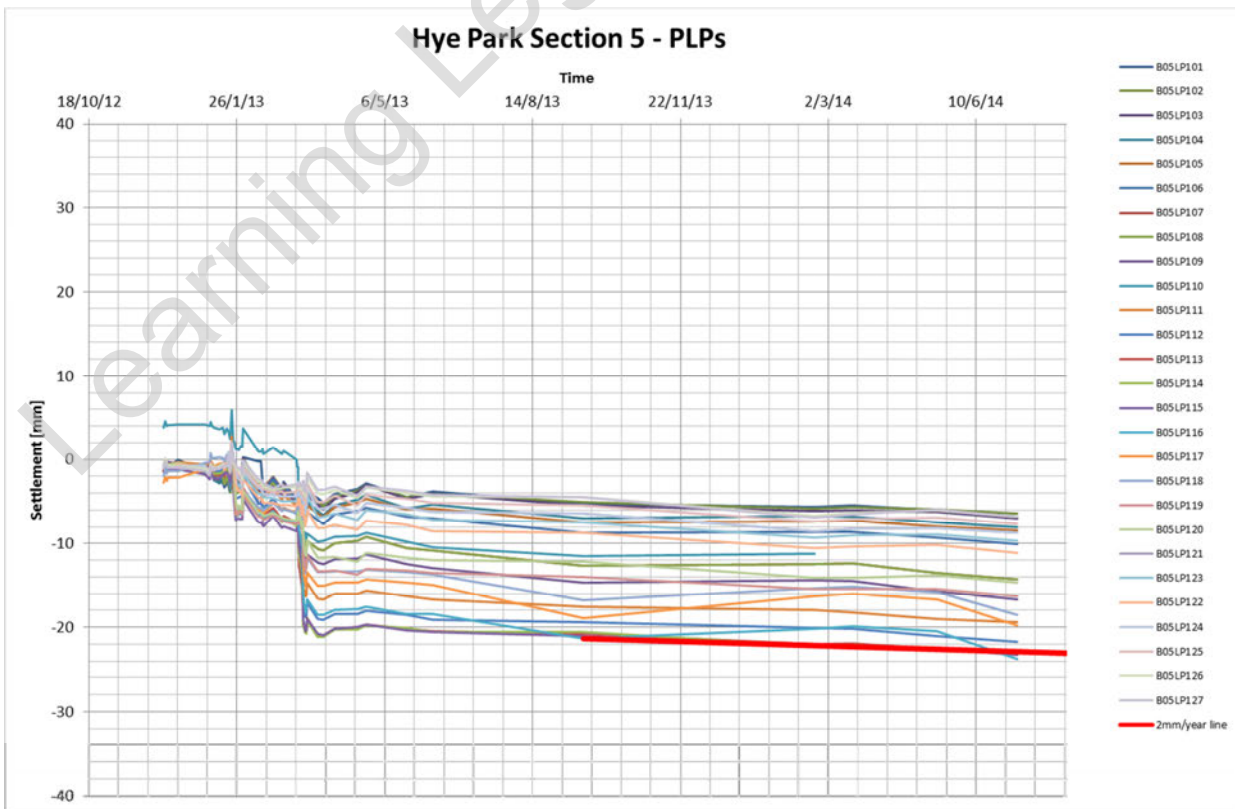


Figure 41: Hye Park Section 5

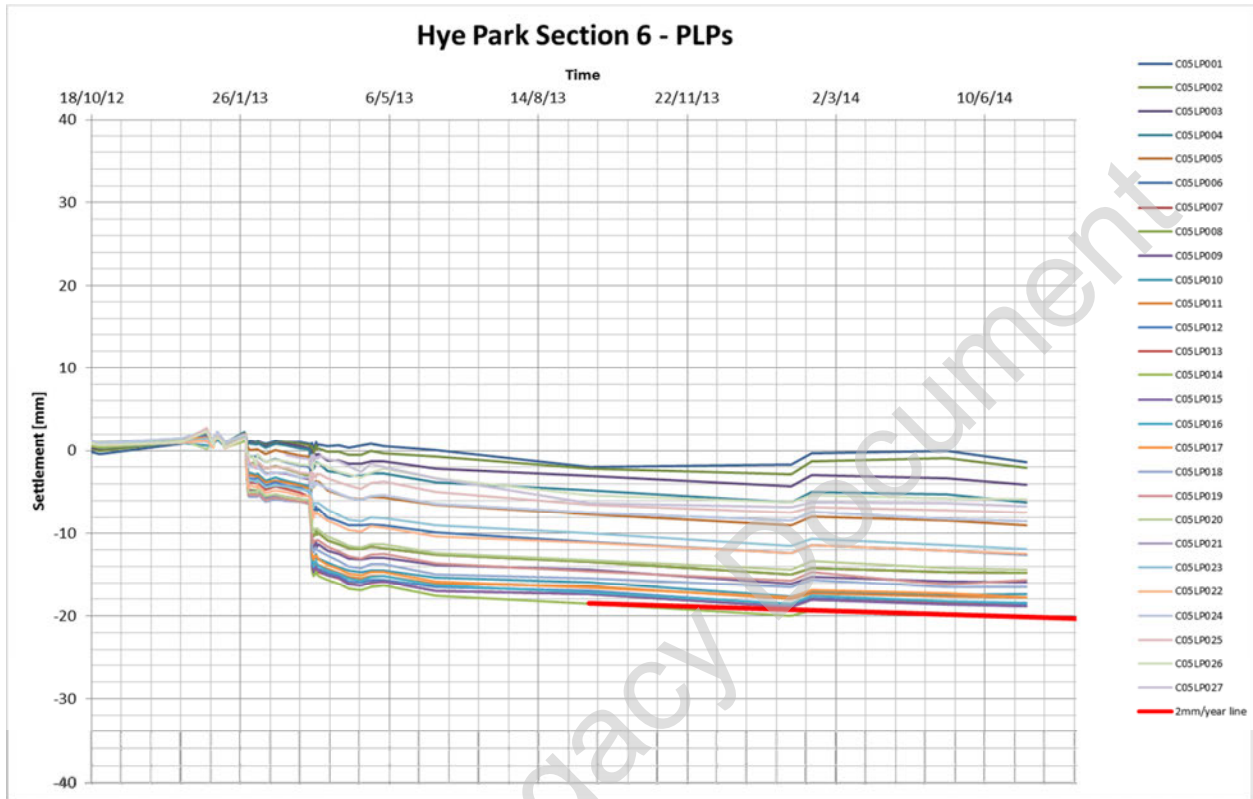


Figure 42: Hyde Park Section 6

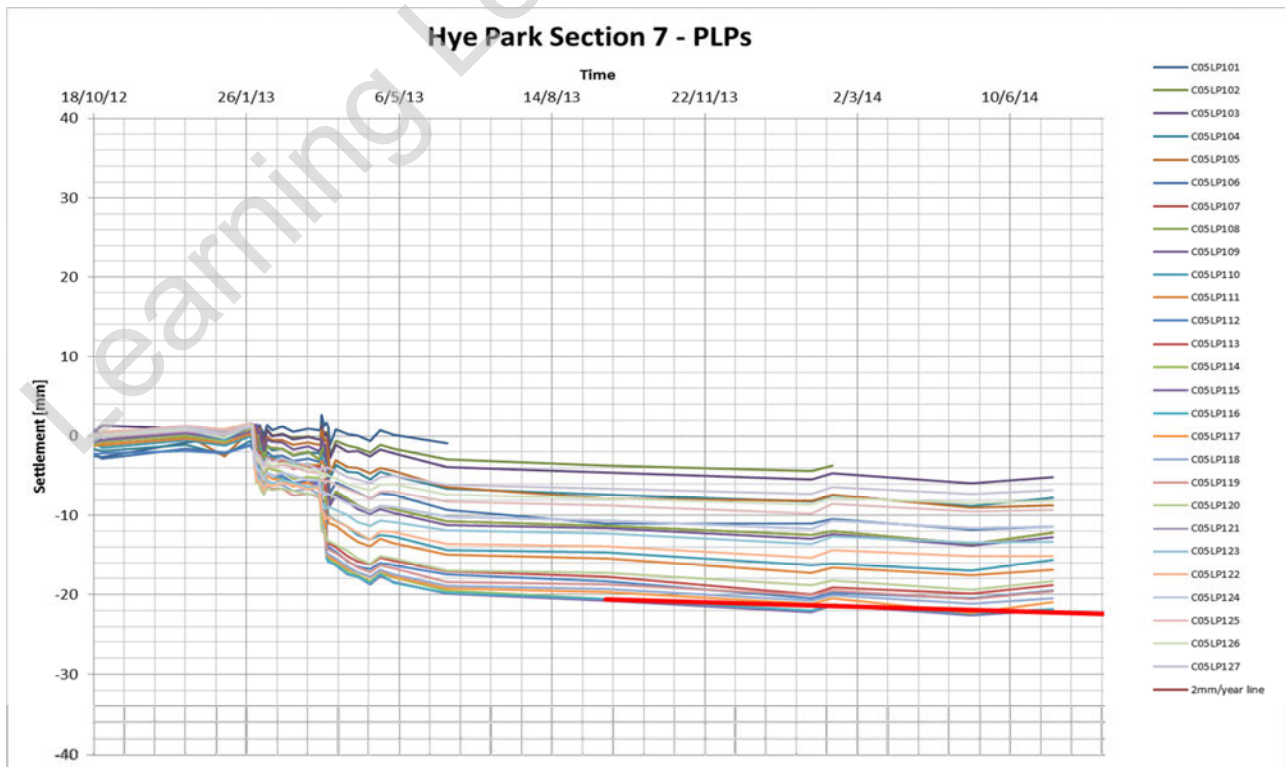


Figure 43: Hyde Park Section 7

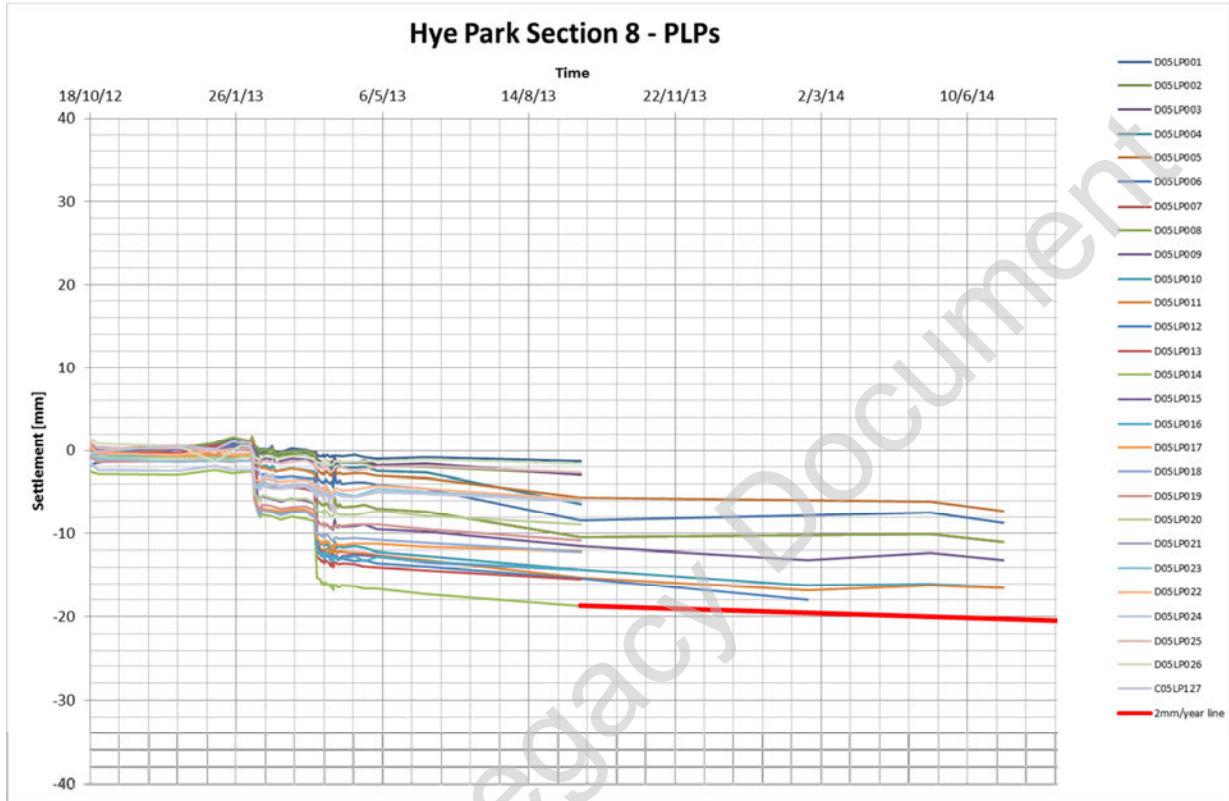


Figure 44: Hyde Park Section 8

Table 9: Breached triggers on Hyde Park PLPs

D04LP022	PLP	Green	A05LP118	PLP	Red
D04LP021	PLP	Green	A05LP117	PLP	Red
D04LP020	PLP	Green	A05LP116	PLP	Red
D04LP019	PLP	Amber	A05LP115	PLP	Red
D04LP018	PLP	Amber	A05LP114	PLP	Red
D04LP017	PLP	Amber	A05LP113	PLP	Red
D04LP016	PLP	Red	A05LP112	PLP	Red
D04LP015	PLP	Amber	A05LP111	PLP	Red
A05LP001	PLP	Amber	A05LP110	PLP	Green
A05LP002	PLP	Amber	A05LP109	PLP	Green
A05LP003	PLP	Red	A05LP103	PLP	Green
A05LP004	PLP	Red	A05LP102	PLP	Green
A05LP005	PLP	Red	A05LP101	PLP	Green
A05LP006	PLP	Amber	B05LP010	PLP	Green
A05LP007	PLP	Amber	B05LP011	PLP	Amber
A05LP008	PLP	Amber	B05LP012	PLP	Amber
A05LP009	PLP	Amber	B05LP013	PLP	Amber
A05LP010	PLP	Amber	B05LP014	PLP	Amber
A05LP011	PLP	Red	B05LP015	PLP	Amber
A05LP012	PLP	Amber	B05LP016	PLP	Amber
A05LP013	PLP	Amber	B05LP017	PLP	Green
A05LP014	PLP	Amber	B05LP018	PLP	Green
A05LP015	PLP	Amber	B05LP109	PLP	Green
A05LP016	PLP	Amber	B05LP111	PLP	Amber
A05LP017	PLP	Red	B05LP112	PLP	Amber
A05LP018	PLP	Red	B05LP113	PLP	Amber
A05LP019	PLP	Red	B05LP114	PLP	Amber
A05LP020	PLP	Red	B05LP115	PLP	Amber
A05LP021	PLP	Red	B05LP116	PLP	Amber
A05LP022	PLP	Red	B05LP117	PLP	Green
A05LP023	PLP	Red	B05LP118	PLP	Green
A05LP025	PLP	Green	B05LP119	PLP	Green
A05LP028	PLP	Amber	C05LP010	PLP	Green
A05LP029	PLP	Amber	C05LP011	PLP	Green
A05LP031	PLP	Amber	C05LP012	PLP	Green
A05LP032	PLP	Amber	C05LP013	PLP	Green
A05LP033	PLP	Green	C05LP014	PLP	Amber
A05LP034	PLP	Green	C05LP015	PLP	Green
A05LP037	PLP	Amber	C05LP016	PLP	Green
A05LP038	PLP	Amber	C05LP017	PLP	Green
A05LP039	PLP	Amber	C05LP018	PLP	Green
A05LP040	PLP	Amber	C05LP0121	PLP	Green

A05LP041	PLP	Amber	C05LP0120	PLP	Green
A05LP042	PLP	Amber	C05LP0119	PLP	Green
A05LP043	PLP	Amber	C05LP0118	PLP	Amber
A05LP044	PLP	Amber	C05LP0117	PLP	Amber
A05LP045	PLP	Amber	C05LP0116	PLP	Amber
A05LP046	PLP	Green	C05LP0115	PLP	Amber
A05LP047	PLP	Green	C05LP0114	PLP	Amber
A05LP048	PLP	Green	C05LP0113	PLP	Green
A05LP049	PLP	Green	C05LP0112	PLP	Green
A05LP123	PLP	Green	C05LP0111	PLP	Green
A05LP122	PLP	Green	C05LP014	PLP	Green
A05LP121	PLP	Green	C05LP012	PLP	Green
A05LP120	PLP	Amber	C05LP011	PLP	Green
A05LP119	PLP	Amber	C05LP010	PLP	Green

2.8.2. Comments

The PLPs in Hyde Park settled up to approx. 30mm due to the C300 running tunnels works. Trials were performed on the WB TBM drive by reducing face pressures in order to understand the effect of the earth pressure on the surface settlements. The trigger values set by C122 have not been amended to reflect this modification to the operation of the TBM. The data from some of the points in Sections 1, 2 and 3 show a strong seasonal variation: it is known that this area of Hyde Park is subject to surface water accumulation and there are a lot of mature trees in the vicinity, hence the variation in elevation of 20 to 30mm is attributed to near surface swelling and consolidation. Within the natural variation in elevation, the long-term behaviour connected with C300 works is not significant. The associated risk is considered low.

2.9. Park Lane PLPs

2.9.1. Data



Figure 45: Location

Hyde Park - PLP transect 2860

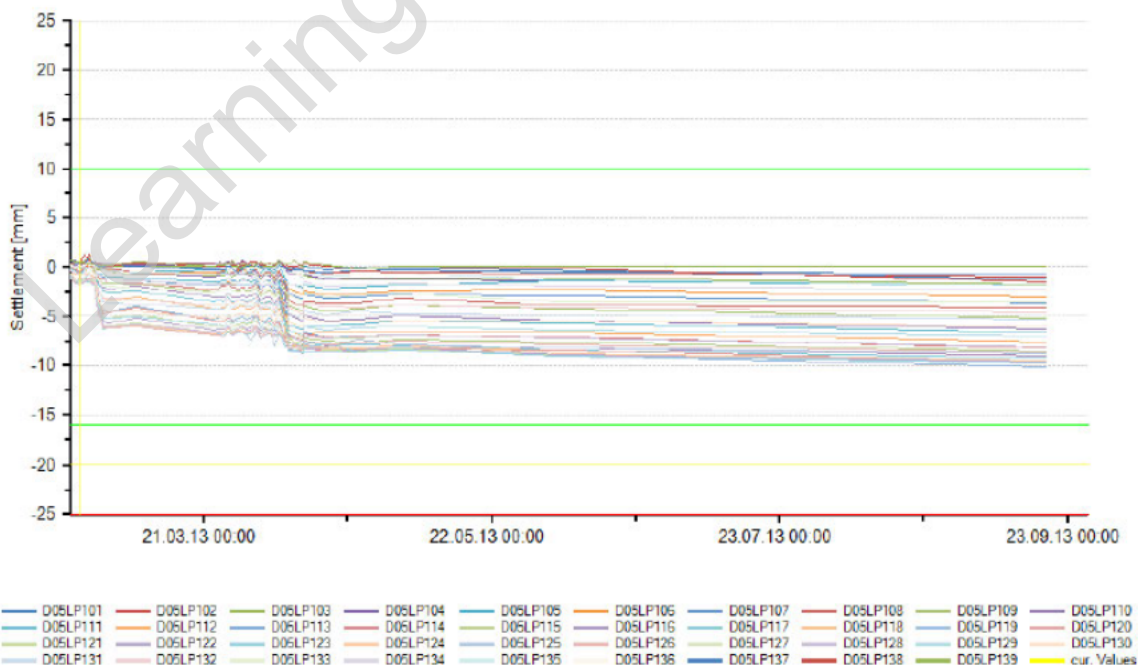


Figure 46: Park Lane East PLPs - data time-plots - comparison against settlement triggers

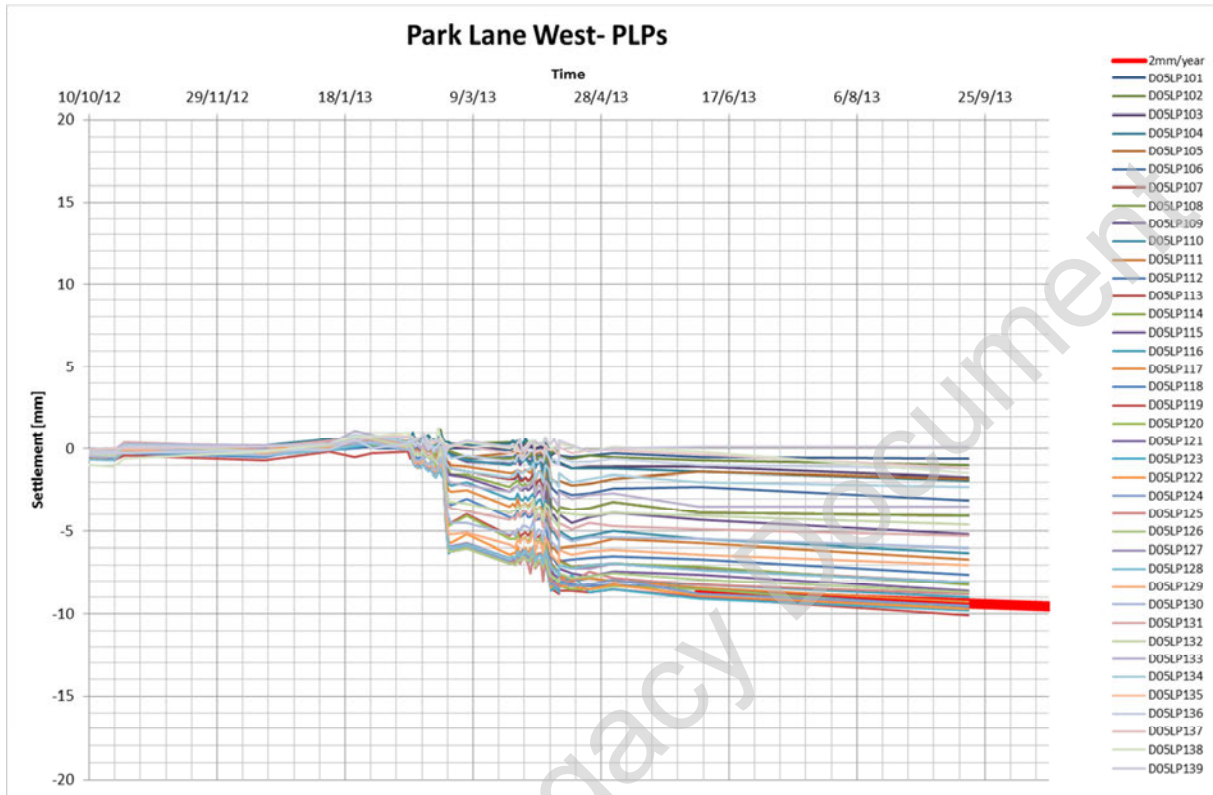


Figure 47: Park Lane West PLPs - data time-plots - comparison against 2mm/year settlement rate (long-term)

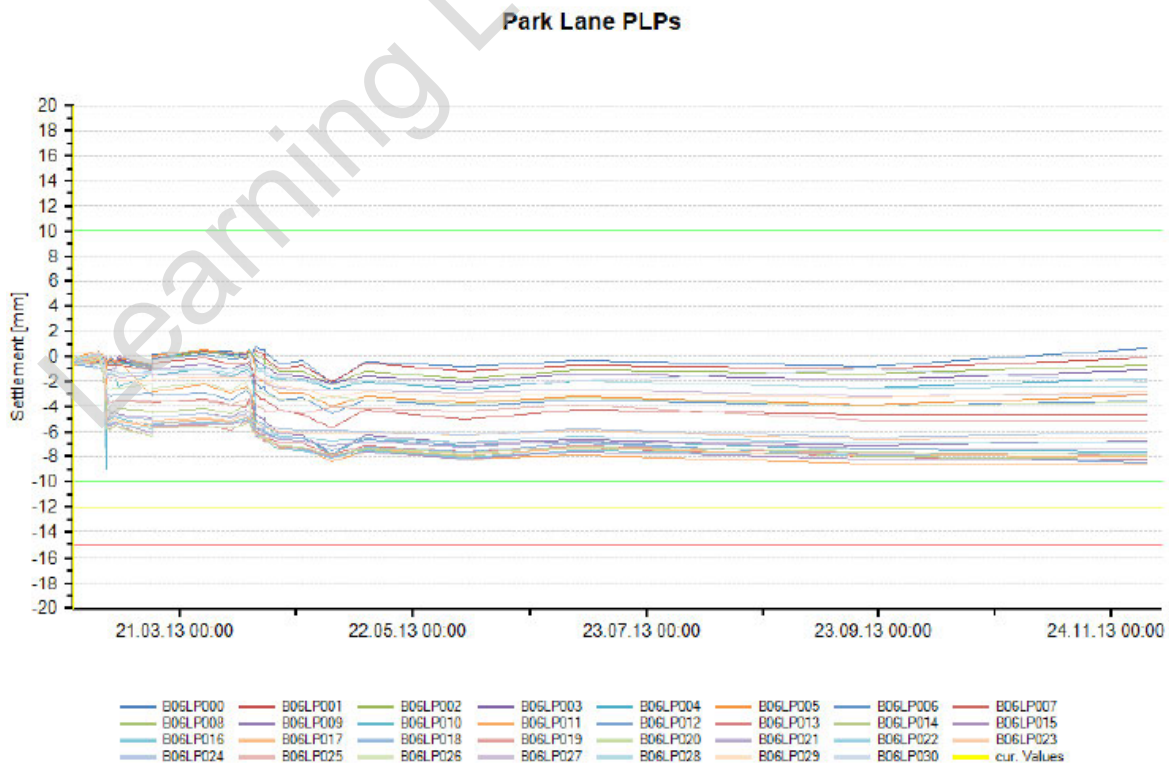


Figure 48: Park Lane West PLPs - data time-plots - comparison against settlement triggers

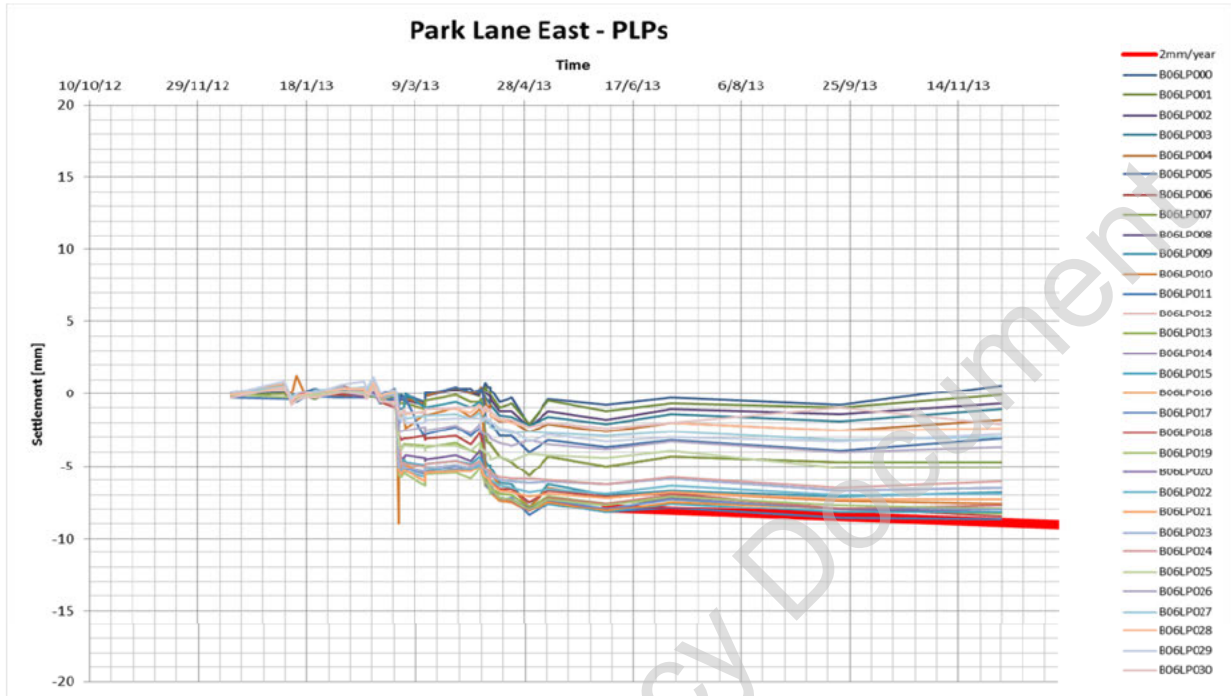


Figure 49: Park Lane East PLPs - data time-plots - comparison against 2mm/year settlement rate (long-term)

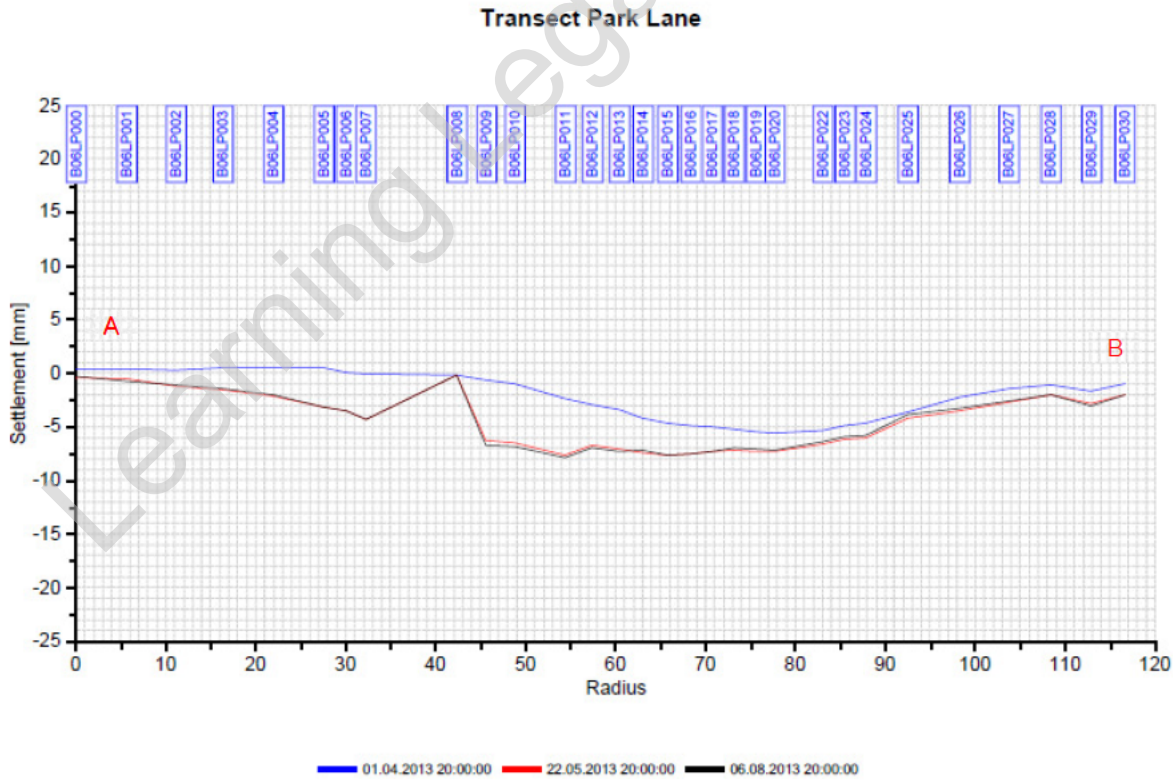


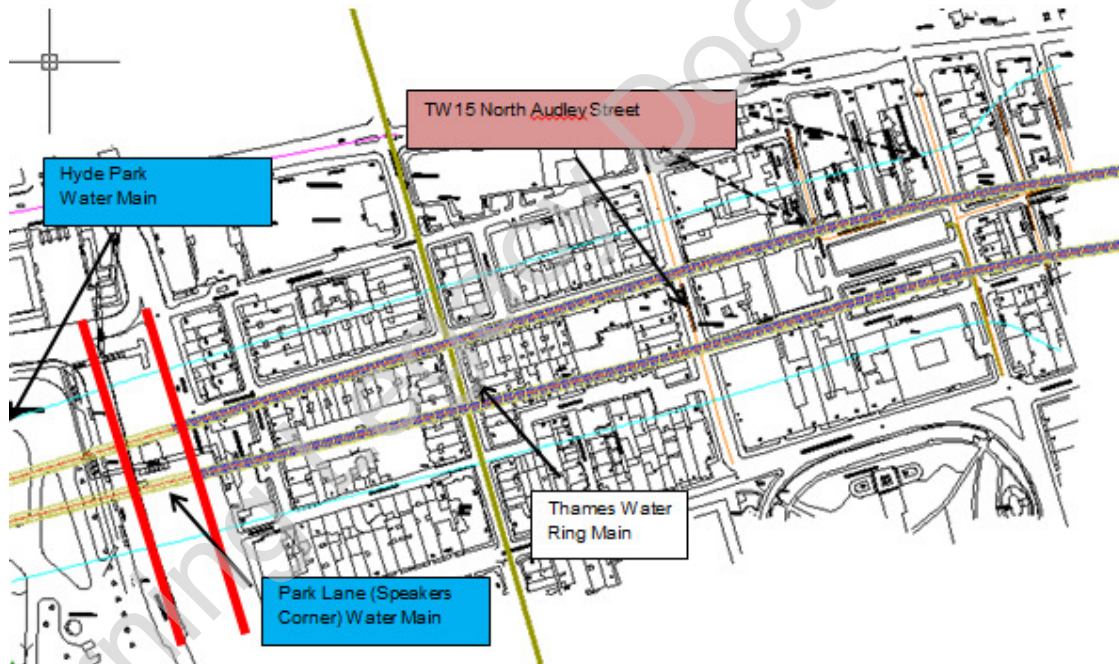
Figure 50: Park Lane East cut

Table 10: Achieved Triggers – deflection ratios

Worst case deflection (average on 3 values)	Trigger
1.49 E+4	no

2.9.2. Thames Water Assets

Water Main	Hyde Park	Hyde Park (Transect No.8, one before Park Lane)	1 in 3000	-
Water Main	Park Lane (Speakers Corner)	Park Lane West	1 in 2800	-



2.9.3. Comments

The PLPs in Park Lane settled up to approx. 9mm due to the C300 running tunnels works. The effect of the WB and EB TBMs is clearly visible from the settlement time-plots. No triggers have been breached. The long-term behaviour connected with C300 works is quite stable and the rate of increase is less than the specified rate of 2mm/year.

The residual risk associated with long-term settlements is considered to be negligible.

2.10. Park Street PLPs

2.10.1. Data



Figure 51: Location

Park Street PLP's

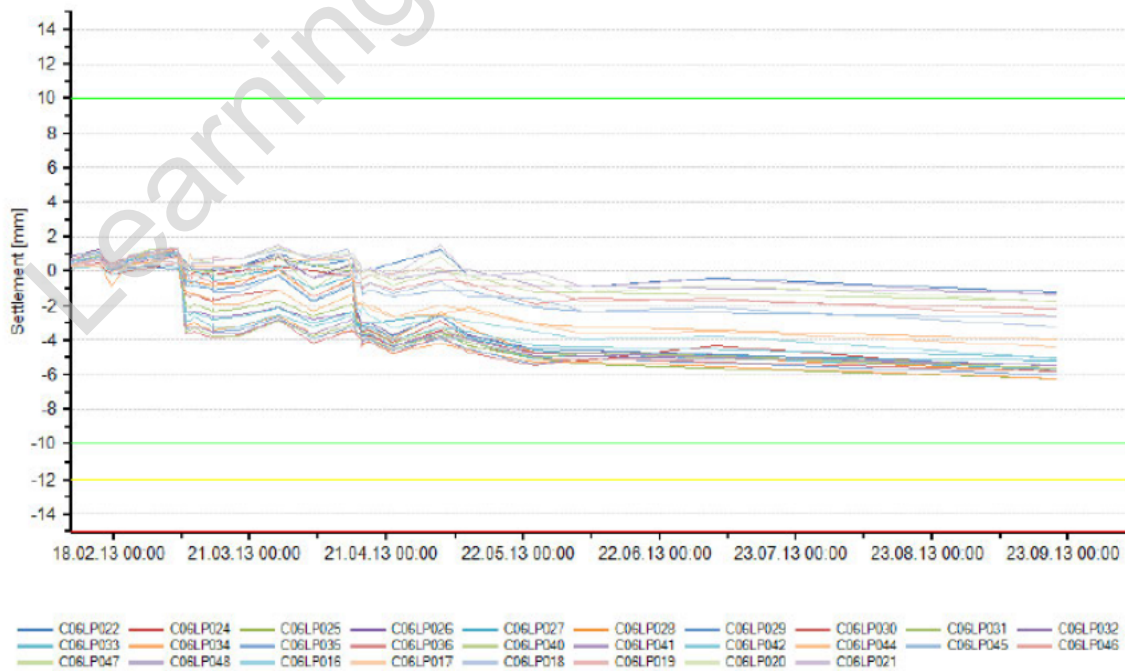


Figure 52: data time-plots - comparison against settlement triggers

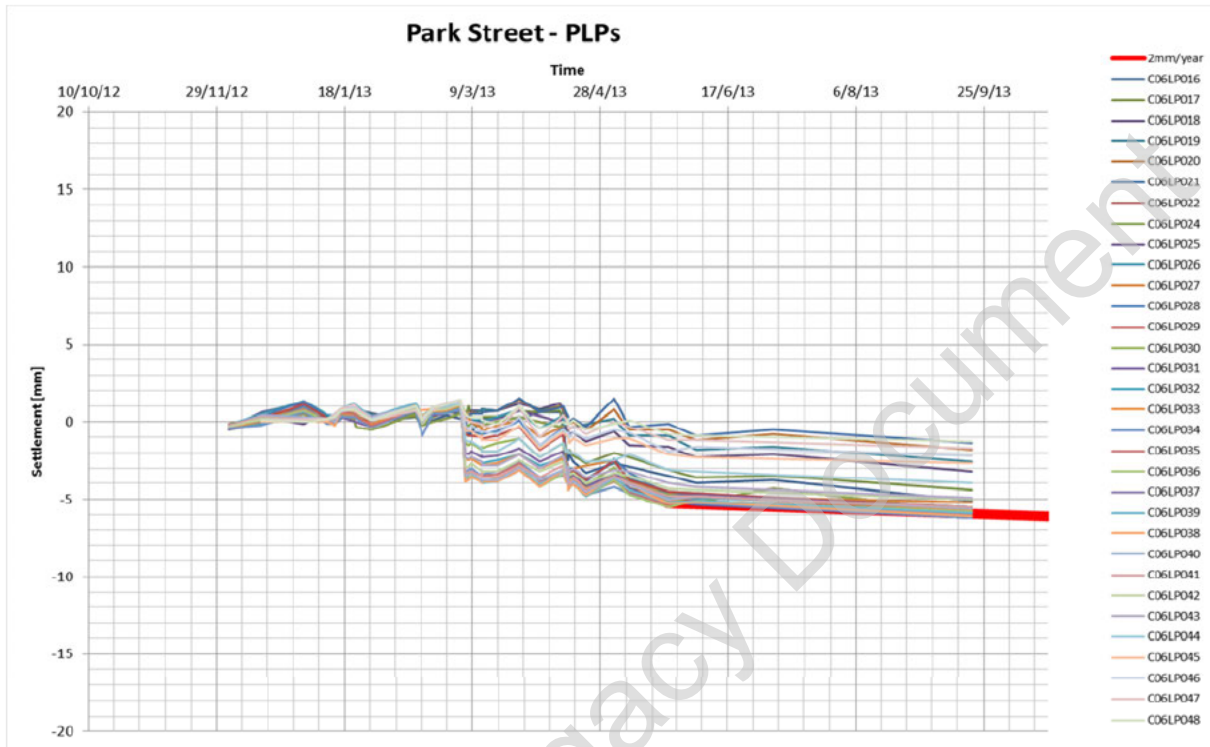


Figure 53: data time-plots - comparison against 2mm/year settlement rate (long-term)

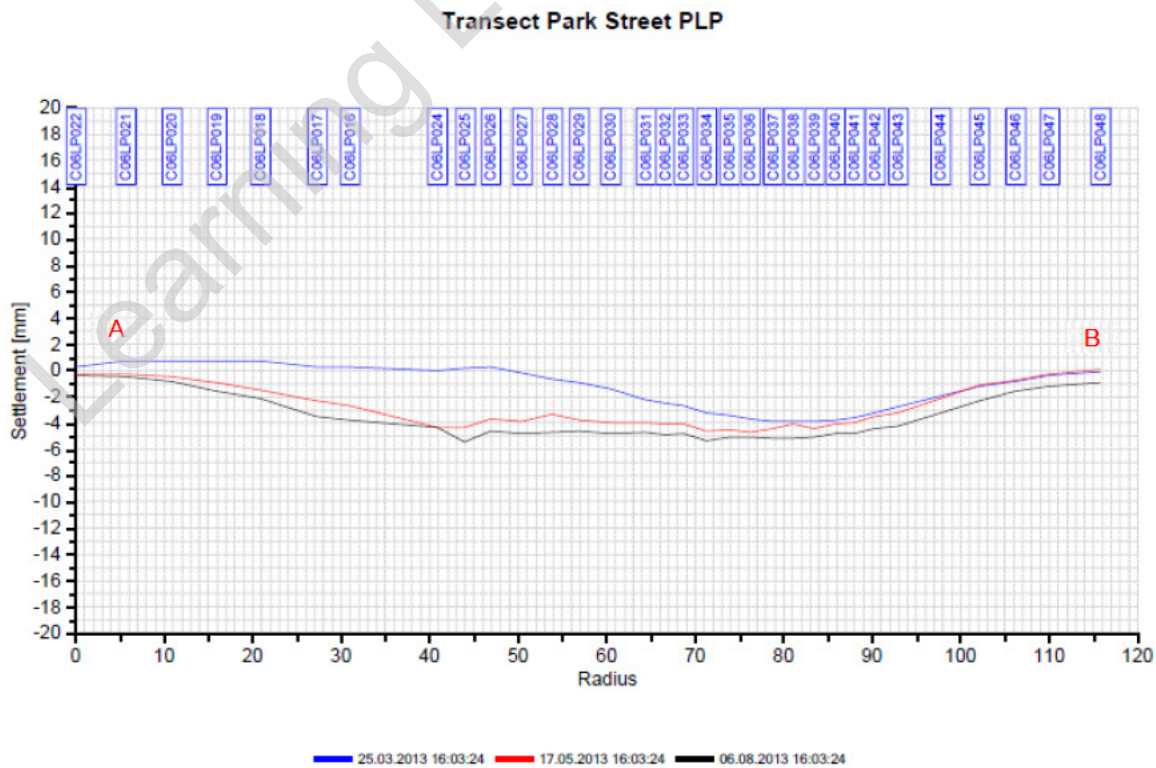


Figure 54: Park Lane cut

Table 11: Achieved Triggers – settlements and deflection ratios

Worst case deflection ratio (average of 3 values) [1/-]	Trigger
2.29E+04	no

2.10.2. Comments

The PLPs in Park Street settled up to approx. 7mm due to the C300 running tunnels works. The effect of the WB and EB TBMs is clearly visible from the settlement time-plots. No triggers have been breached. The long-term behaviour connected with C300 works is quite stable and the rate of increase is less than the specified rate of 2mm/year.

The residual risk associated with long-term settlements is considered to be negligible.

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2.11. North Audley Street PLPs



Figure 55: Location

North Audley Street PLP's

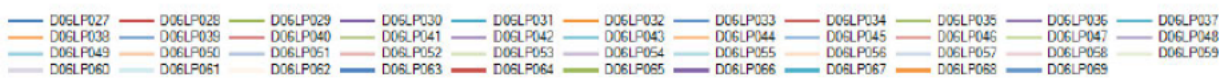
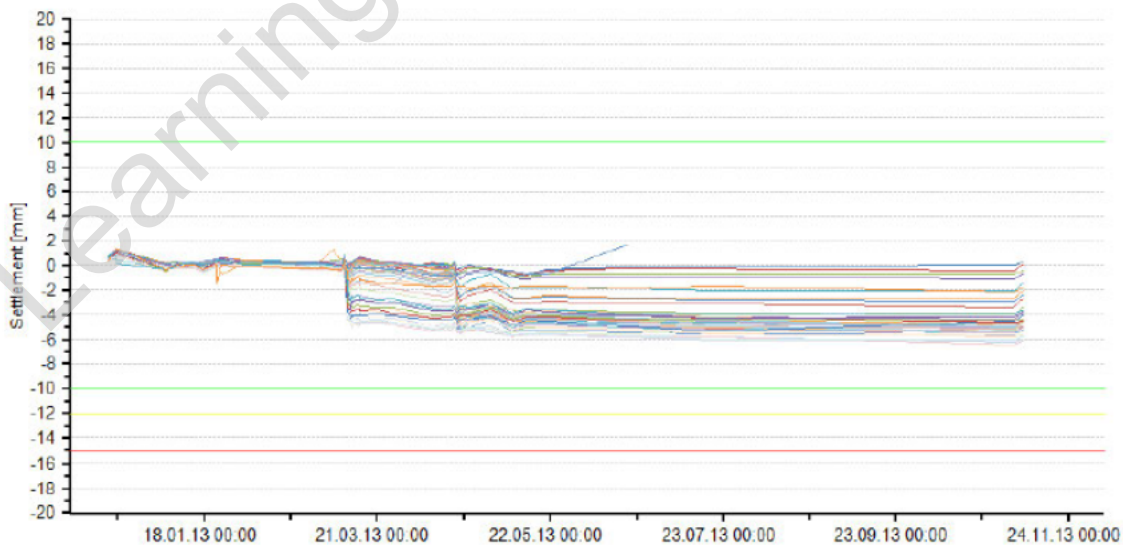


Figure 56: data time-plots - comparison against settlement triggers

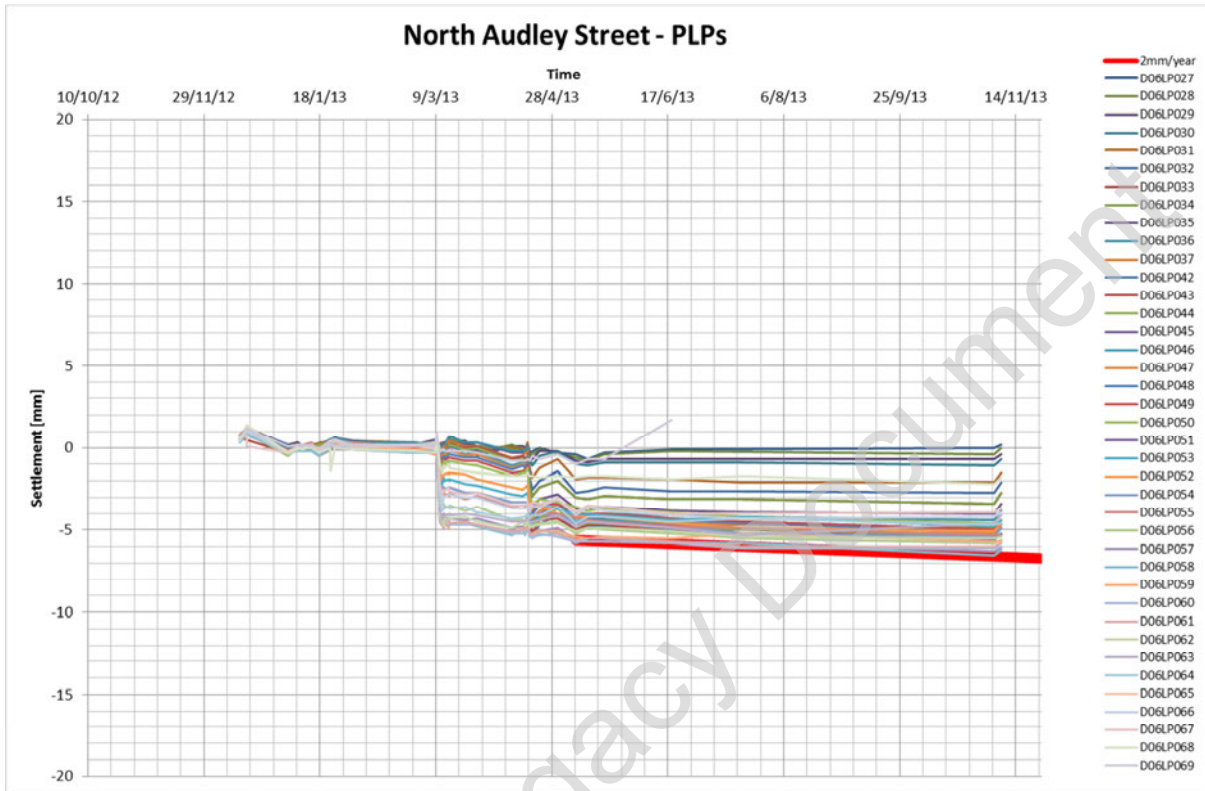


Figure 57: data time-plots - comparison against 2mm/year settlement rate (long-term)

Worst case deflection ratio (average of 3 values) [1/-]	Trigger
2.29E+04	no

2.11.1. Comments

The PLPs in Park Lane settled up to approx. 8mm due to the C300 running tunnels works. The effect of the WB and EB TBMs is clearly visible from the settlement time-plots. No triggers have been breached. The long-term behaviour connected with C300 works is quite stable and the rate of increase is less than the specified rate of 2mm/year.

The residual risk associated with long-term settlements is considered to be negligible.

2.12. Balderton Street PLPs

2.12.1. Data



Figure 58: Location

Balderton Street (West) PLP

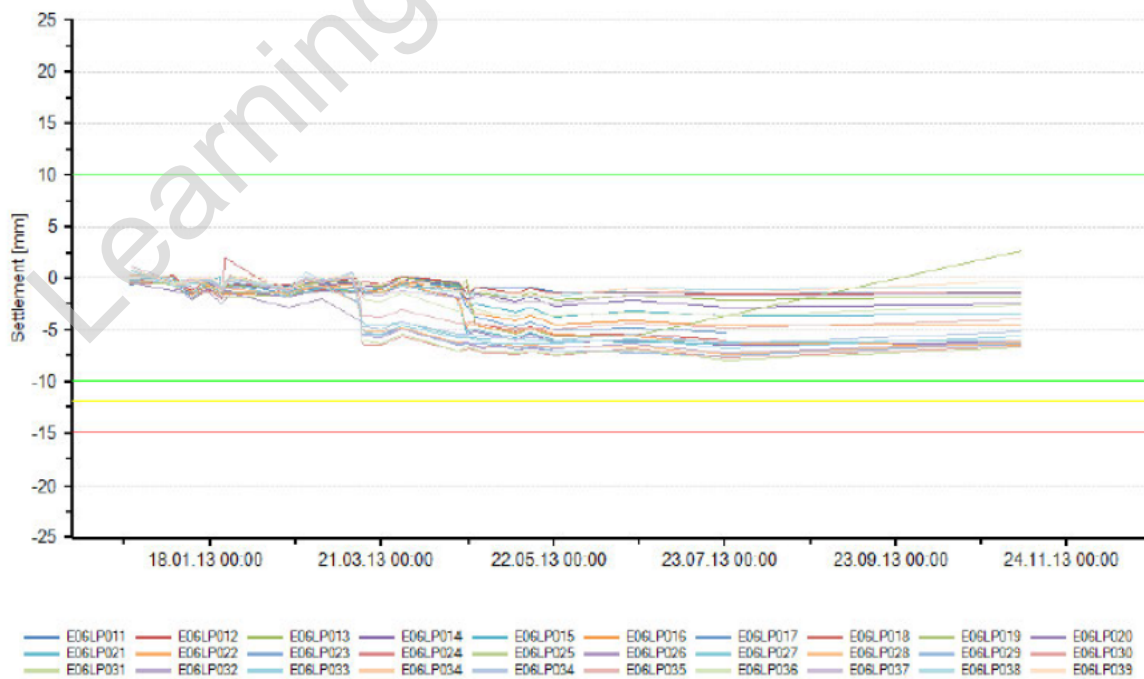


Figure 59: data time-plots - comparison against settlement triggers

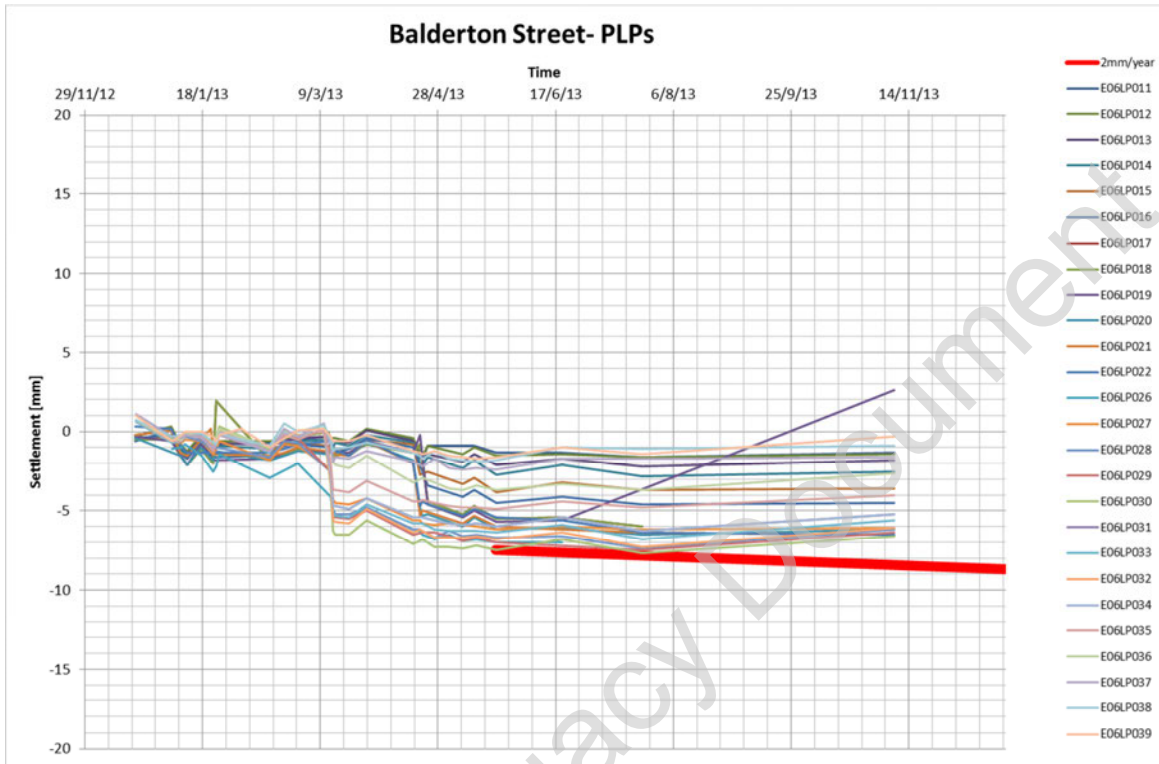


Figure 60: data time-plots - comparison against 2mm/year settlement rate (long-term)

Worst case deflection ratio (average of 3 values) [1/-]	Trigger
2.99E+04	no

2.12.2. Comments

The PLPs in Balderton Street settled up to approx. 9mm due to the C300 running tunnels works. The effect of the WB and EB TBMs is clearly visible from the settlement time-plots. No triggers have been breached. The long-term behaviour connected with C300 works is quite stable and the rate of increase is less than the specified rate of 2mm/year.

The residual risk associated with long-term settlements is considered to be negligible.

2.13. Duke Street

2.13.1. Data



Figure 61: Location

Figure 62: data time-plots - comparison against settlement triggers

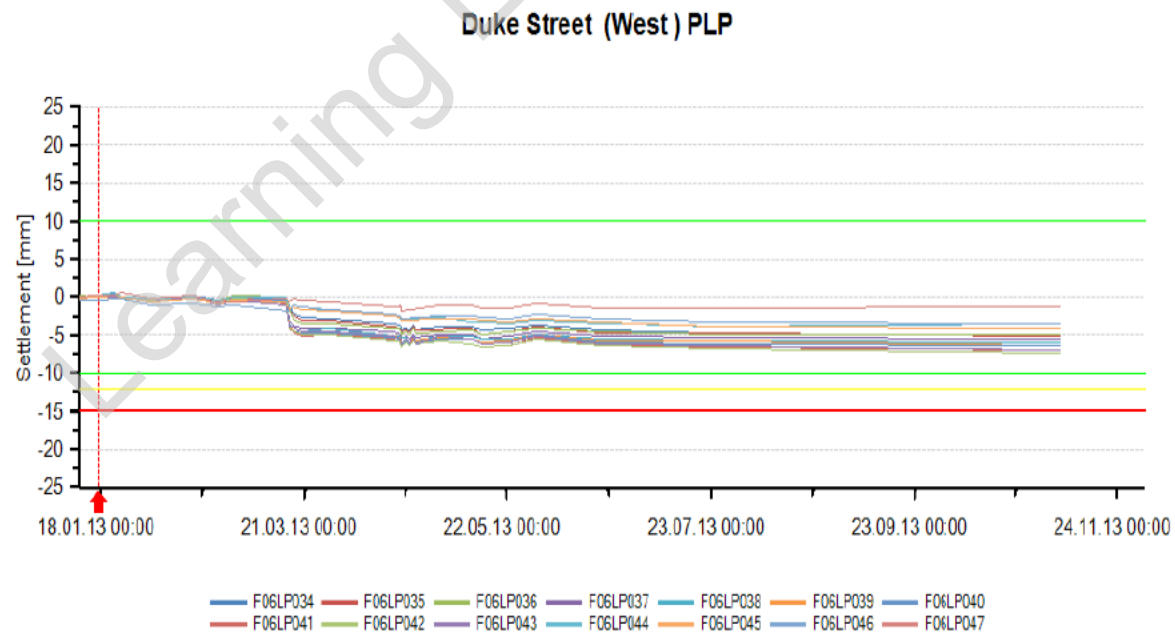


Figure 63: data time-plots - comparison against settlement triggers

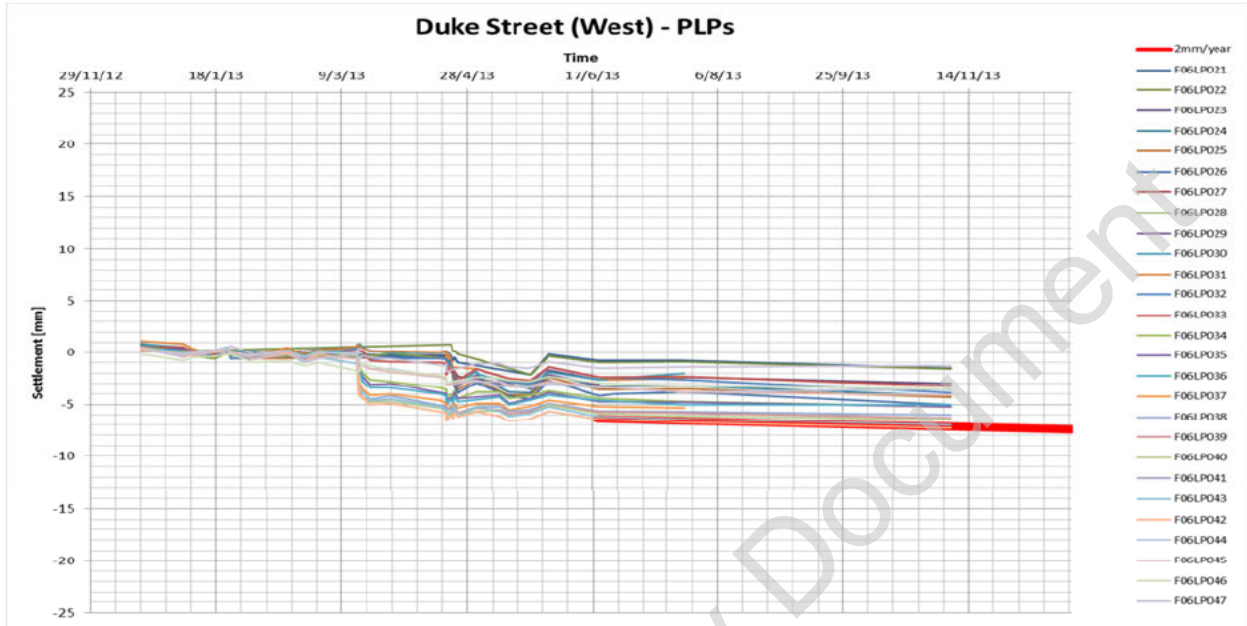


Figure 64: data time-plots - comparison against 2mm/year settlement rate (long-term)

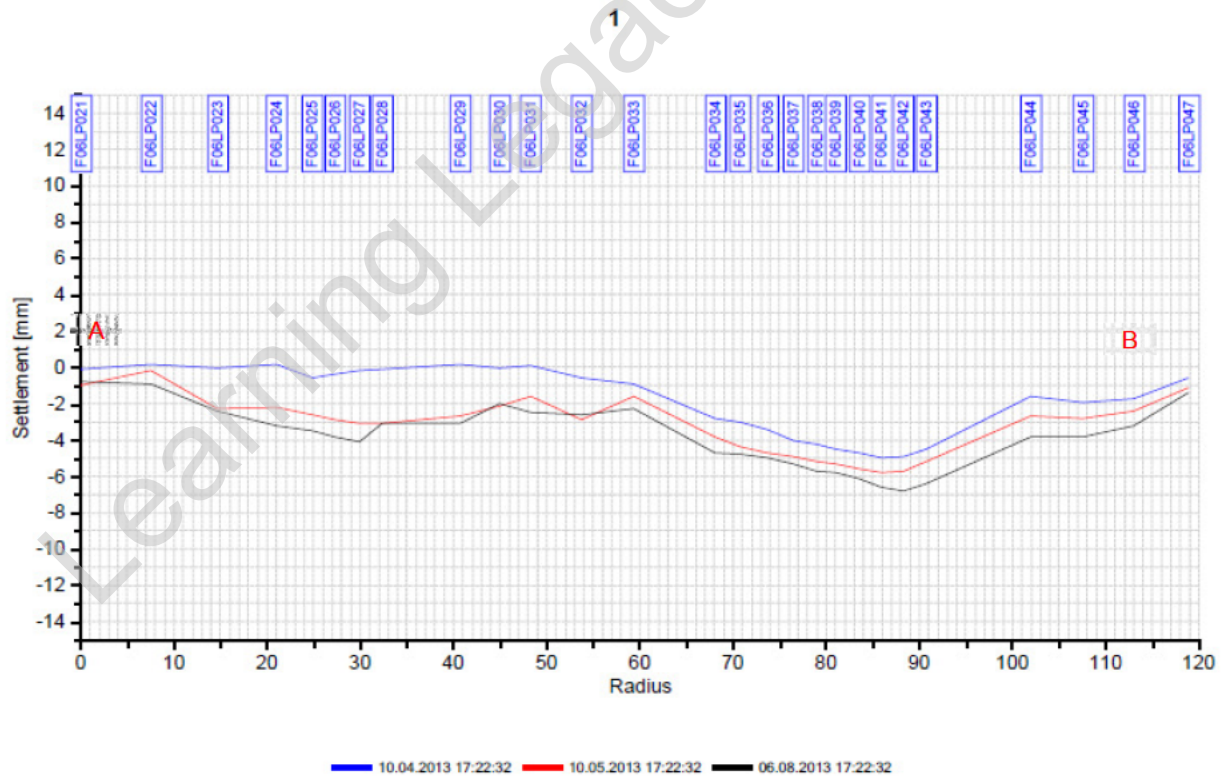


Figure 65: Duke Street cut

Worst case deflection ratio (average of 3 values) [1/-]	Trigger
1.18E+04	no

2.13.2. Comments

The PLPs in Duke Street settled up to approx. 8mm due to the C300 running tunnels works. The effect of the WB and EB TBMs is clearly visible from the settlement time-plots. No settlement triggers have been breached. The long-term behaviour connected with C300 works is quite stable and the rate of increase is less than the specified rate of 2mm/year.

The residual risk associated with long-term settlements is considered to be negligible.

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2.14. Cross Passage 2 (CP2)

2.14.1. Data

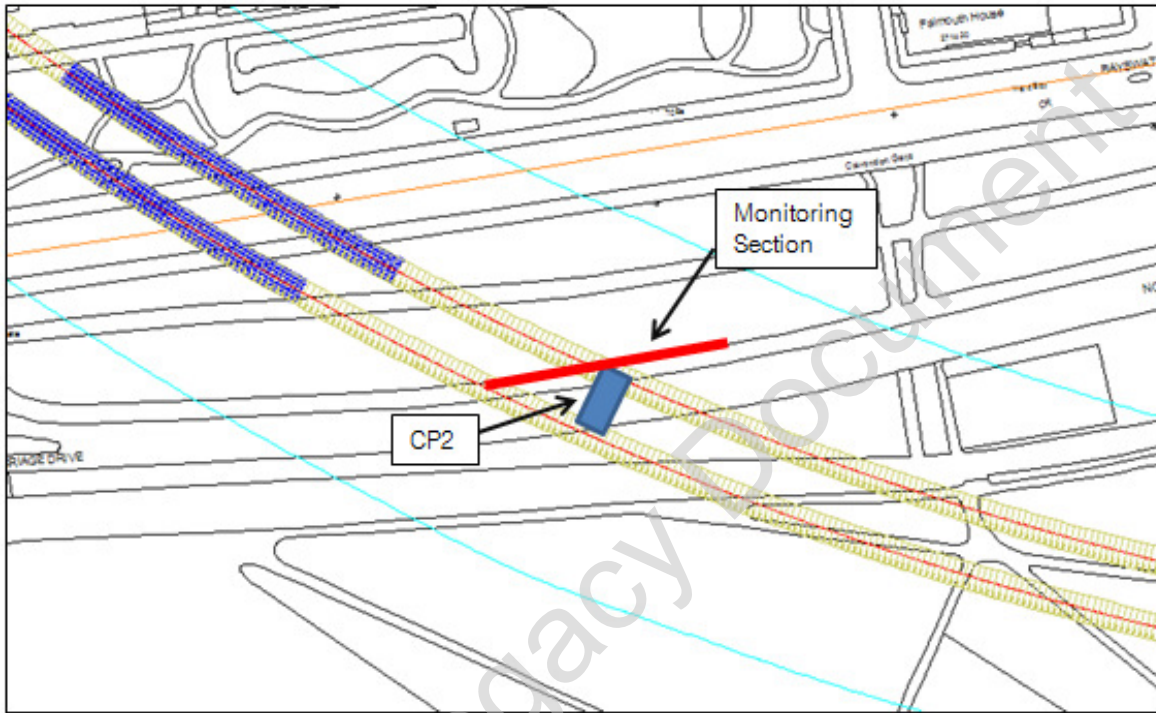


Figure 66: CP2 location

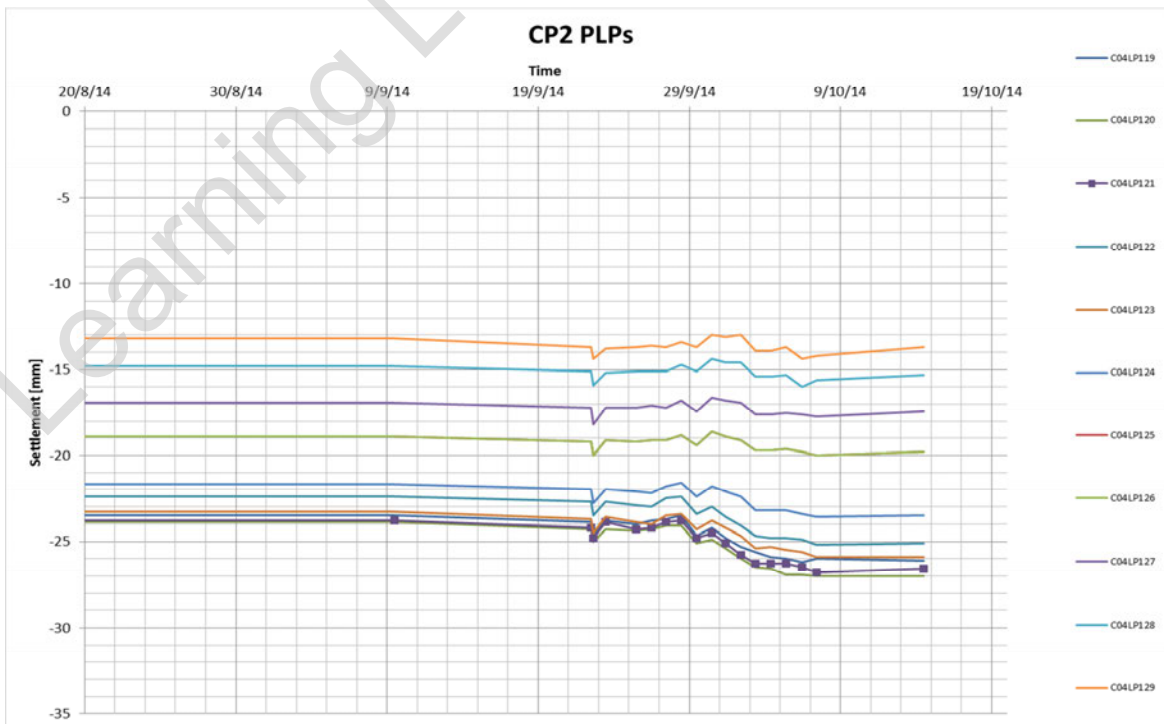


Figure 67: CP2 data time-plot (absolute)

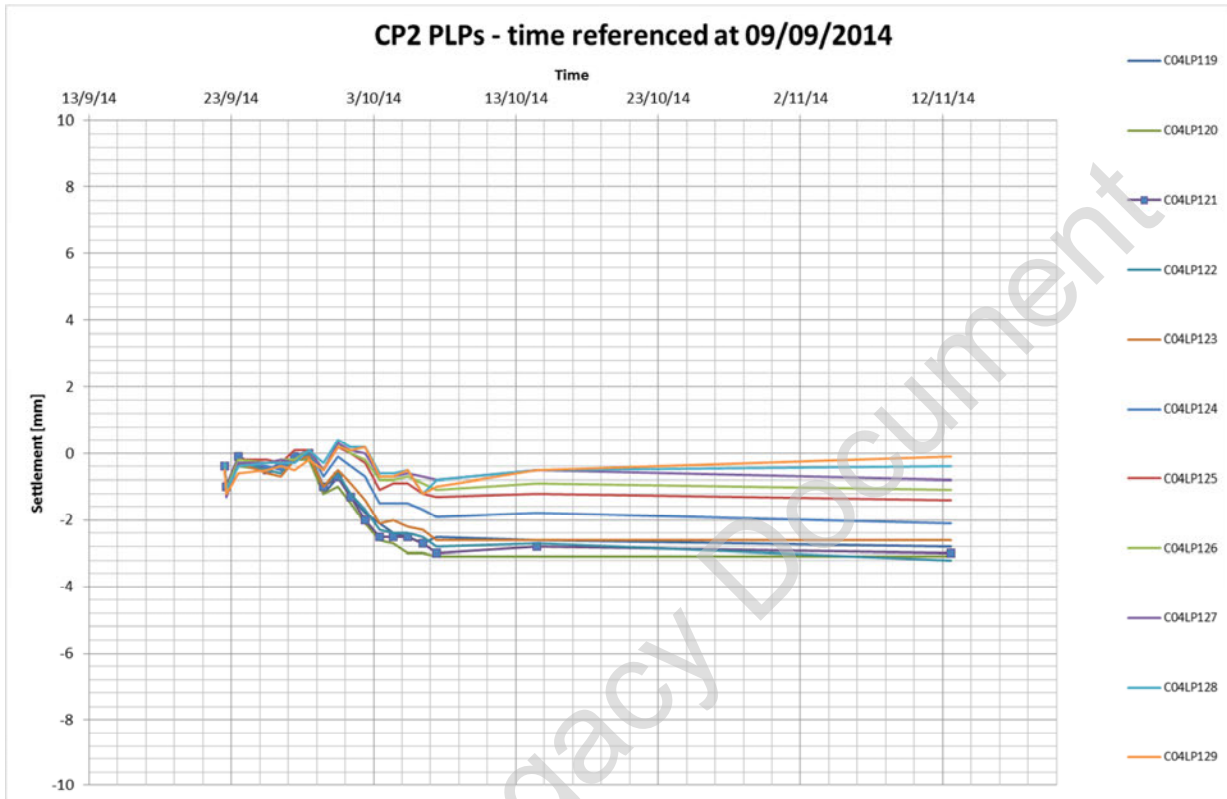


Figure 68: CP2 data time-plot (time-referenced)

2.14.2. Comments

The maximum settlement achieved as a result of CP2 excavation works is approx.. 3mm. Settlements have stabilised. The residual risk is considered to be negligible.

2.15. Cross Passage 3 (CP3)

2.15.1. Data

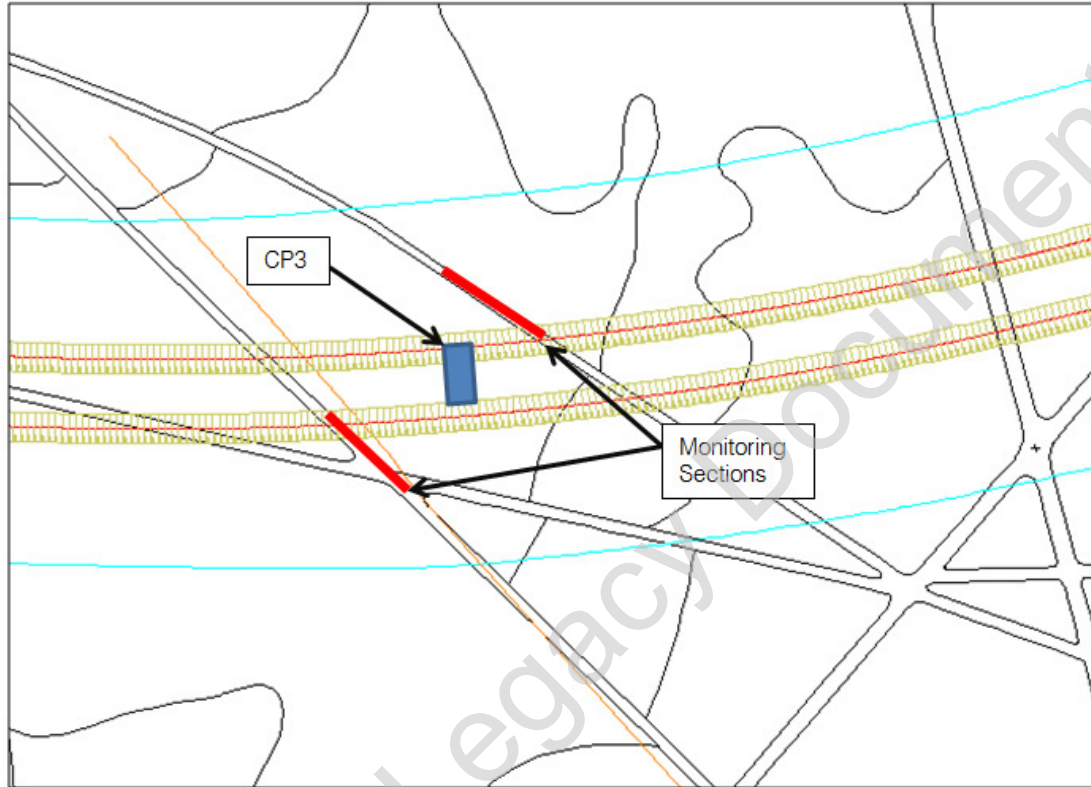


Figure 69: Location

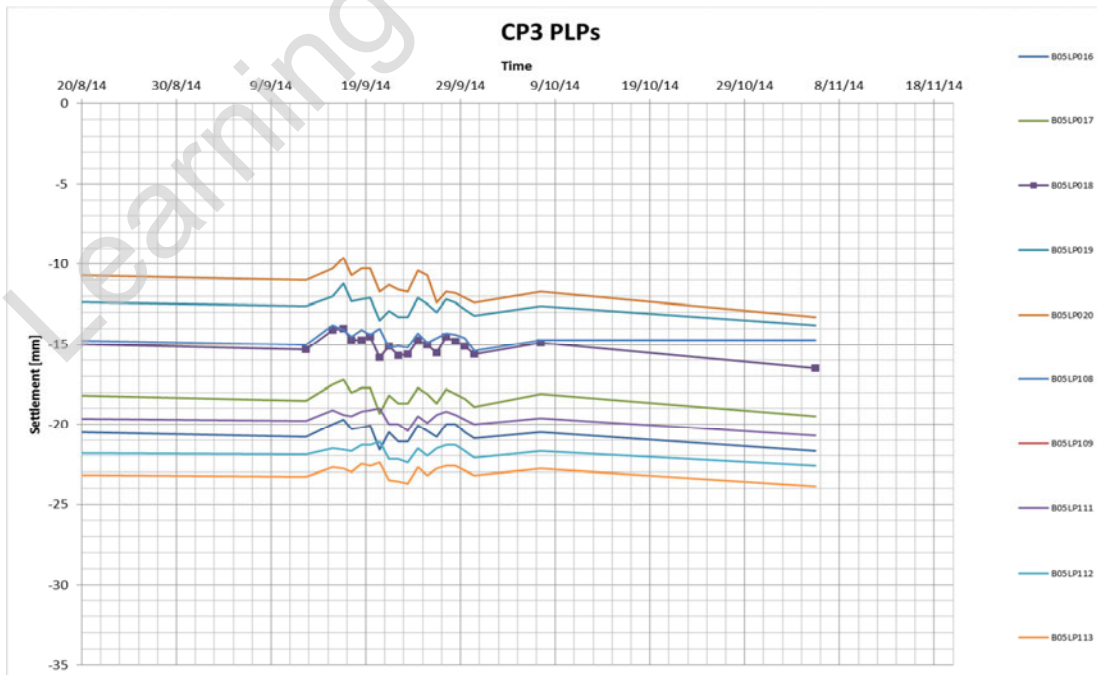


Figure 70: CP3 data time-plot (absolute)

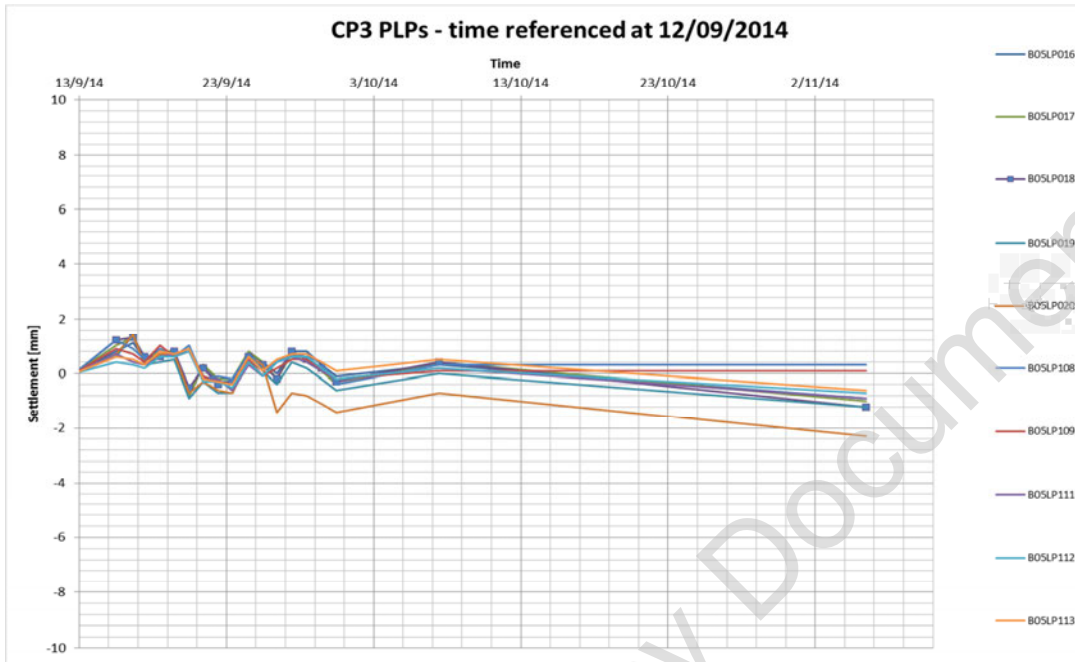


Figure 71: CP3 data time-plot (time-referenced)

2.15.2. Comments

The maximum settlement observed during construction of CP3 excavation works is 1mm. Subsequent data is within the tolerances for monitoring within the Park Settlements are now essentially stable. The residual risk is considered to be negligible.

2.16. Cross Passage 4 (CP4)

2.16.1. Data

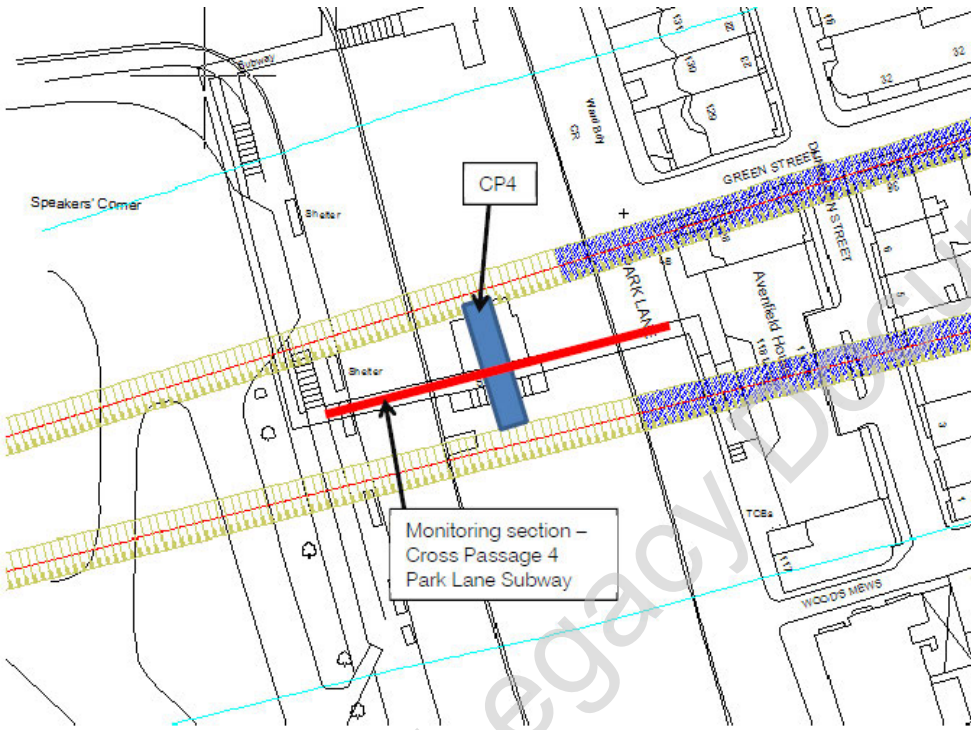


Figure 72: Location

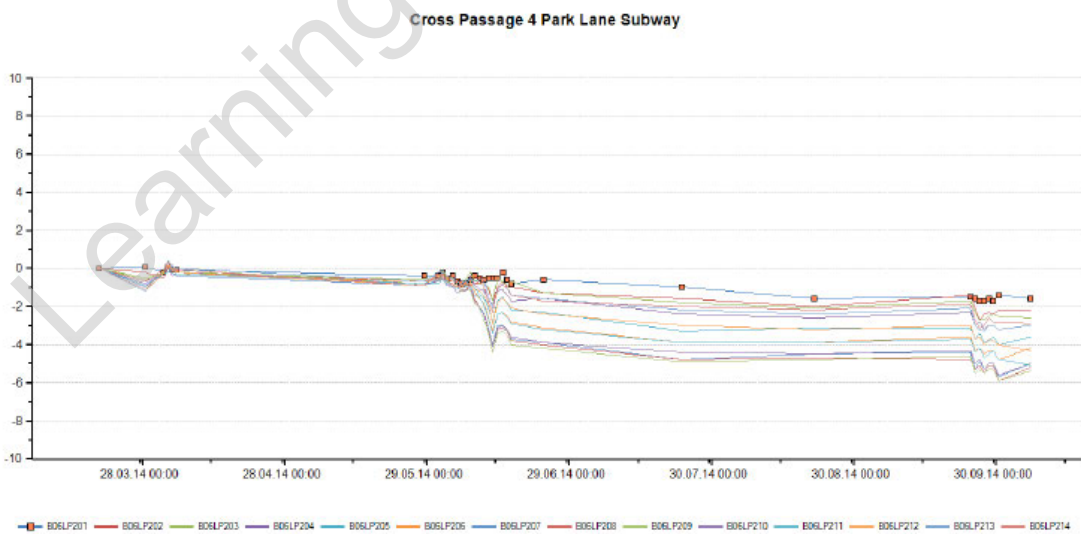


Figure 73: data time plot

2.16.2. Comments

The PLPs in Park Lane Subway settled up to approx. 5mm due to the CP4 excavation works. The last readings are showing stability and the deflections along the monitoring section are negligible.

2.17. Shallow datums

2.17.1. Data

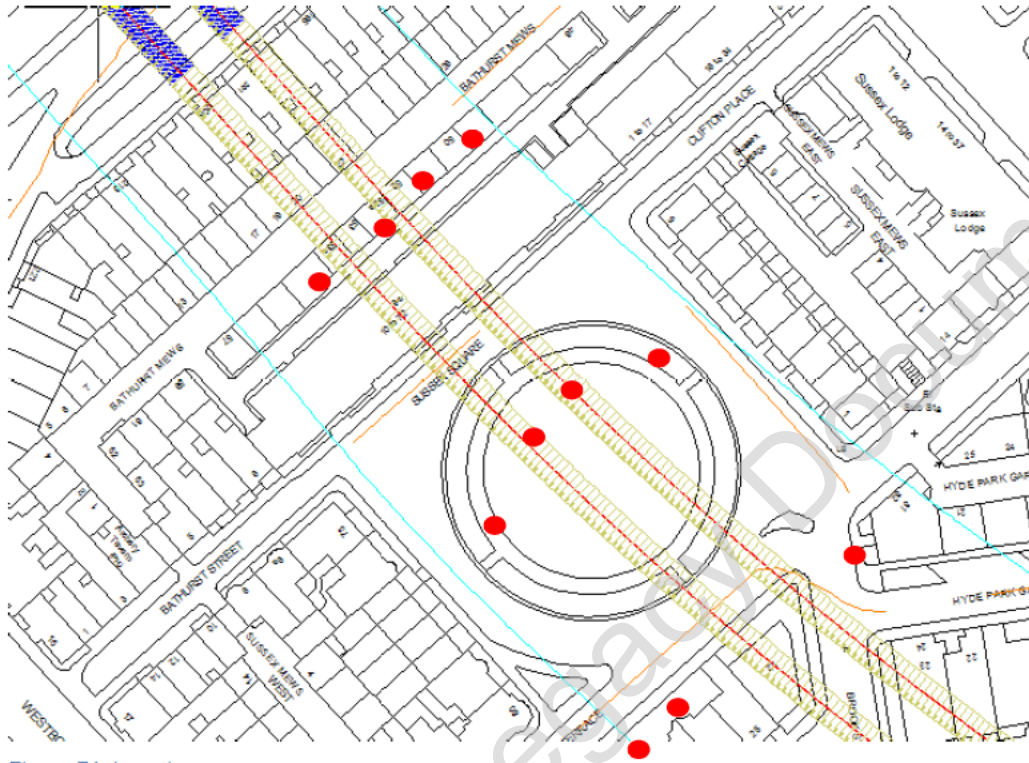


Figure 74: Location

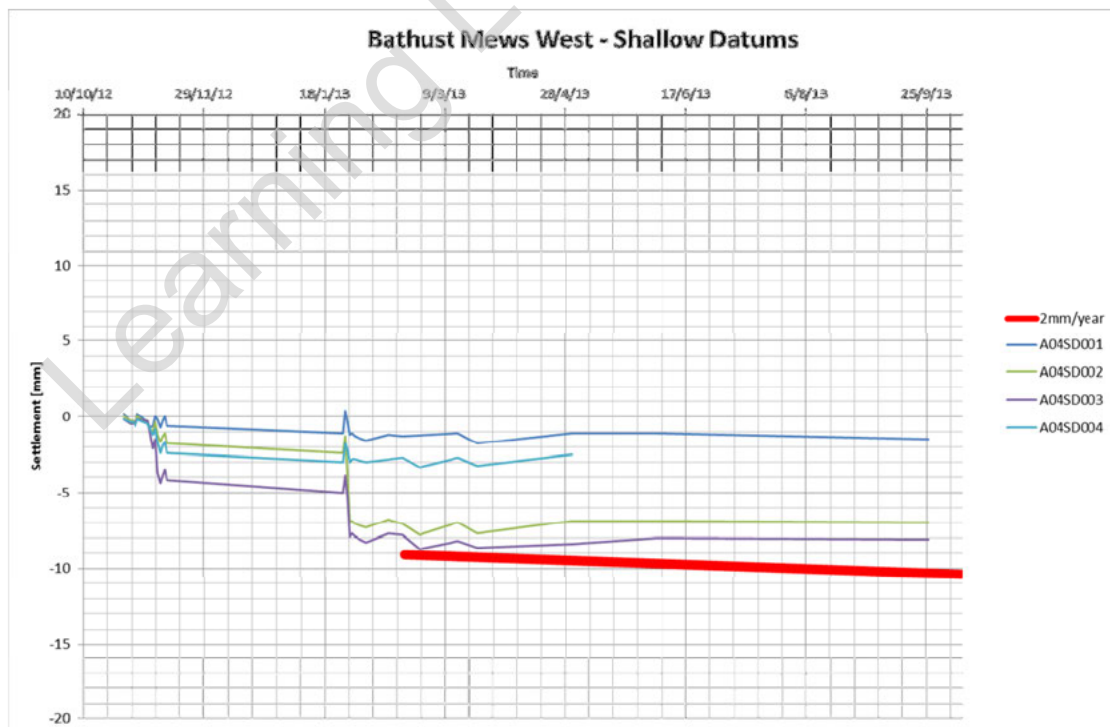


Figure 75: Bathurst Mews West Shallow Datums time plot

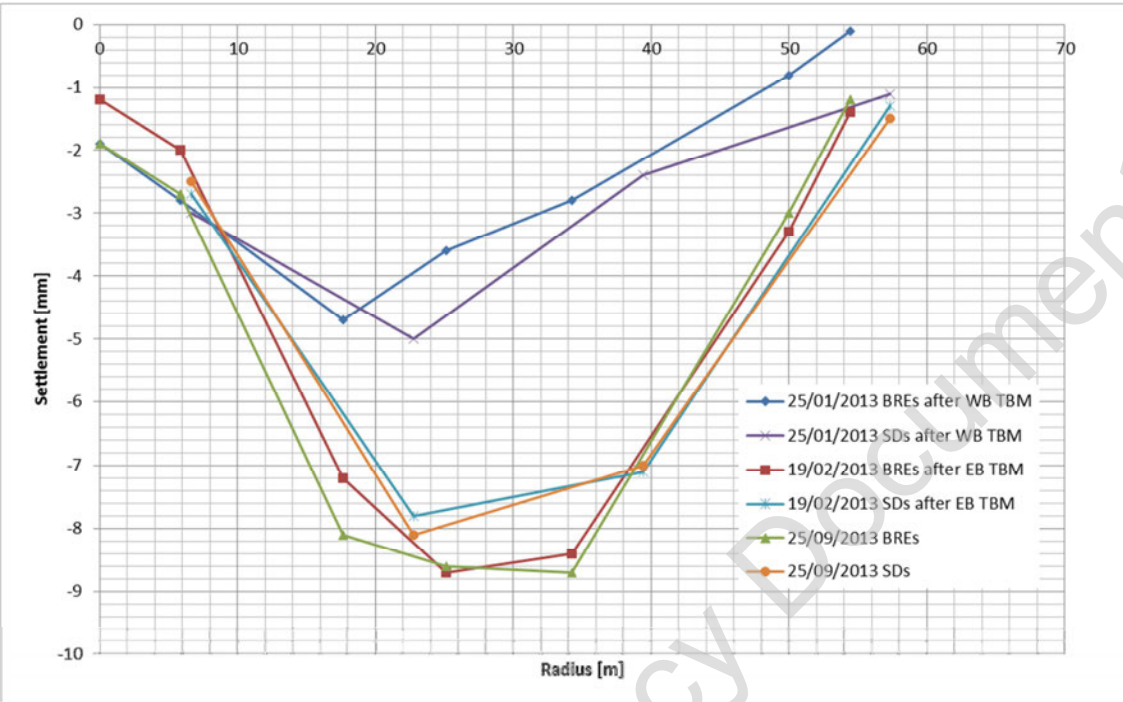


Figure 76: Transect - Bathurst Mews West Shallow Datums vs. BREs

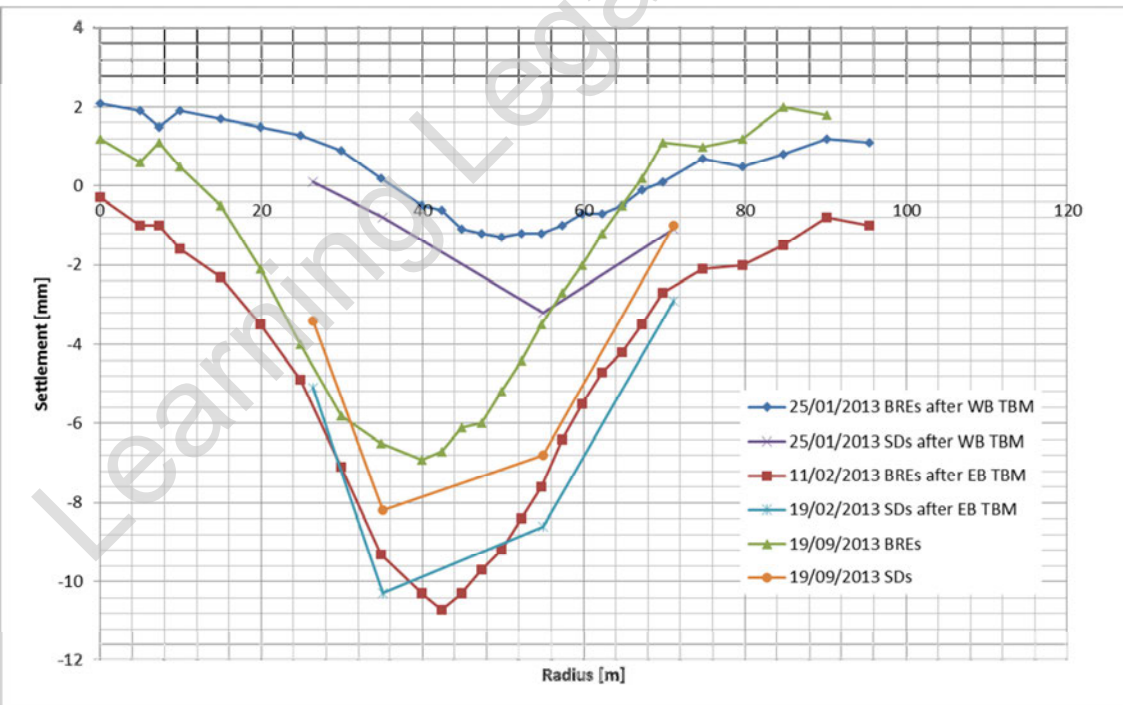


Figure 77: Transect - Sussex Square North Shallow Datums vs. PLPs

2.17.2. Comments

The Shallow Datums data is in good agreement with data from nearby PLPs. The long-term behaviour is stable and below 2mm/year.

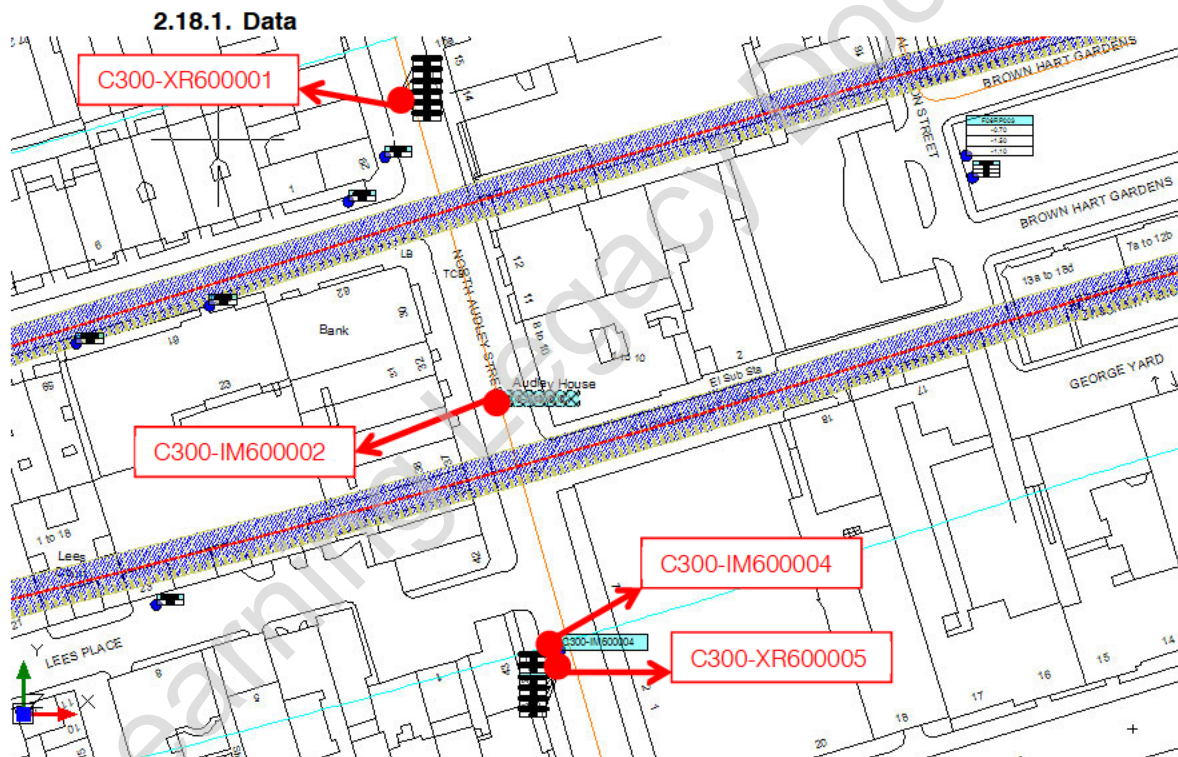
The residual risk associated with long-term settlements is then considered to be negligible.

2.18. Deep instruments

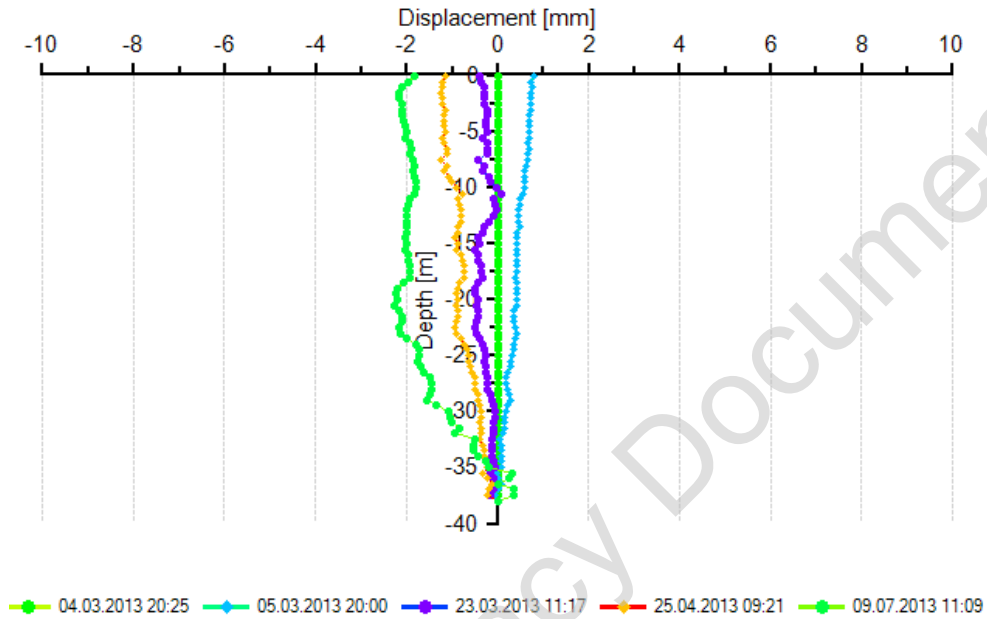
The following deep instruments have been installed and read in connection with WB and EB TBM drives:

- C300-XR600001: multi-base rod extensometer
- C300-XR600005: multi-base rod extensometer
- C300-IM600002: inclinometer
- C300-IM600004: inclinometer

Their position on map (North Audley Street) and the data obtained are reported in this section



Inclinometer: C300-IM600004 Dir. X/A 100.0 Grad



Inclinometer: C300-IM600002 Dir. X/A 100.0 Grad

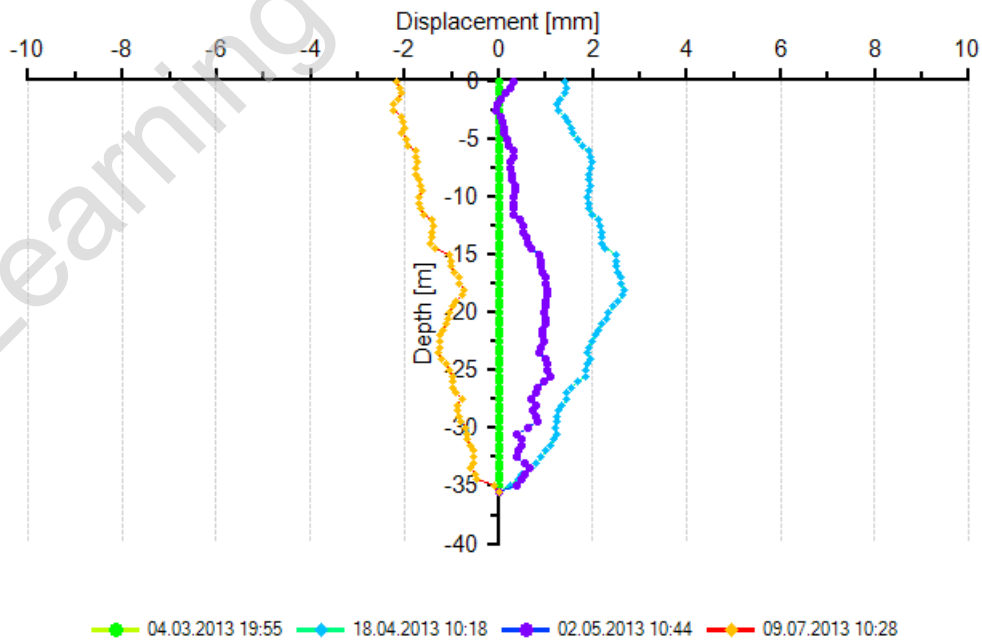
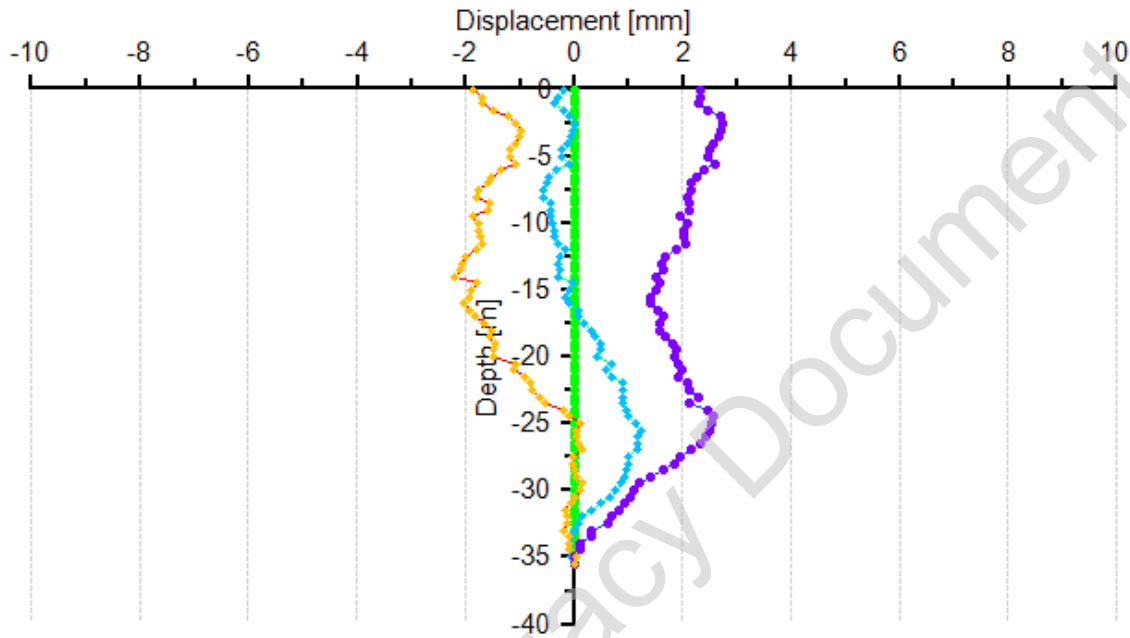
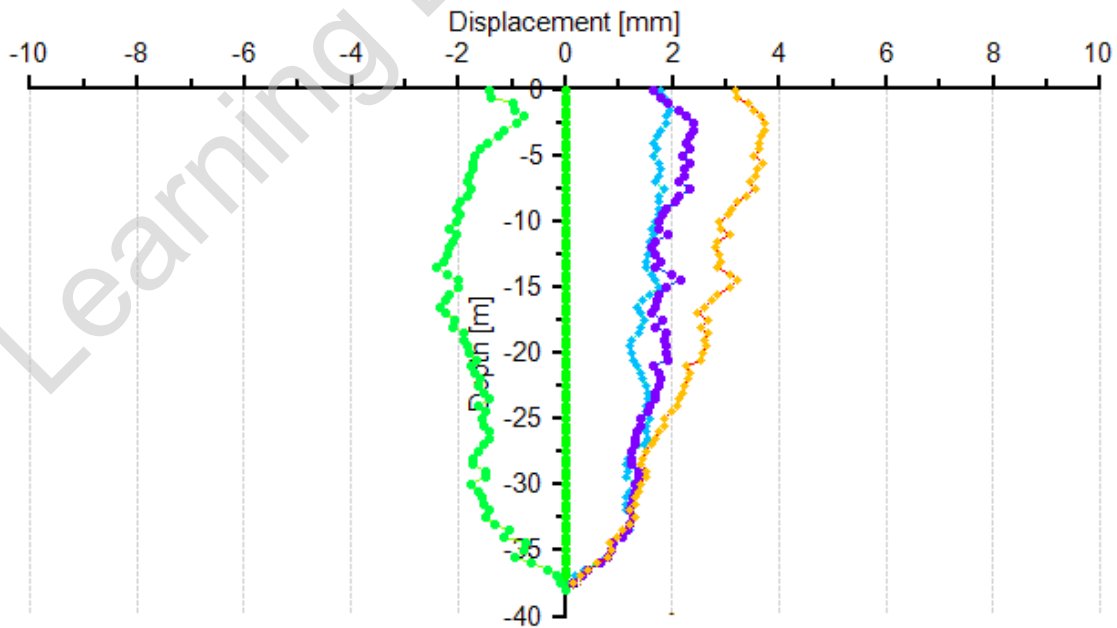


Figure 78a,b: inclinometer data from C300-IM600004 along x and y axes

Inclinometer: C300-IM600002 Dir. Y/B 0.0 Grad



Inclinometer: C300-IM600004 Dir. Y/B 0.0 Grad



04.03.2013 20:25 05.03.2013 20:00 23.03.2013 11:17 25.04.2013 09:21 09.07.2013 11:09

Figure 79a,b: inclinometer data from C300-IM600002 along x and y axes

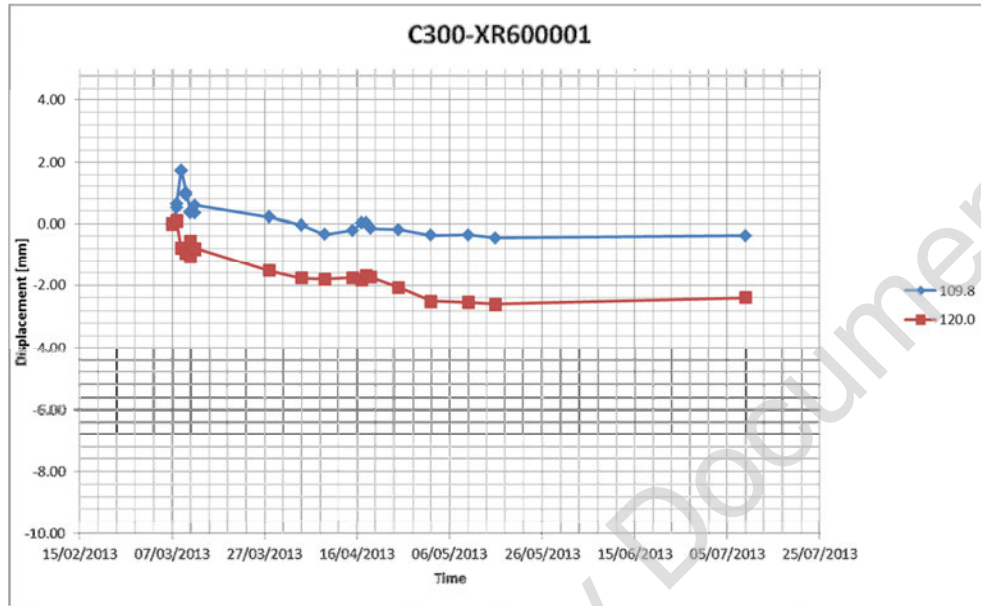
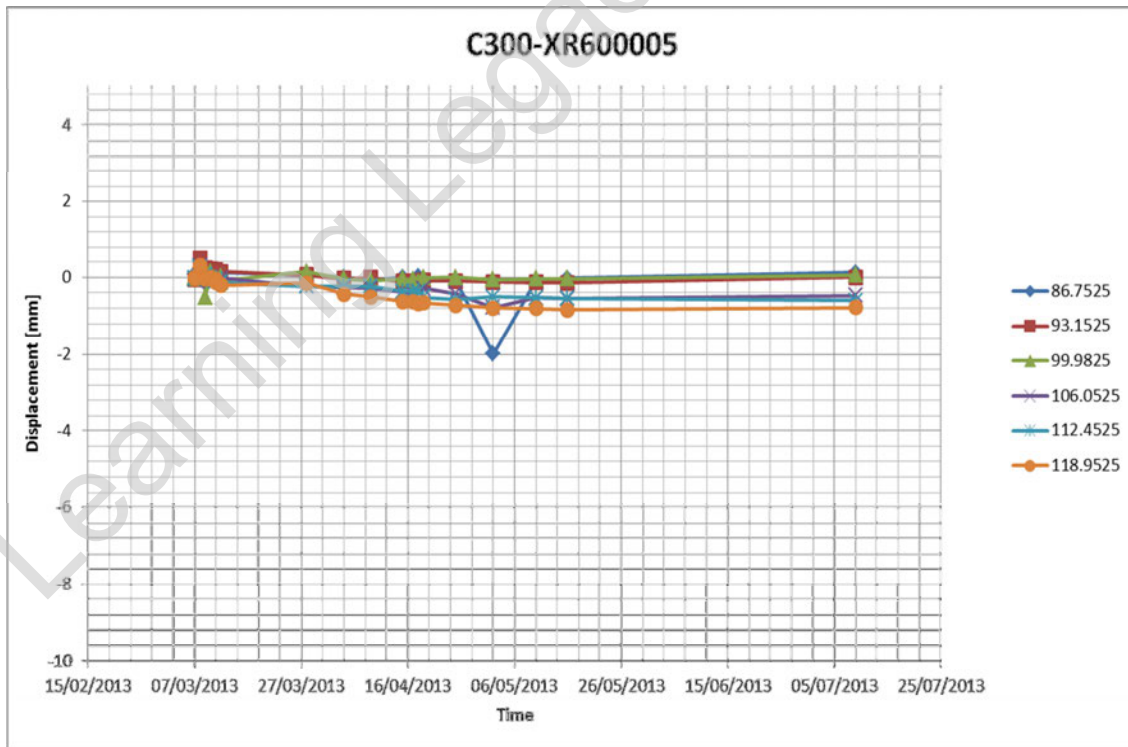


Figure 80: extensometer data from C300-XR600001



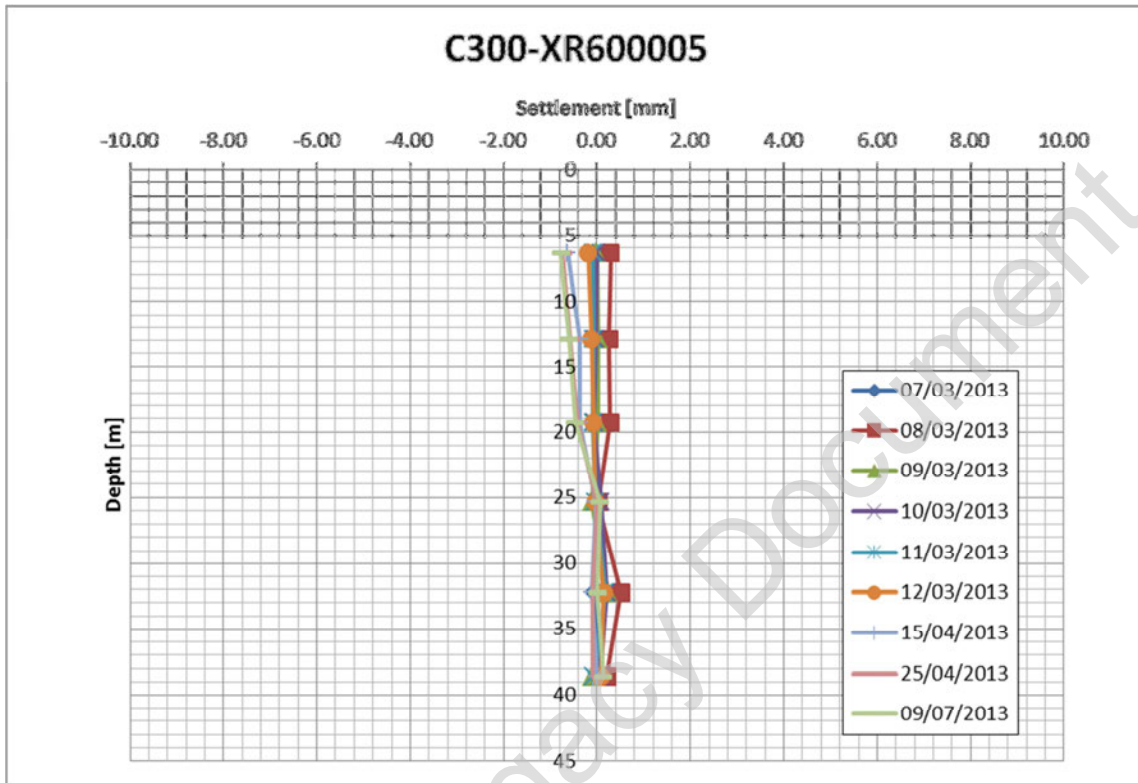


Figure 81a,b: extensometer data from C300-XR600005 – including settlement data from near PLP

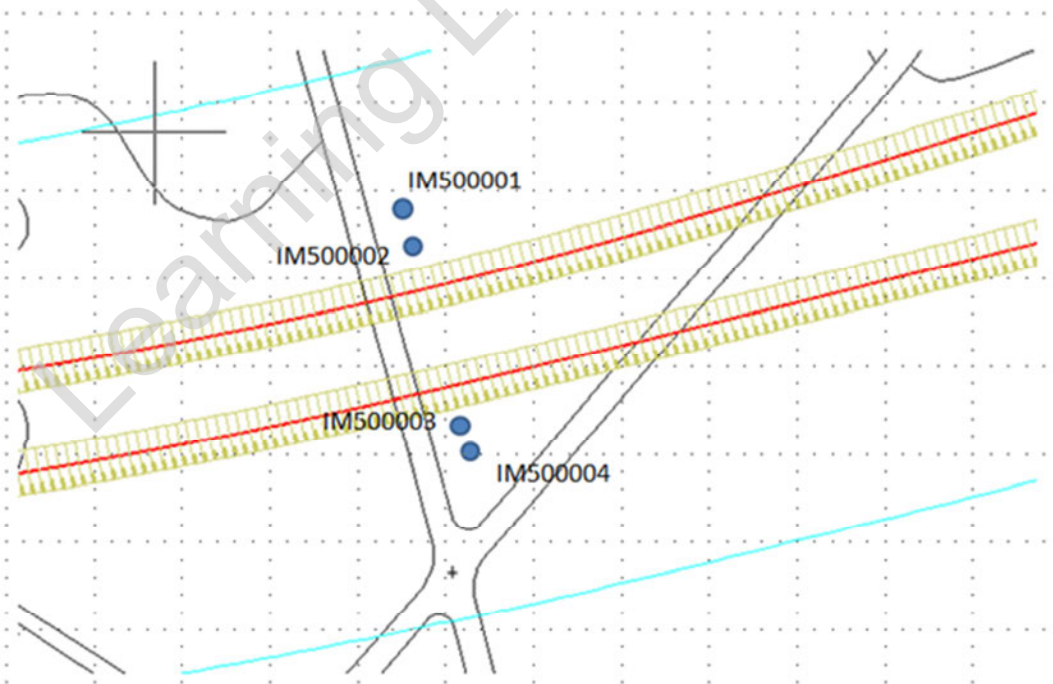
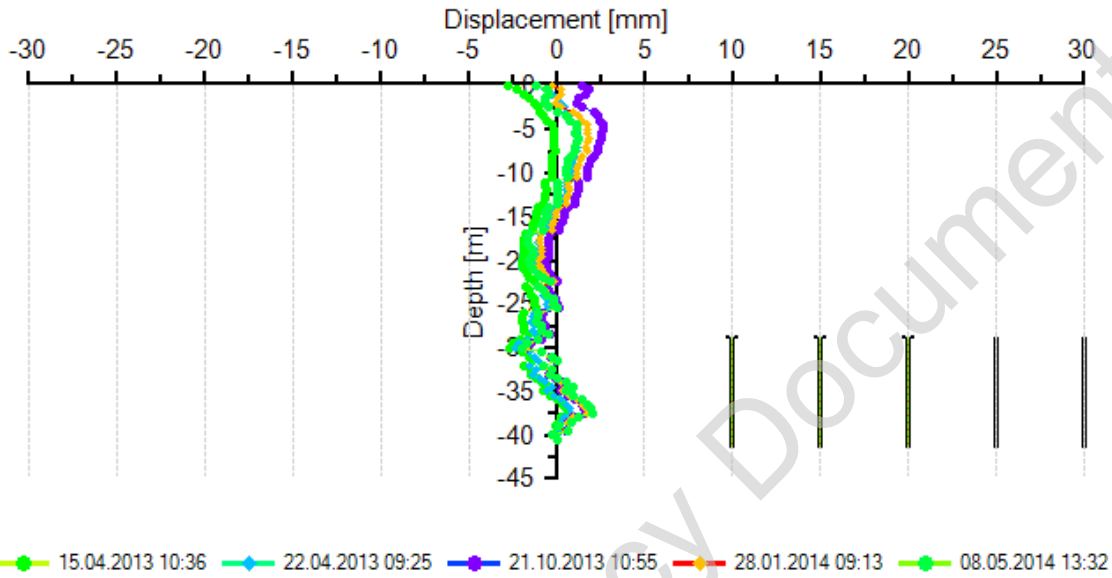
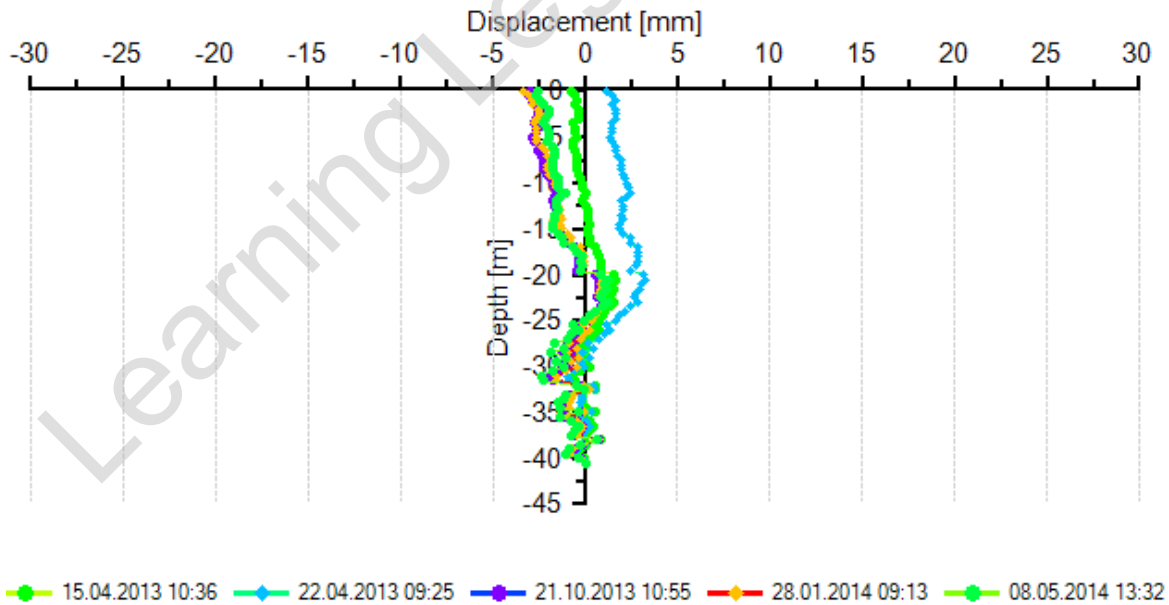


Figure 82: position of the inclinometers in Hyde Park

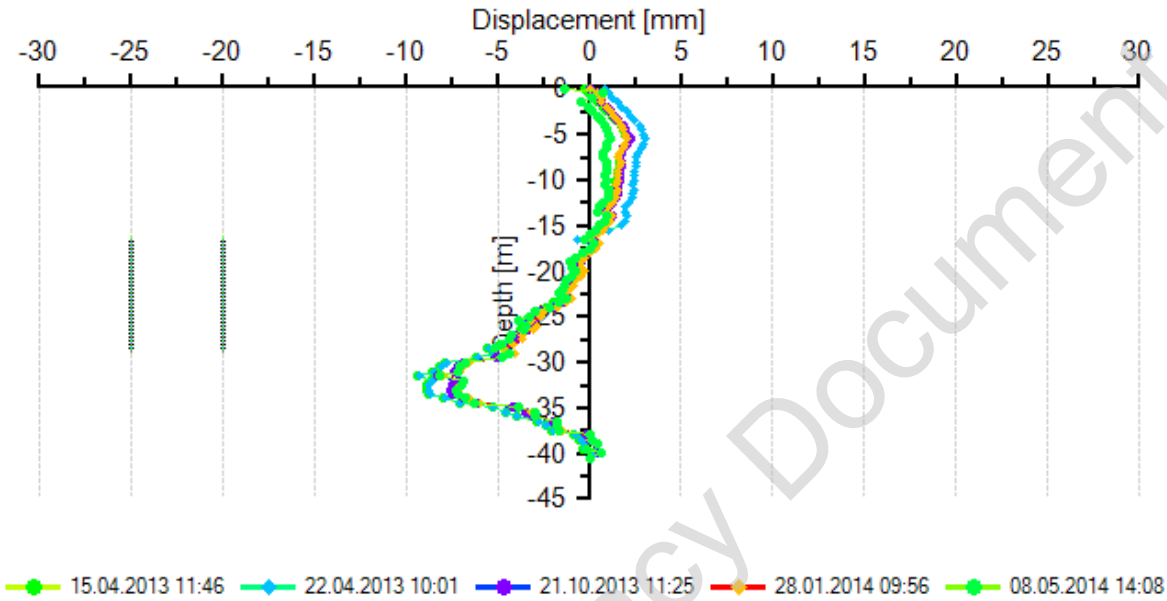
Inclinometer: IM500001 Dir. X 100.0 Grad



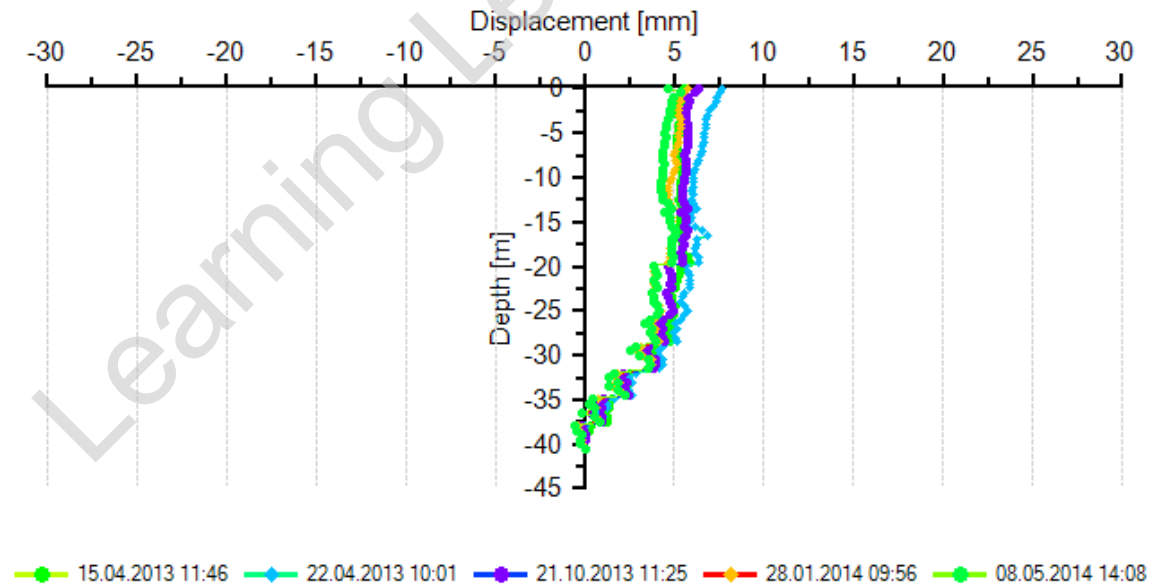
Inclinometer: IM500001 Dir. Y 0.0 Grad



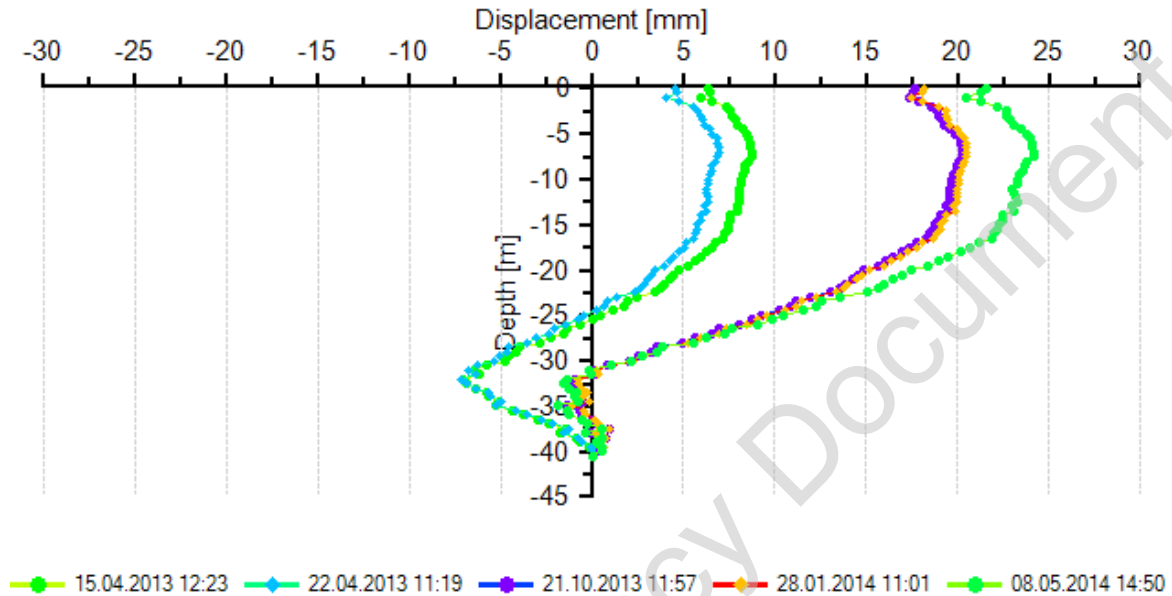
Inclinometer: IM500002 Dir. X 100.0 Grad



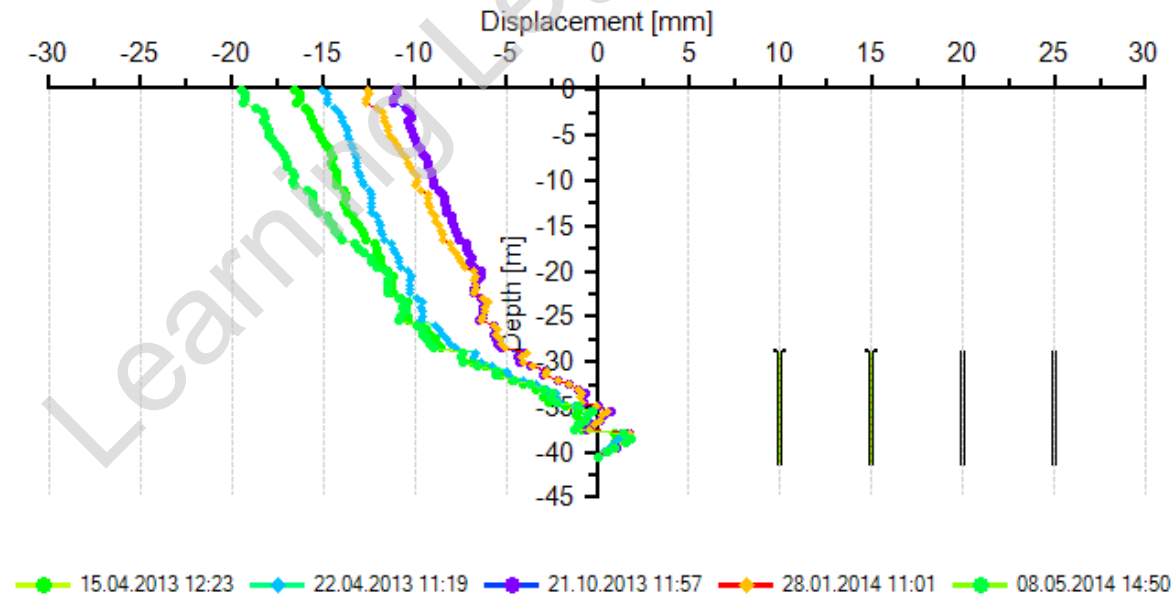
Inclinometer: IM500002 Dir. Y 0.0 Grad



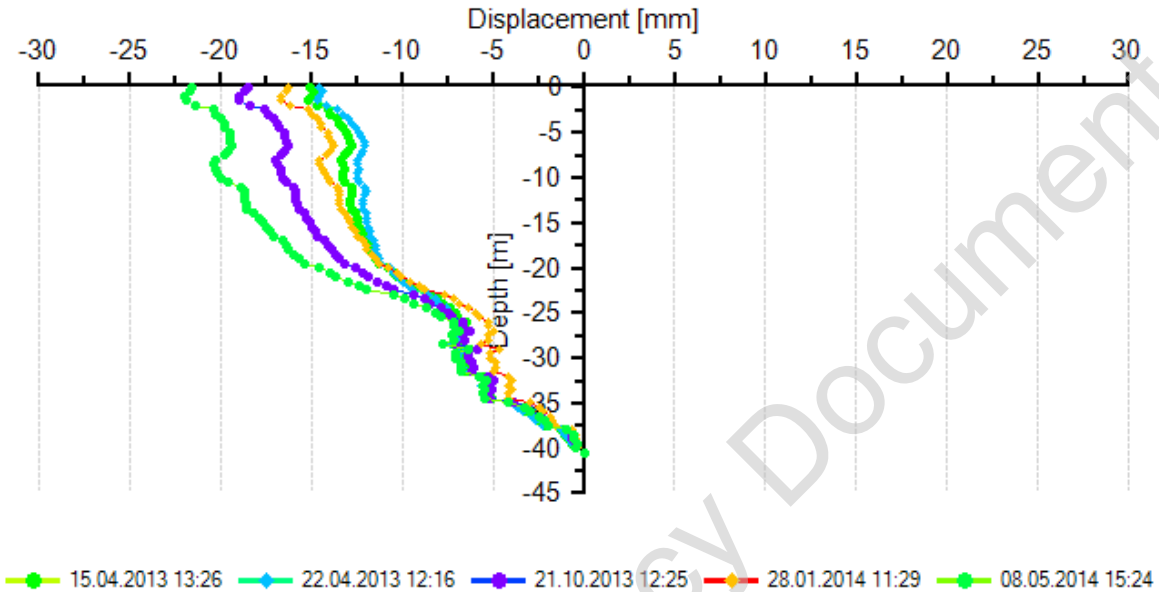
Inclinometer: IM500003 Dir. X 100.0 Grad



Inclinometer: IM500003 Dir. Y 0.0 Grad



Inclinometer: IM500004 Dir. X 100.0 Grad



Inclinometer: IM500004 Dir. Y 0.0 Grad

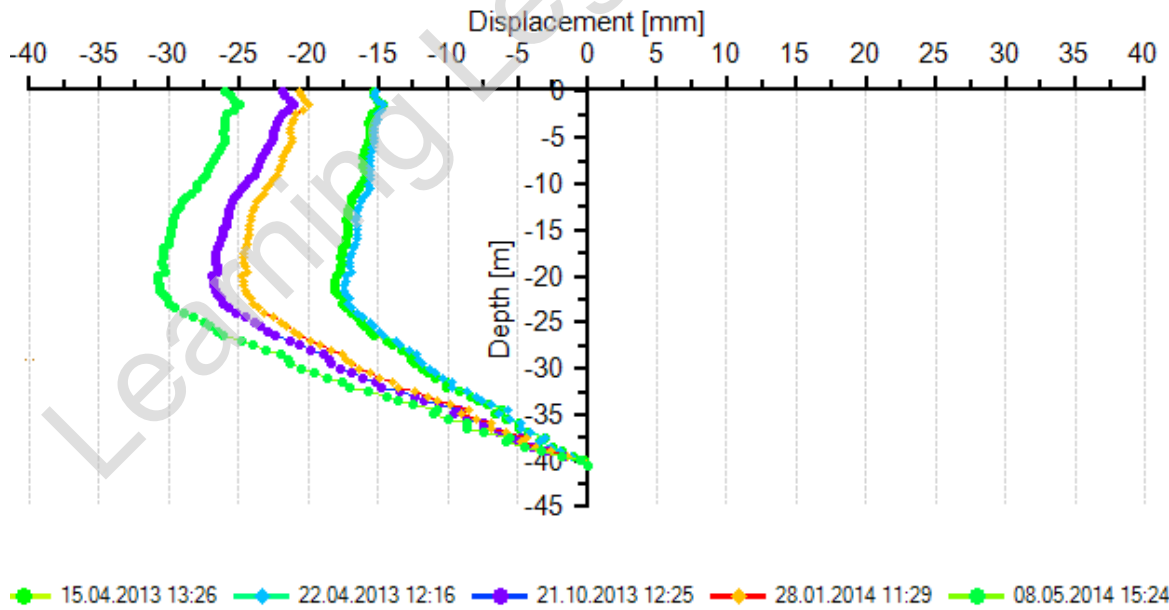


Figure 83a,b,c,d,e,f,g,h: Inclinometers in Hyde Park

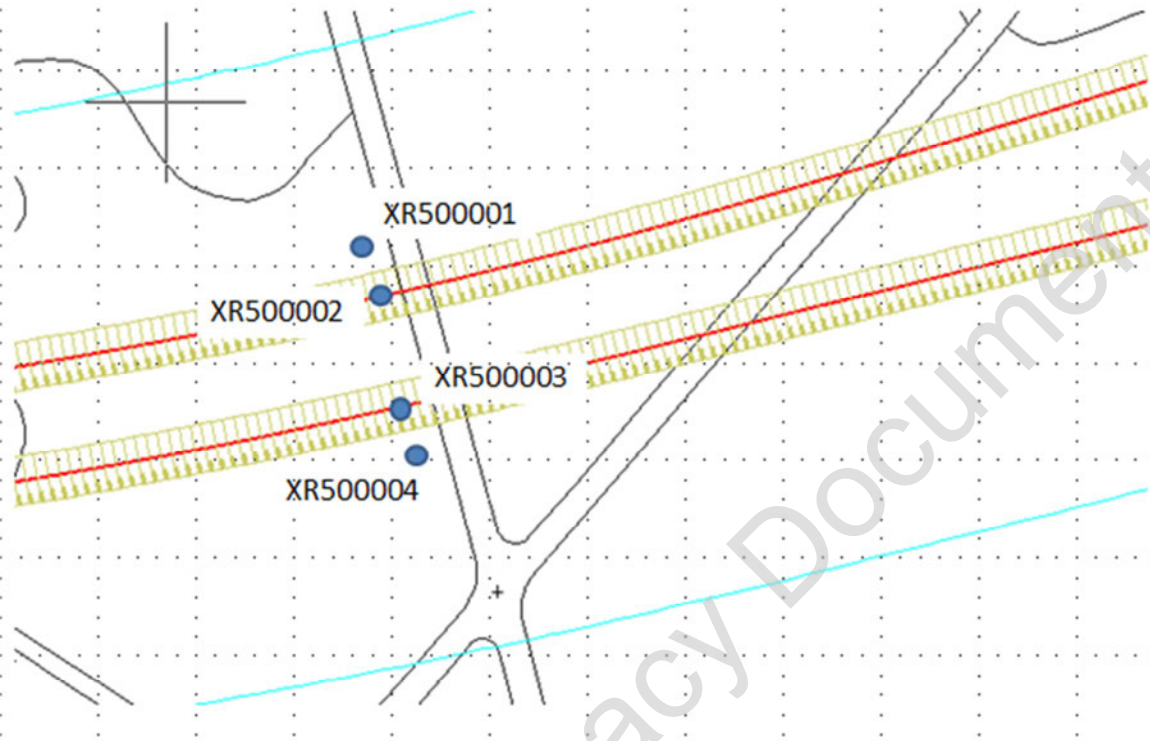
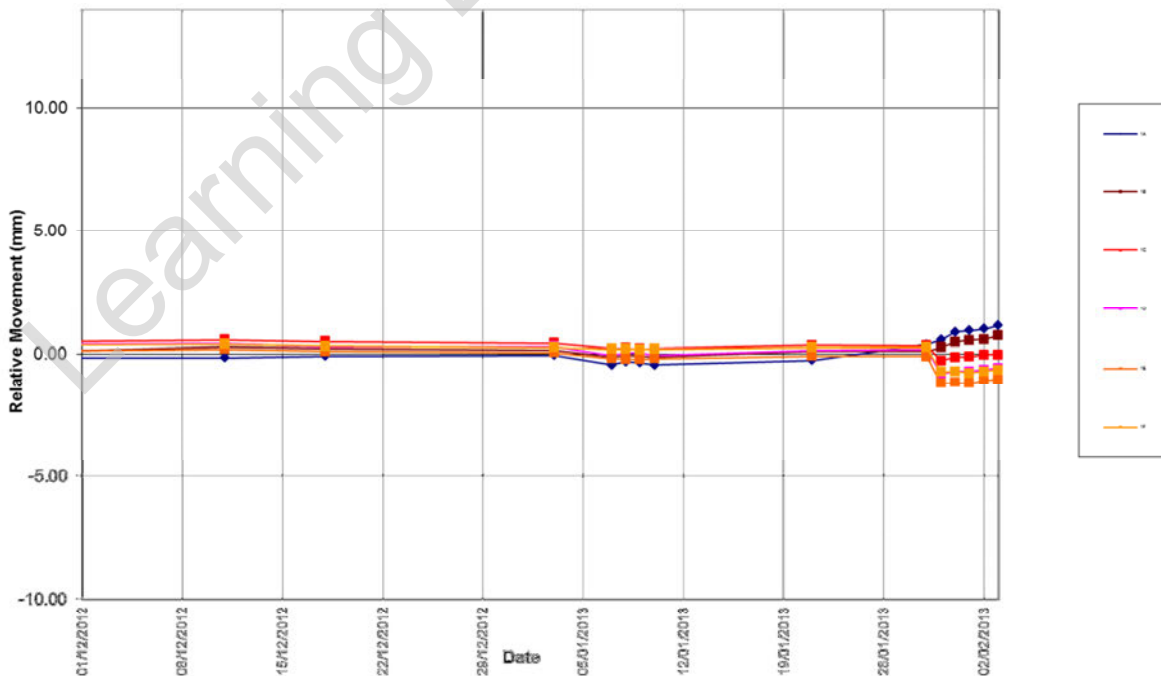
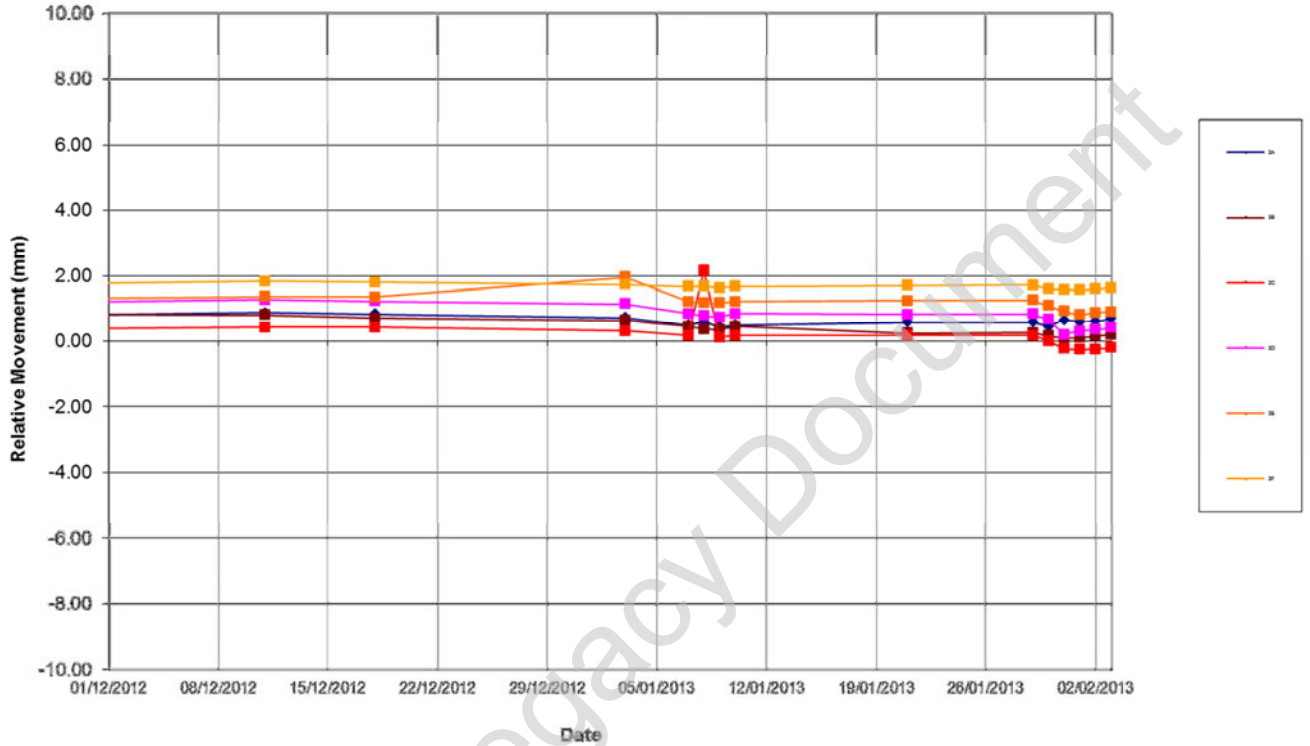


Figure 84: position of extensometers in Hyde Park

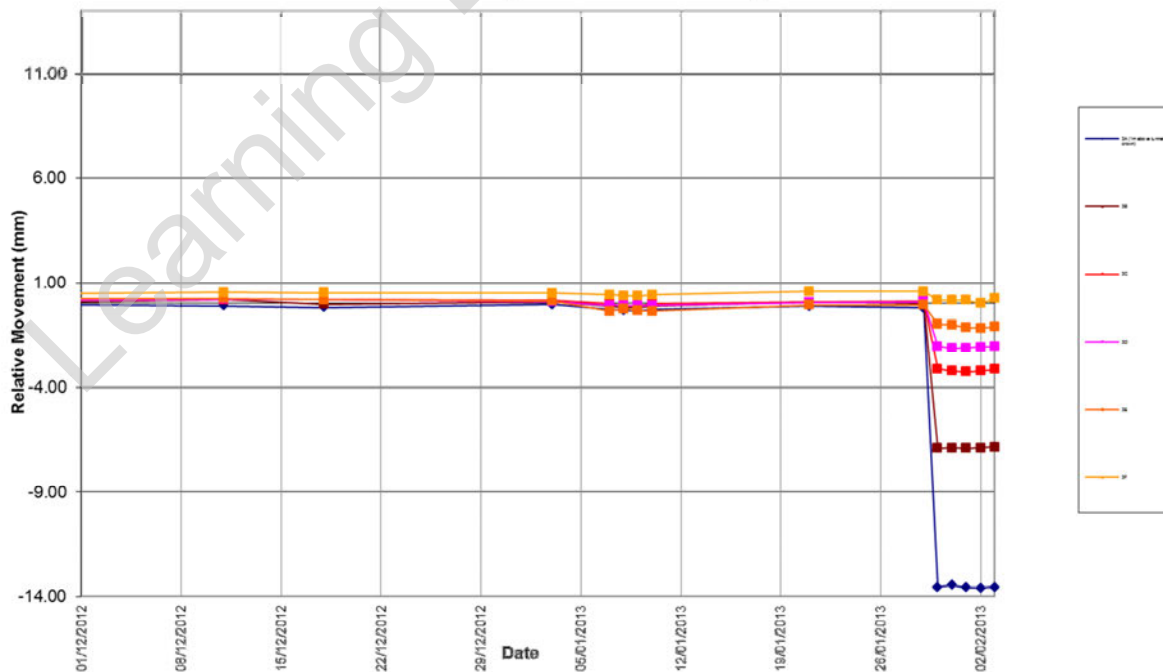
C300-C410 Hyde Park - Rod Extensometer XR500001
Relative Movement of Targets Since Commissioning.



**C300-C410 Hyde Park - Rod Extensometer XR500002
Relative Movement of Targets Since Commissioning.**



**C300-C410 Hyde Park - Rod Extensometer XR500003 (Over WB Alignment)
Relative Movement of Targets Since Commissioning.**



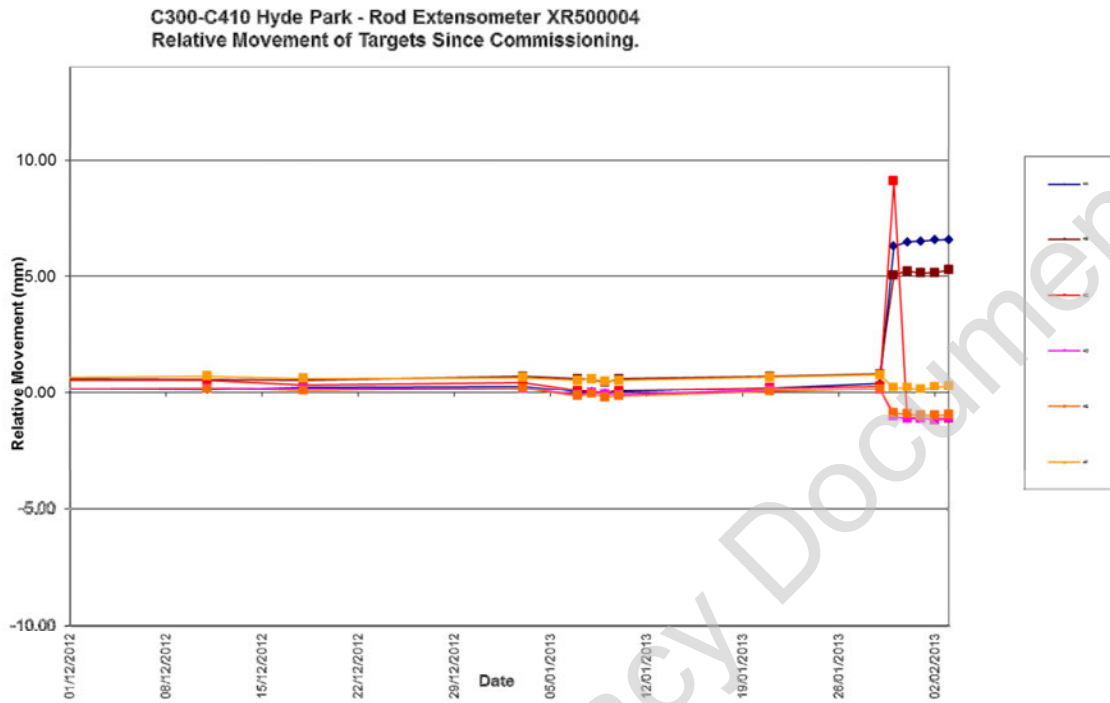


Figure 85a,b,c,d: extensometers in Hyde Park

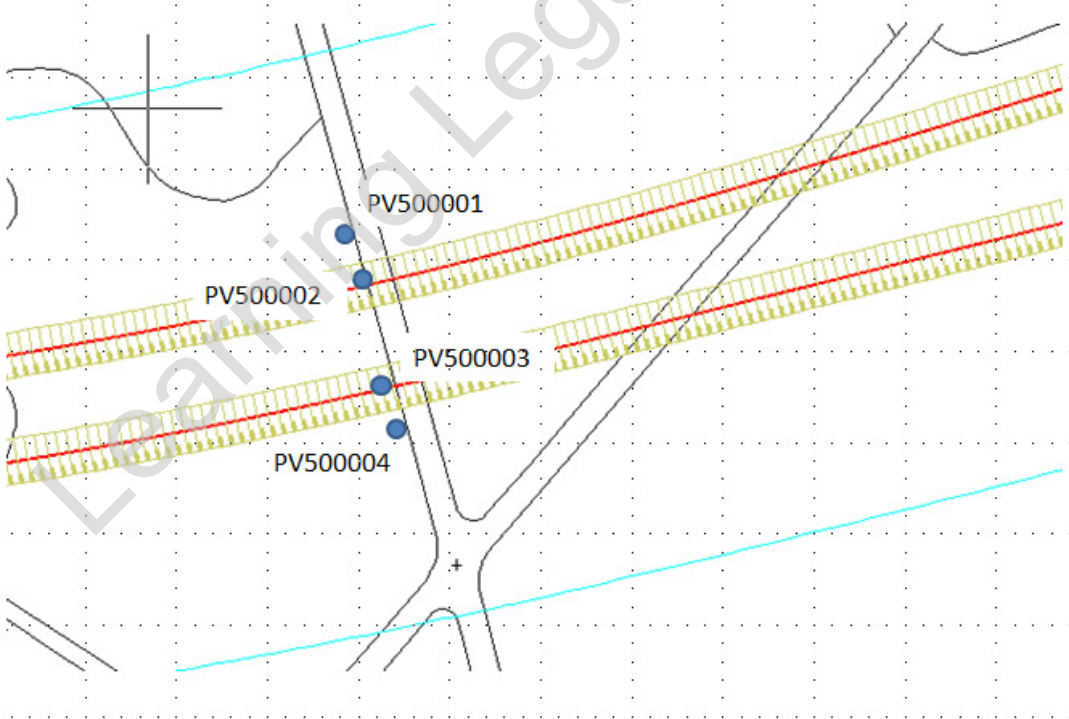


Figure 82: position of piezometers in Hyde Park

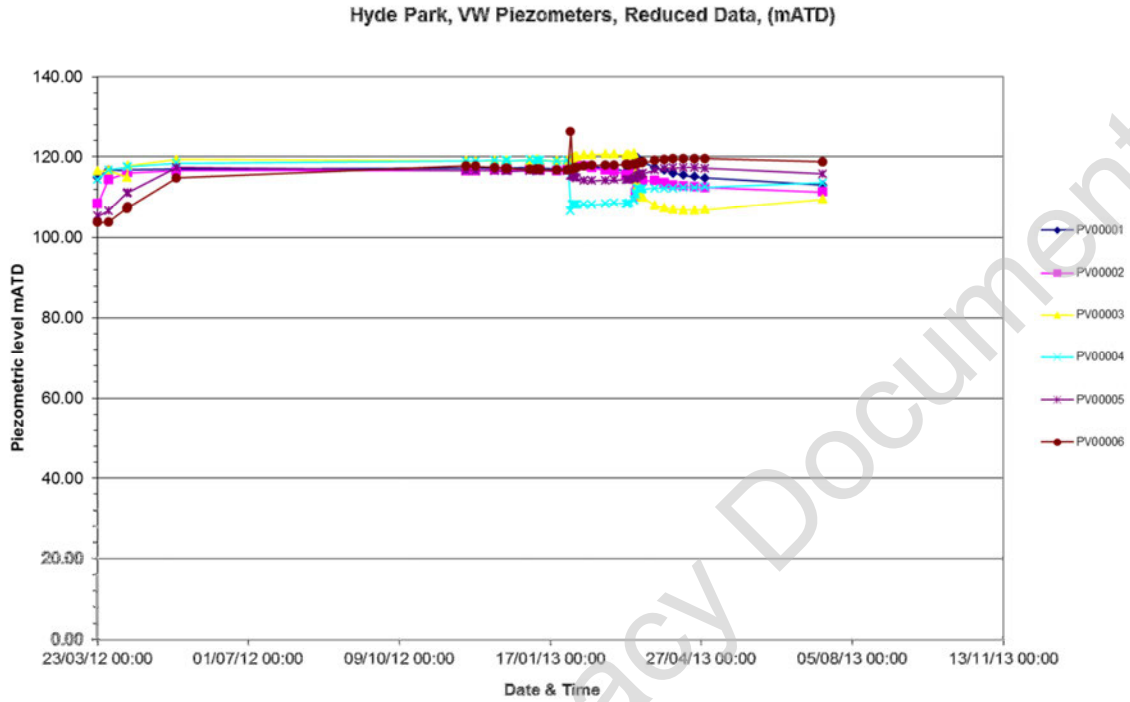


Figure 83: piezometers in Hyde Park

Appendix 1. TBMs charts and sections' chainages

TBMs progress chart

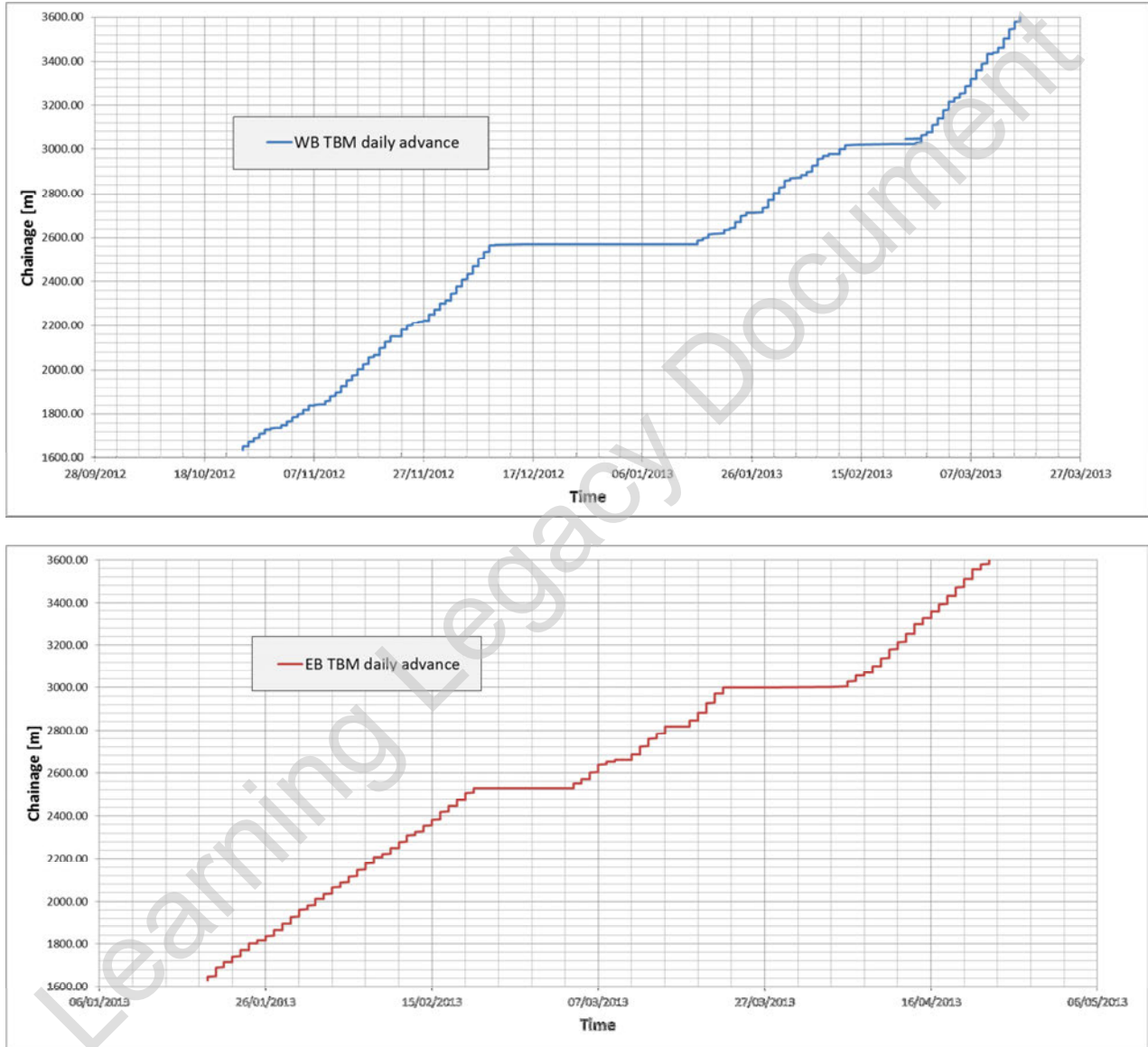


Figure 84: WB and EB TBMs progress charts along PAD-HYD drive

Table 12: Reference EB chainages

Section Location	Approx. EB Chainage
Conduit Place	1667
Spring Street	1702
Sussex Gardens East	1771
Sussex Gardens West	1804
Bathurst Mews East	1842
Bathurst Mews West	1848
Sussex Square North	1884
Sussex Square South	1975
North Carriage Drive	2218
Park Lane West	3019
Park Lane East	3084
Park Street	3236
North Audley Street	3382
Balderton Street	3475
Duke Street	3557

NOTE: the EB and WB running tunnels from PAD to BOS are generally parallel and the chainages are very similar. Therefore, only the EB chainages are reported in the above table.

Appendix 2. Reference documents

Code	Document
C300-BFK-C4-STP-CRT00_ST005-50046	MANAGEMENT PLAN FOR THE CONTROL OF GROUND MOVEMENTS: ADDENDUM 23: TBM DRIVES 3 - PADDINGTON TO PARK LANE
C122-OVE-C2-RGN-CRG01-50076	Instrumentation & Monitoring Plan C300 Running Tunnels Ground Movement And Asset Protection
C122-OVE-U-RGN-CRG01-50003	Instrumentation and Monitoring Plans: Thames Water Assets: Drive X (C300) Instrumentation Plan for large or Deep Sewers
C300-BFK-C4-RGN-CRT00_ST005-51941	Grout Report Route-wide subsurface
C300-BFK-C4-RGN-CRT00_ST005-50400	Hyde Park I&M Subsurface Installation report
C300-BFK-C4-RGN-CRT00_ST005-50404	Bathurst Mews / Sussex Square

	I&M subsurface installation report
C300-BFK-C4-RGN-CRT00_ST005-50500	Installation report -Internal monitoring of the Bayswater Mid Level Sewer No.1
C300-BFK-C4-RGN-CRT00_ST005-50505	Installation report for PLP's Hyde Park to Bond Street
C300-BFK-C4-RGN-CRT00_ST005-50520	Stanhope Terrace I&M Subsurface Pin Installation Report
C300-BFK-C4-RGN-CRT00_ST005-50521	Installation report - Internal monitoring of sussex square Sewer
C300-BFK-C4-RGN-CRT00_ST005-50528	Installation report - internal monitoring of the conduit mews sewer
C300-BFK-C4-RGN-CRT00_ST005-50529	Installation report -Internal Monitoring of the sussex Gardens Sewer
C300-BFK-C4-RGN-CRT00_ST005-50541	Installation Report for PLP's in 193-209 Sussex Gardens (PMI 164)
C300-BFK-C4-RGN-CRT00_ST005-50566	Installation Report - Internal Monitoring of the Ranleigh Sewer Hyde Park
C300-BFK-C4-RGN-CRT00_ST005-50571	Installation Report - Internal Monitoring of the Spring Street Sewer
C300-BFK-C4-RGN-CRT00_ST005-50580	As built report for Hyde Park strain guages
C300-BFK-C4-RGN-CRT00_ST005-50600	Installation of Geodetic Prisms and retros Paddington to Hyde Park
C300-BFK-C4-RGN-CRT00_ST005-50601	Installation of BRE's and barcodes in Paddington to Hyde Park (PMI 54)
C300-BFK-C4-RGN-CRT00_ST005-50602	Installation og geodetic prisms hyde park to bond street
C300-BFK-C4-RGN-CRT00_ST005-50603	Installation report for barcodes in Hyde park underground car park (PMI182)
C300-BFK-C4-RGN-CRT00_ST005-50604	Installation of BRE's Barcodes and PLP's in Hyde Park to Bonds Street
C300-BFK-C4-RGN-CRT00_ST005-50609	North Audley Street I&M Subsurface Installation Report
C300-BFK-C4-RGN-CRT00_ST005-50618	Installation OF PLP's In Brown Hart Gardens and Balderton Street (PMI203)
C300-BFK-C4-RGN-CRT00_ST005-50649	Installationd=s of PLP's and Retros In Duke St UKPN Tunnel (PMI 272)
C300-BFK-C4-RGN-CRT00_ST005-50660	Crackmeters As-built report for 13 North Audley Street
C300-BFK-C4-RGN-CRT00_ST005-50856	Installation Report for PLP's in Paddington to Hyde Park Area

C300-BFK-C4-RGN-CRT00_ST005-50857	Installation Report for PLP's in Eastbourne Terrace Paddington (PMI 178)
C300-BFK-C4-RGN-CRT00_ST005-51939	Installation Report for LU03 - District and Circle Line Paddington - Manual Track Survey
C300-BFK-C-RGN-CRT00_ST005-50437	HYDE PARK PLP INSTALLATION REPORT

Appendix 3. Thames Water Assets summary table

Area	Type	Sewer Name	Address	Alert Value (mm)	Deflection Alert Value	Deflection Amber Trigger Value	Deflection achieved (average of 3 values)
PADD - HYD	Sewer	TW08 Conduit Mews, Spring Street Sewer, Sussex Gardens	Conduit Mews, Spring Street & Sussex Gardens	-	-	-	
	Water Main	Fraed Street	Fraed Street	-	-	1 in 2600	
	Water Main	Sussex Gardens	Sussex Gardens	-	-	1 in 3200	1 in 4500
	Water Main	Sussex Gardens		-	-	1 in 3400	
	Water Main	Sussex Gardens		-	-	1 in 2700	
	Water Main	Sussex Gardens		-	-	1 in 2900	
	Sewer	TW10 Sussex Square Sewer	Sussex Square	-	-	-	
	Water Main	Stanhope Terrace	Stanhope Terrace	-	1 in 2900	-	1 in 5300
	Sewer	TW11 Middle Level Sewer No 1 Main Line	Baywater Road	-	1 in 2300	-	1 in 5300
	Water Main	Baywater Road	Baywater Road	-	1 in 3000	-	1 in 5300
	Water Main	Baywater Road		-	1 in 2900	-	
	Water Main	Baywater Road		-	1 in 3200	-	
HYD-BOS	Sewer	TW12 Fanelagh main Sewer main line	Hyde Park (Transect No.4)	-	1 in 4600	-	1 in 20000
	Water Main	Hyde Park	Hyde Park (Transect No.8, one before Park Lane)	-	1 in 3000	-	1 in 7000
	Water Main	Park Lane (Speakers Corner)	Park Lane West	-	1 in 2800	-	1 in 14000
	Sewer	TW15 North Audley Street	North Audley Street - Brown Hart Gardens - Duke Street	10mm	-	-	

Appendix 4. C300 Buildings Claims

The sketches show the locations of the buildings for which damages claims were raised. The building addresses are reported in the yellow boxes and the position on the plan is indicated with a red arrow. This information was provided by C122. These sketches are reported at the end of this document

Appendix 5. LU data

A) LU/05 Central Line (East of Lancaster Gate)

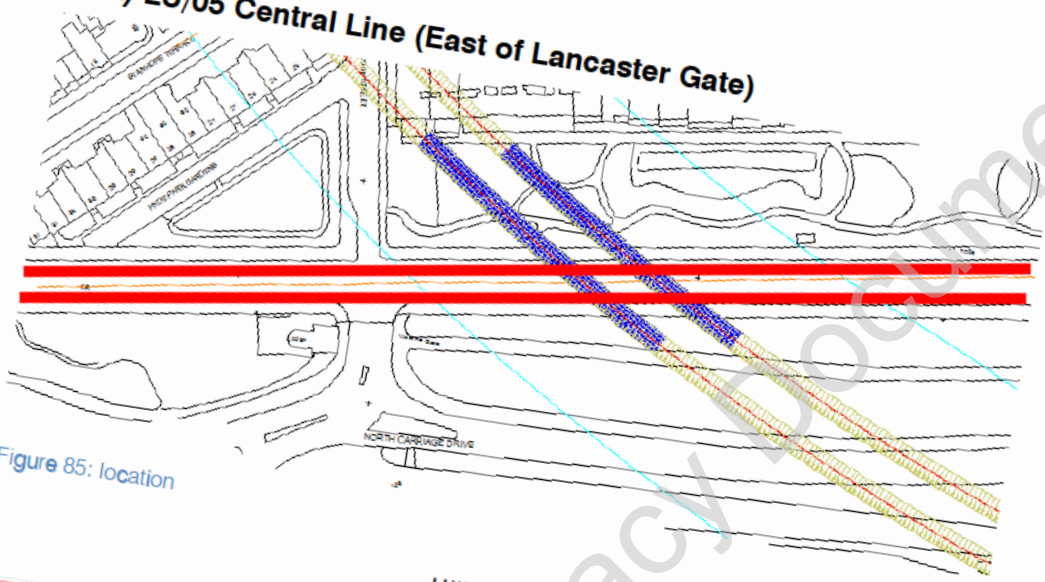


Figure 85: location

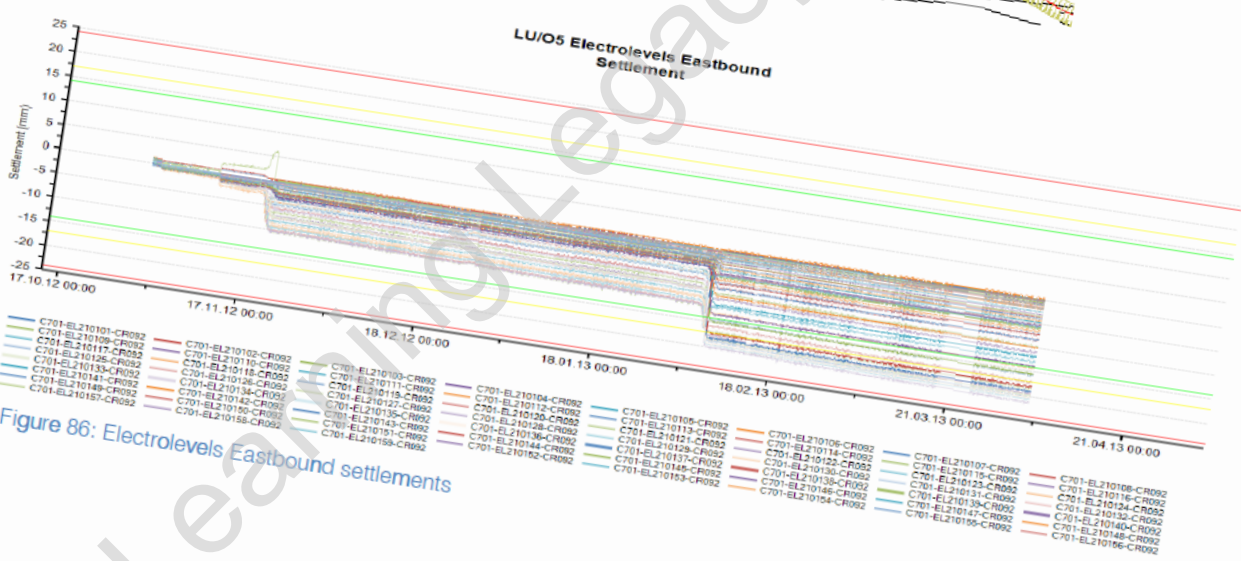


Figure 86: Electrolevels Eastbound settlements

LU/O5 Electrolevels Westbound
Settlement

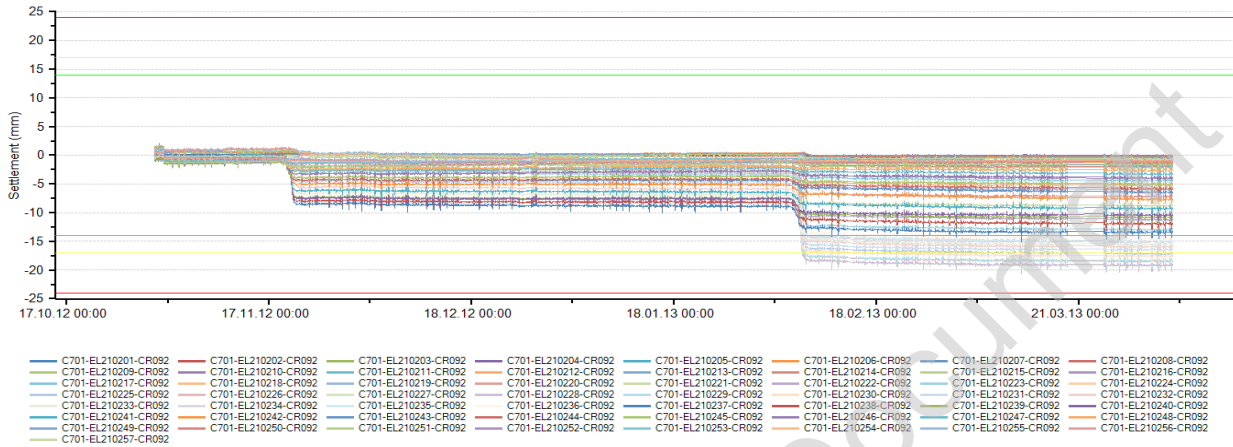


Figure 87: Electrolevels Westbound settlements

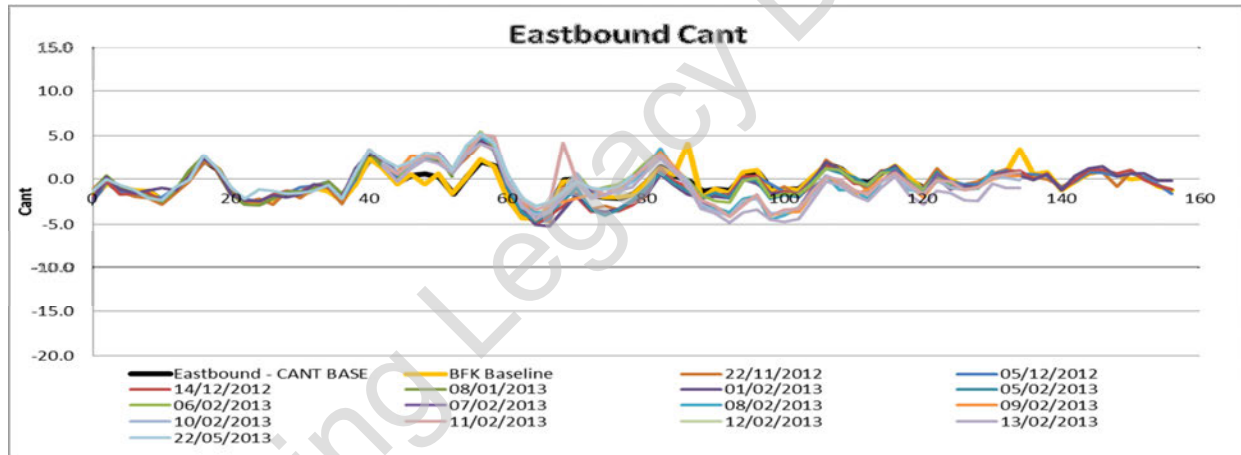


Figure 88: LU05 –Eastbound Cant

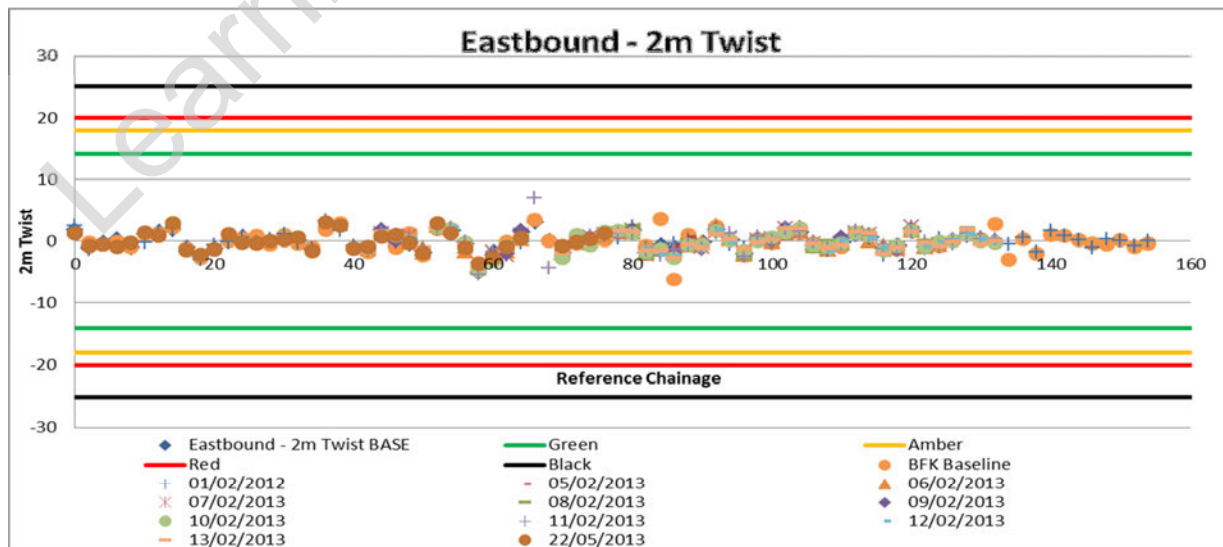


Figure 89: LU05 – Eastbound 2m twist

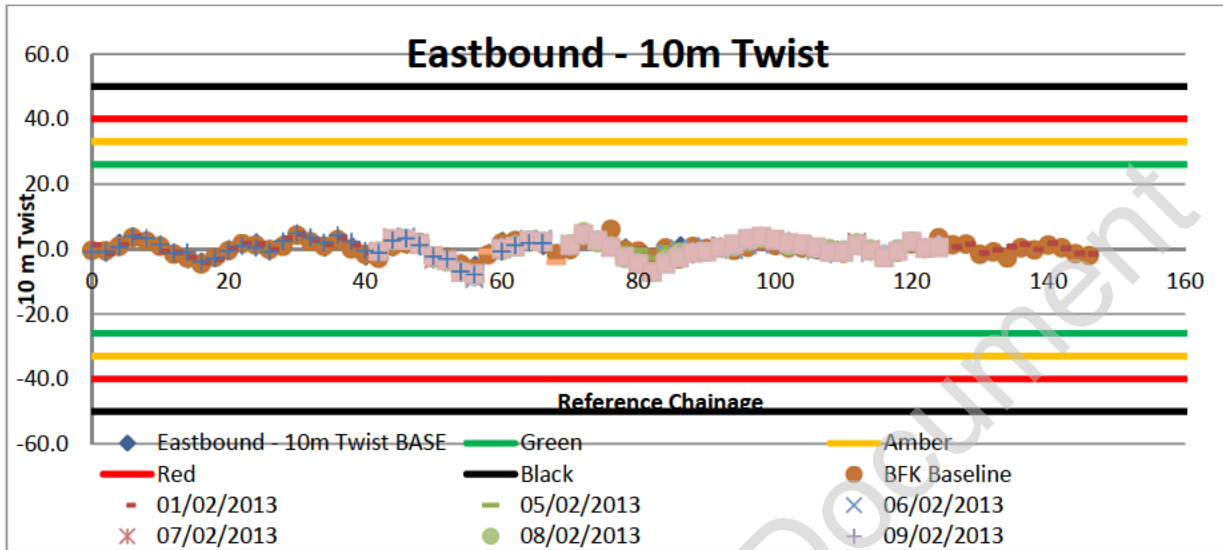


Figure 90: LU05 – Eastbound 10m twist

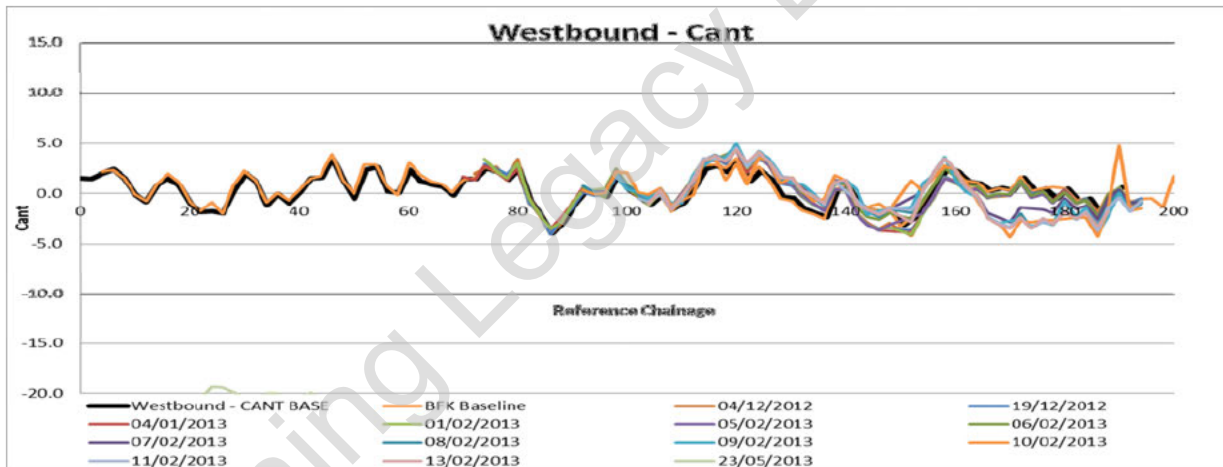


Figure 91: Westbound Cant

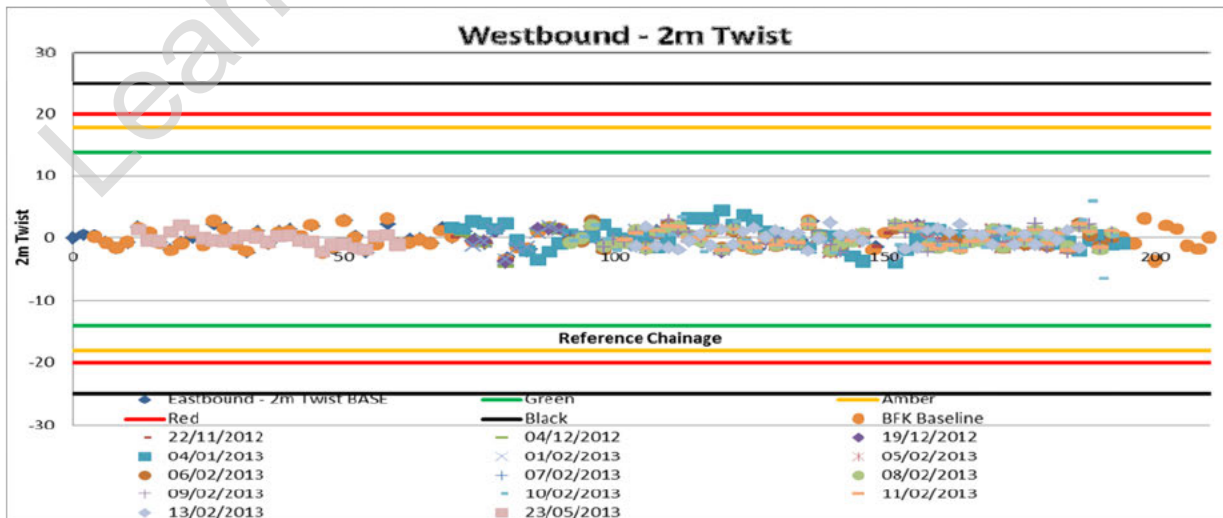


Figure 92: LU05 – Westbound 2m twist

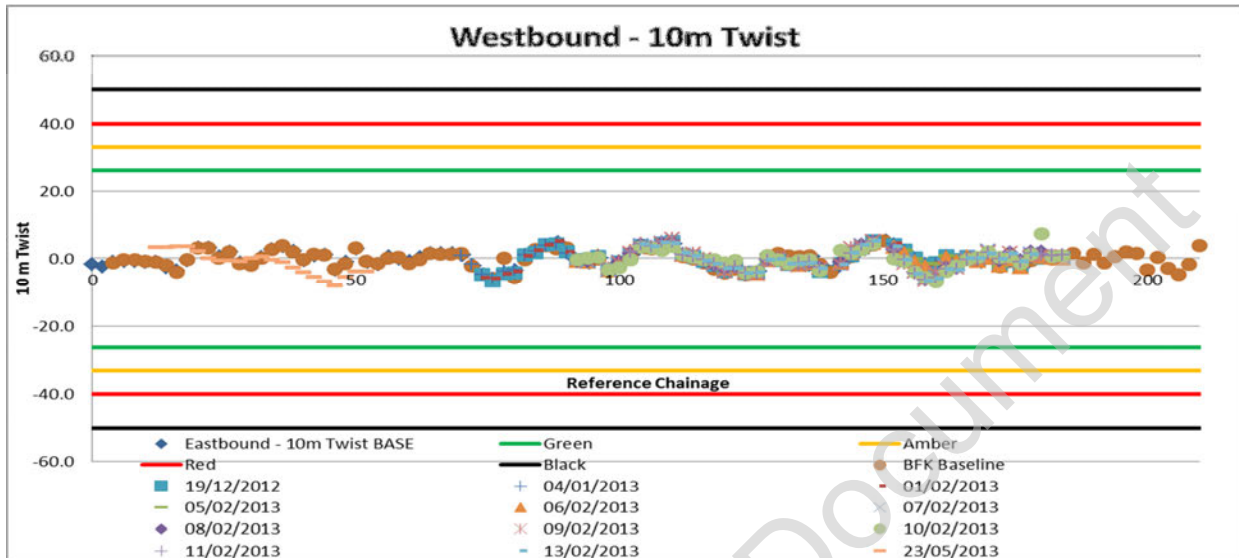


Figure 93: LU05 – Westbound 10m twist

Comments

The maximum measured settlement on both LU05 Eastbound and Southbound is approx. 20mm. The passage of the WB and EB TBMs are clearly visible on the Electrolevels charts. The geometry of the tracks did not change significantly due to TBMs passage.

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B) LU03 – District and Circle Line



Figure 94: location

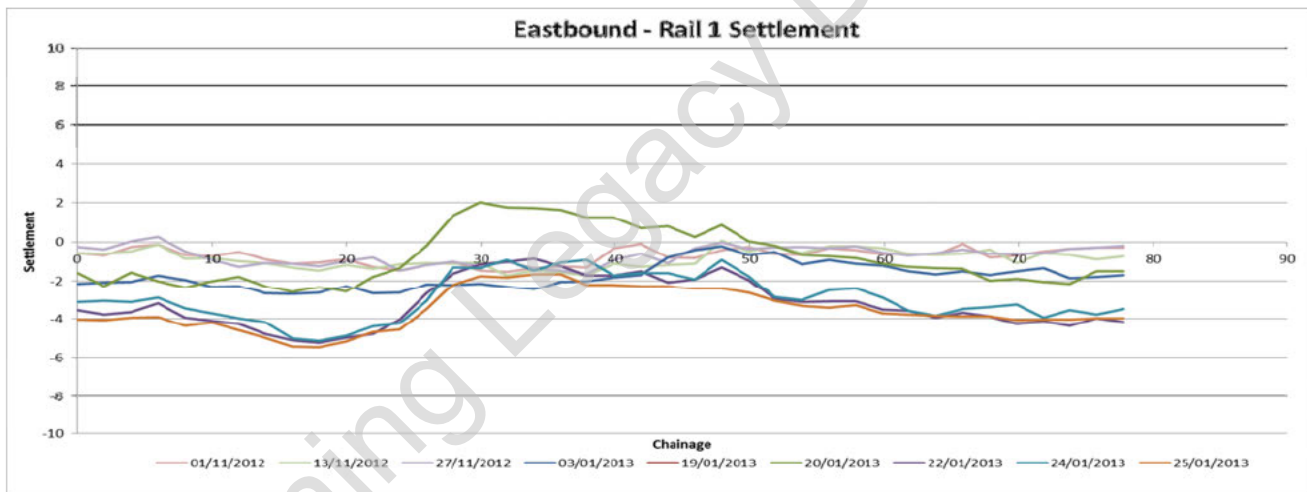


Figure 95: LU03 – Eastbound settlement

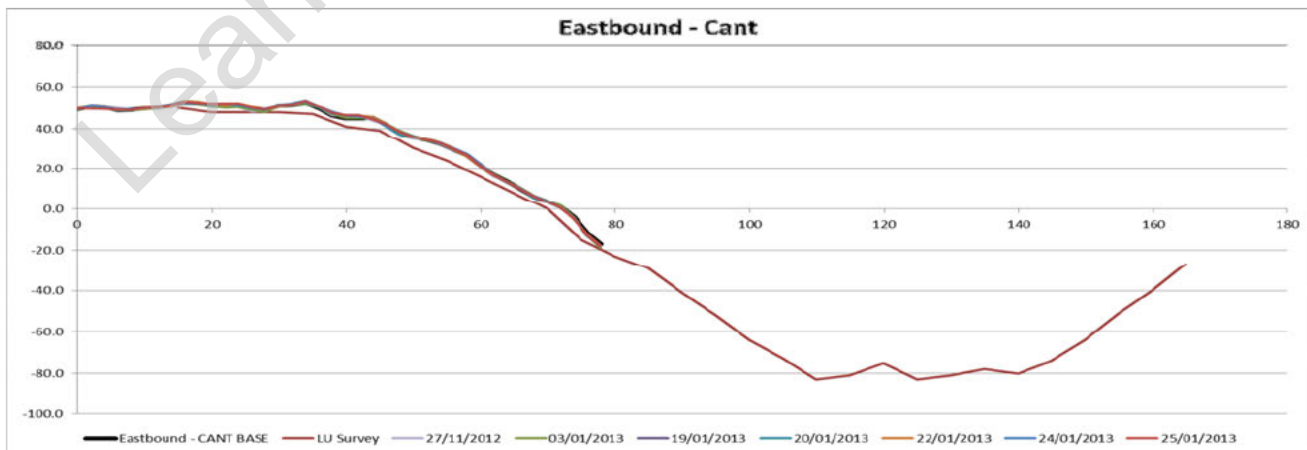


Figure 96: LU03 – Eastbound cant

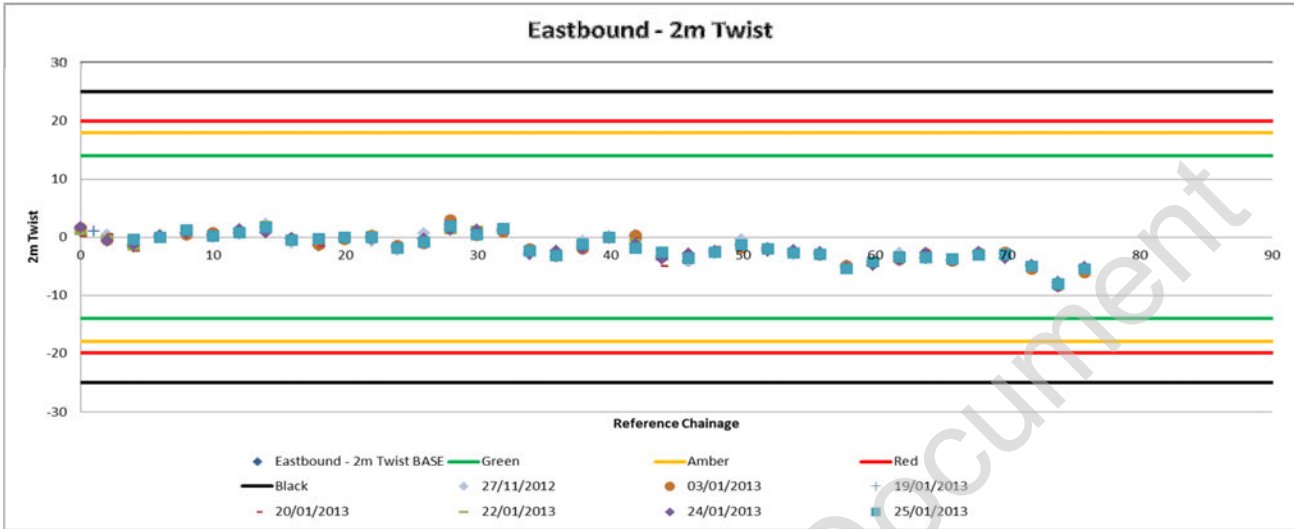


Figure 97: LU03 – Eastbound 2m twist

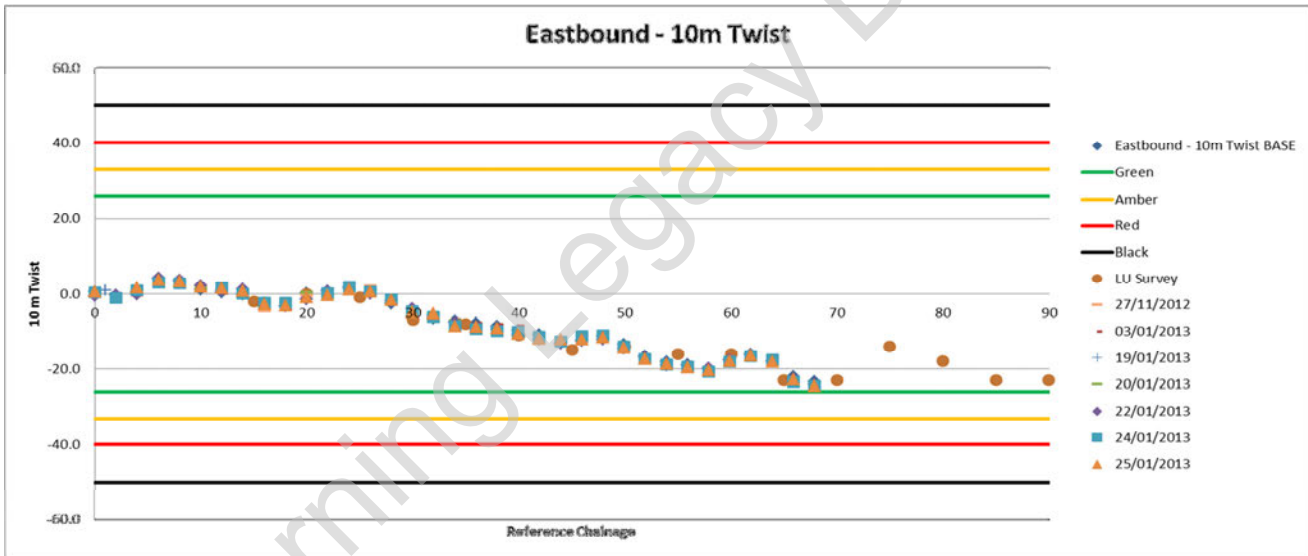


Figure 98: Eastbound 10m twist

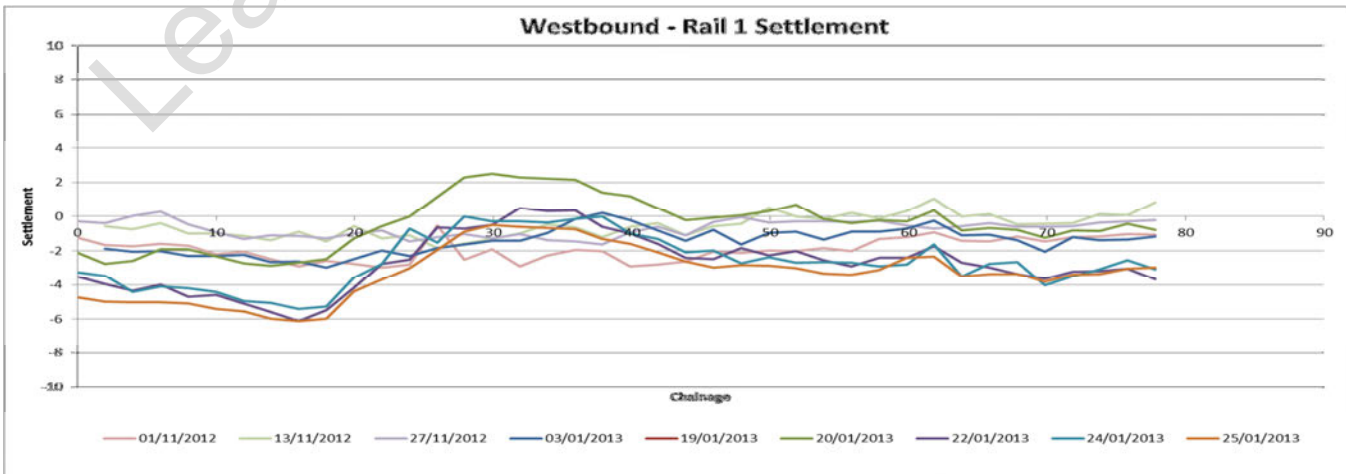


Figure 99: LU03 – Westbound settlement

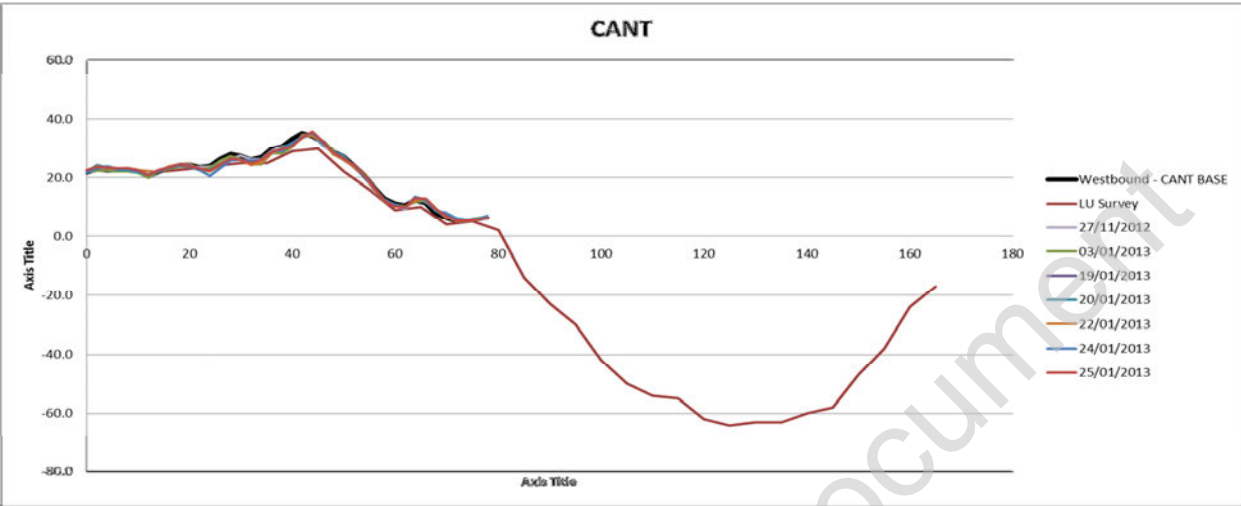


Figure 100: LU03 – Westbound cant

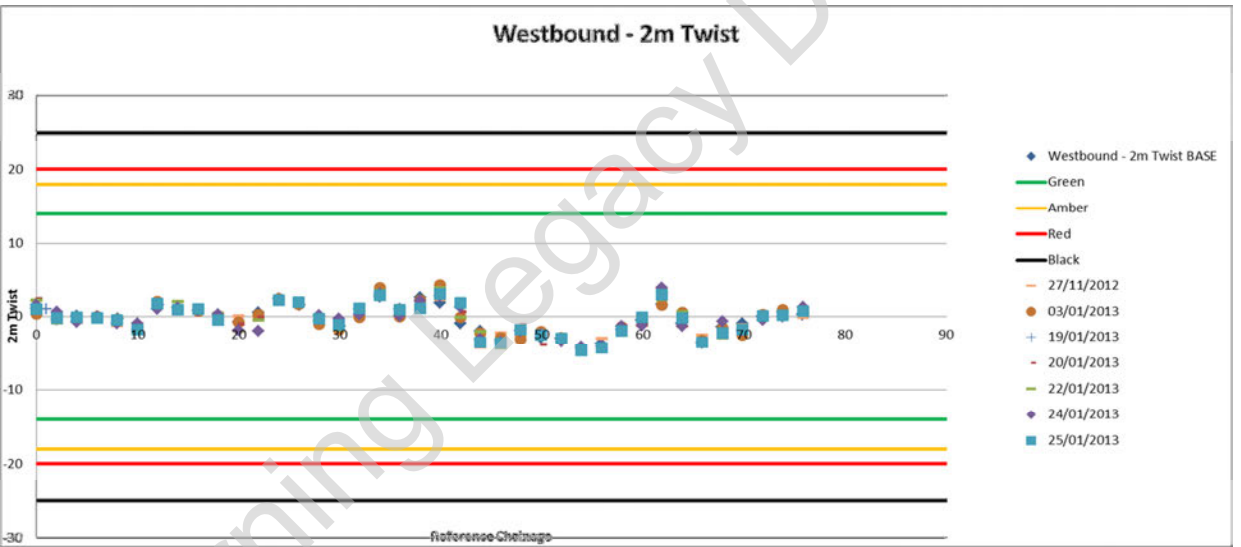


Figure 101: LU03 – Westbound 2m twist

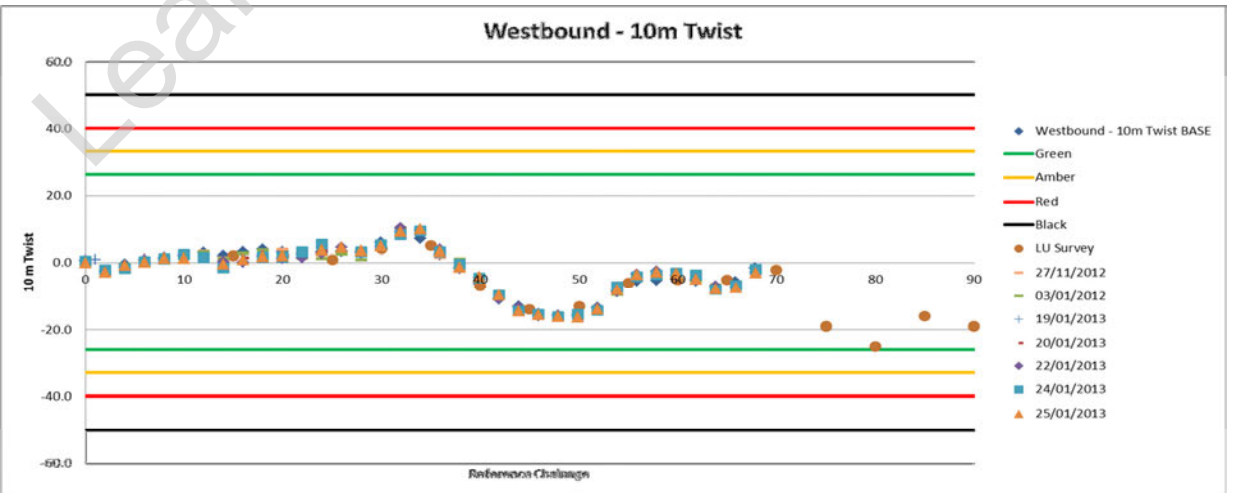


Figure 102: LU03 – Westbound 10m twist



Comments

It is noted that the District & Circle line (LU03) is within the zone of influence of the Paddington Station works (C405) and reference should be made to the C405 close out report for information subsequent to the termination of C300 monitoring.

The maximum measured settlement on both LU03 Eastbound and Southbound is approx. 6mm. The geometry of the tracks did not change significantly due to TBMs passage.

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Appendix 6. Data along the PAD-BOS TBMs drive

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C300/410
Western Tunnels & Caverns Project



Final Monitoring Report: C300-BFK-C4-RGN-CRT00_ST005-51015 Rev 2.0

TBM DRIVES ~ from
Paddington Station to Bond
Street Station

Page 84 of 90

#

Learning Legacy Document



Appendix 7. Summary Plots





Figure 1037: Location of PLP transects (west) – data from those circled are presented in the indicated Section of the report

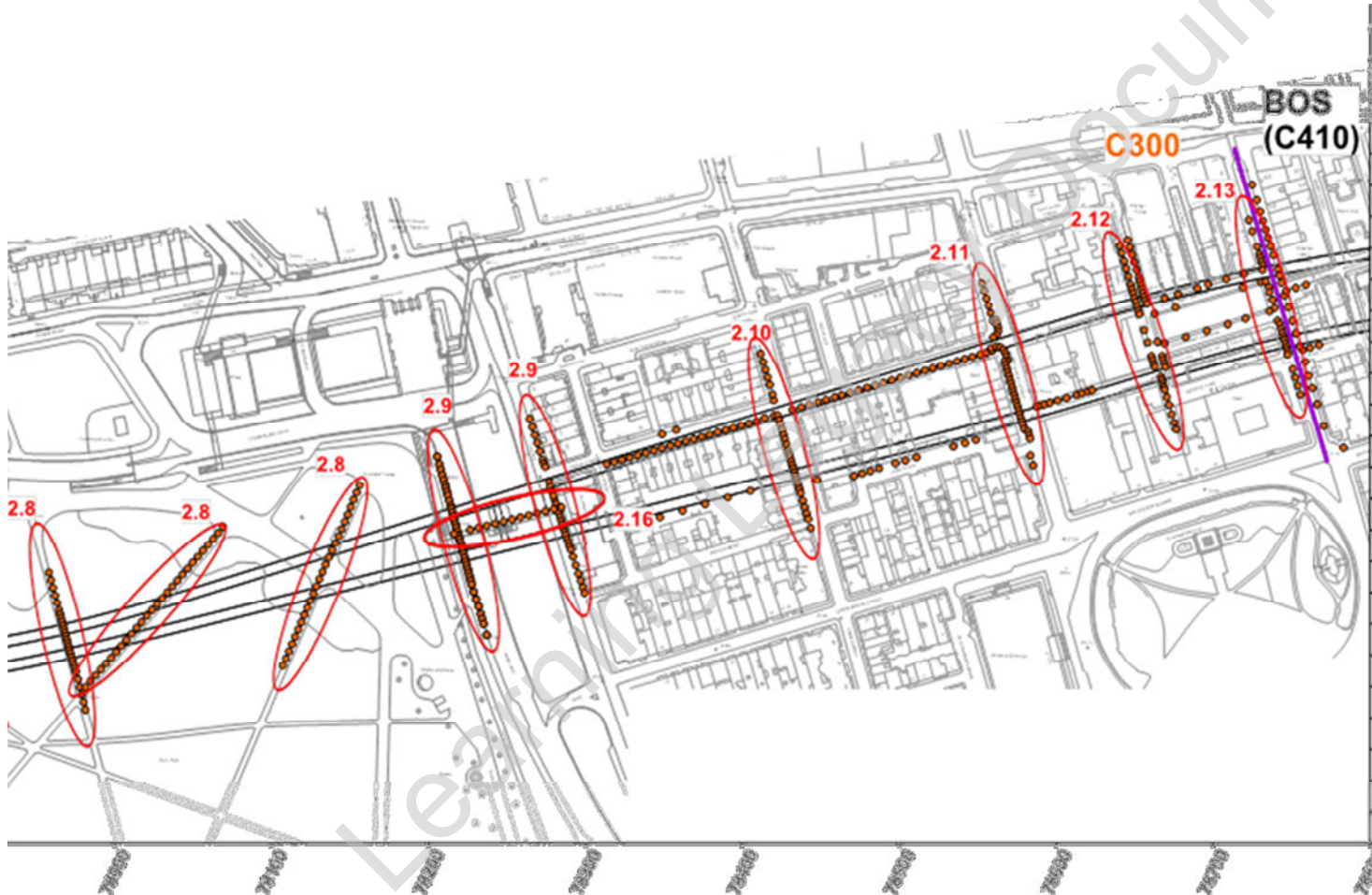


Figure 1048: Location of PLP transects (east) – data from those circled are presented in the indicated Section of the report

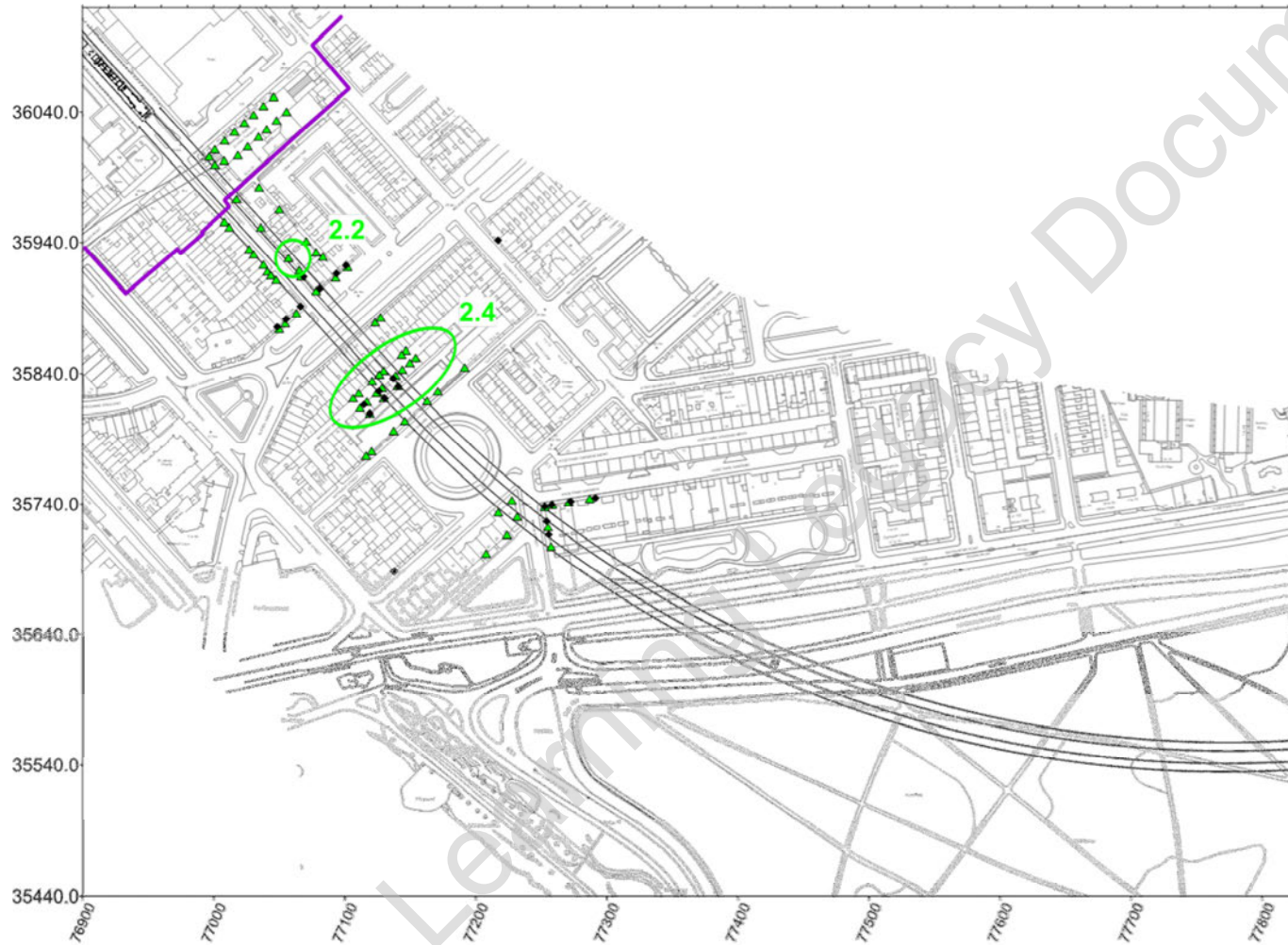


Figure 1059: Location of BRE (green triangle) & prisms (black diamond) (west) – data from those circled are presented in the indicated Section of the report

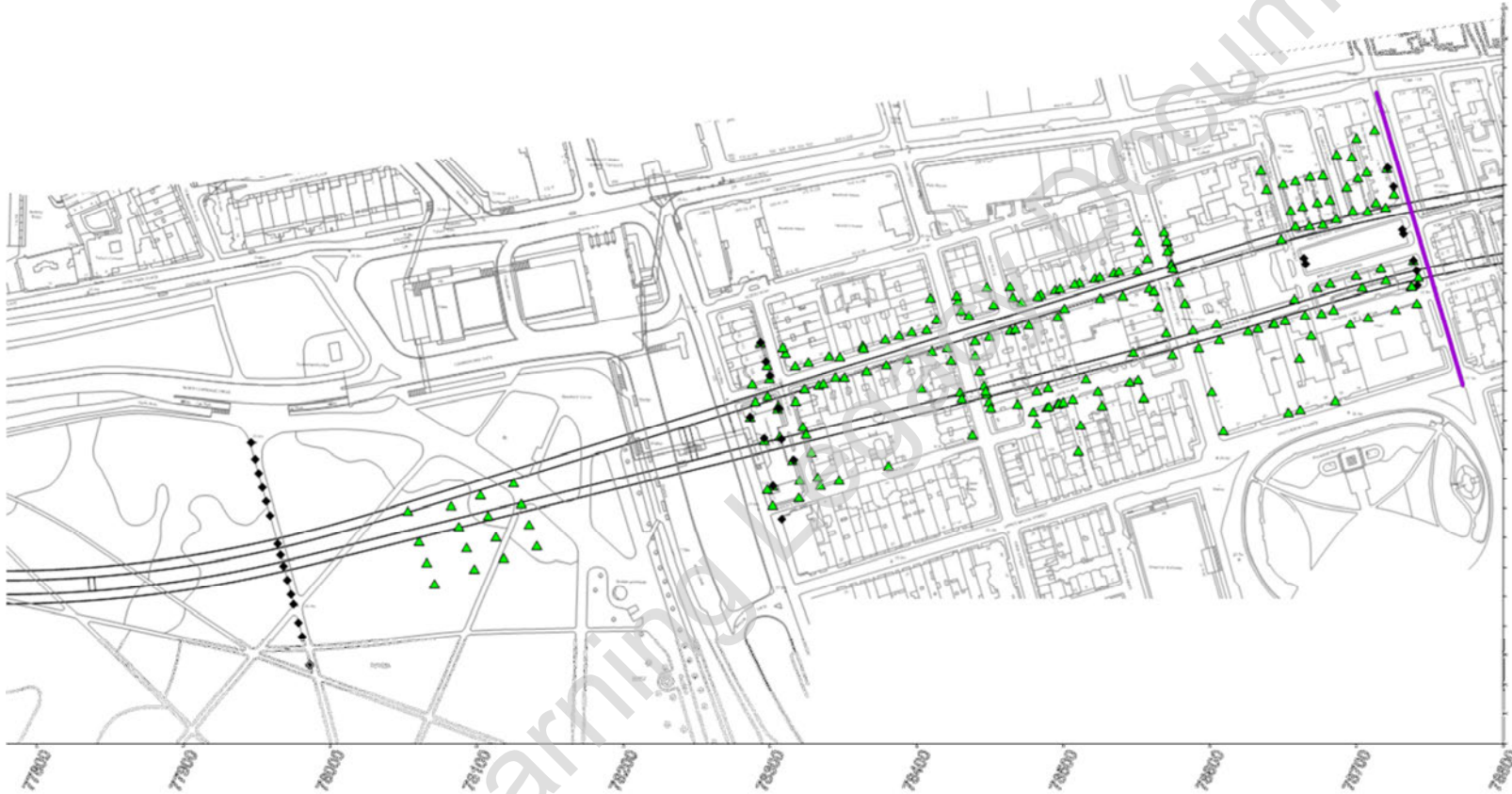


Figure 106: Location of BRE (green triangle) & prisms (black diamond) (east) – data from those circled are presented in the indicated Section of the report

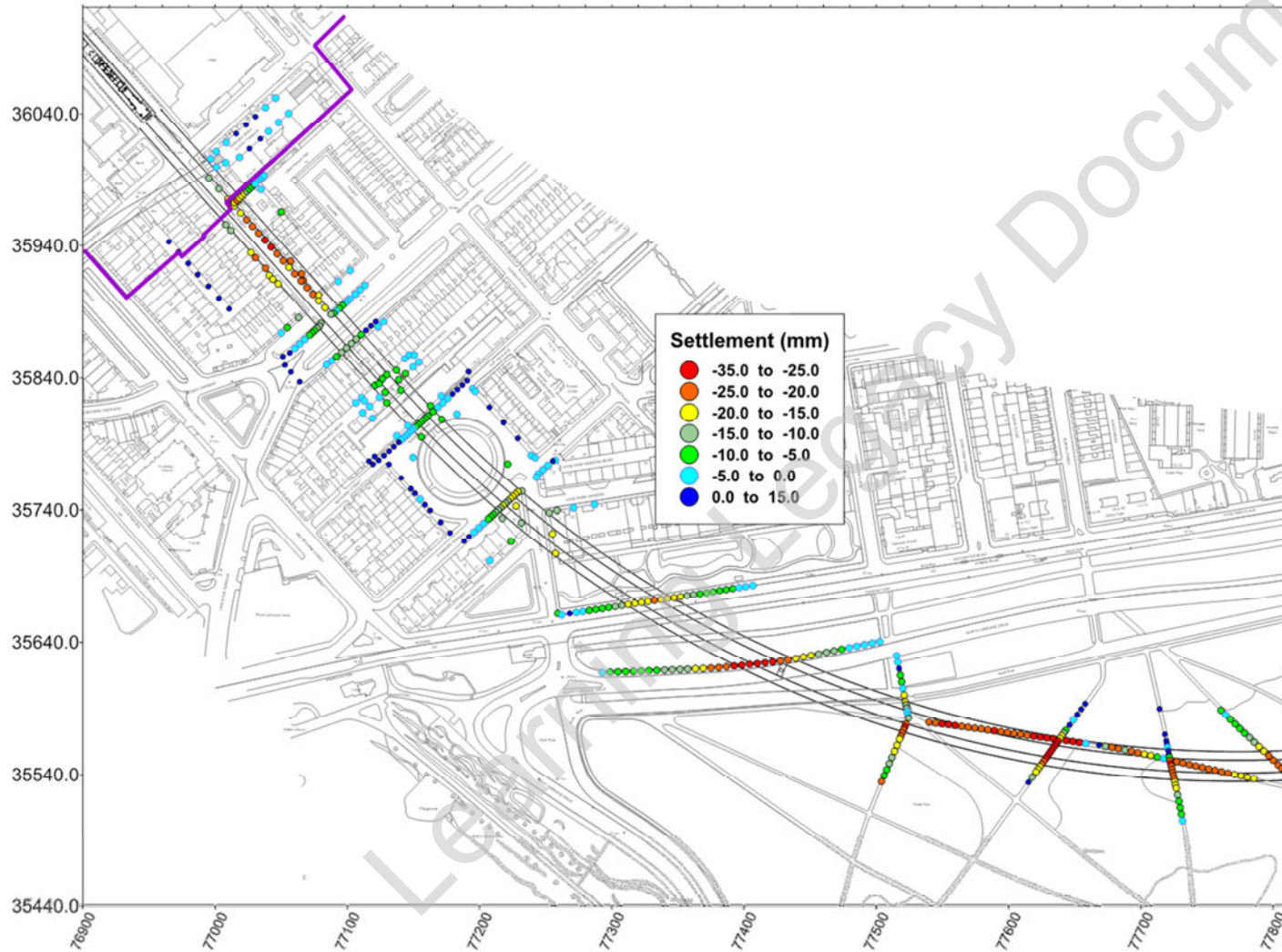


Figure 107: Final recorded settlements – BRE & PLP (west)

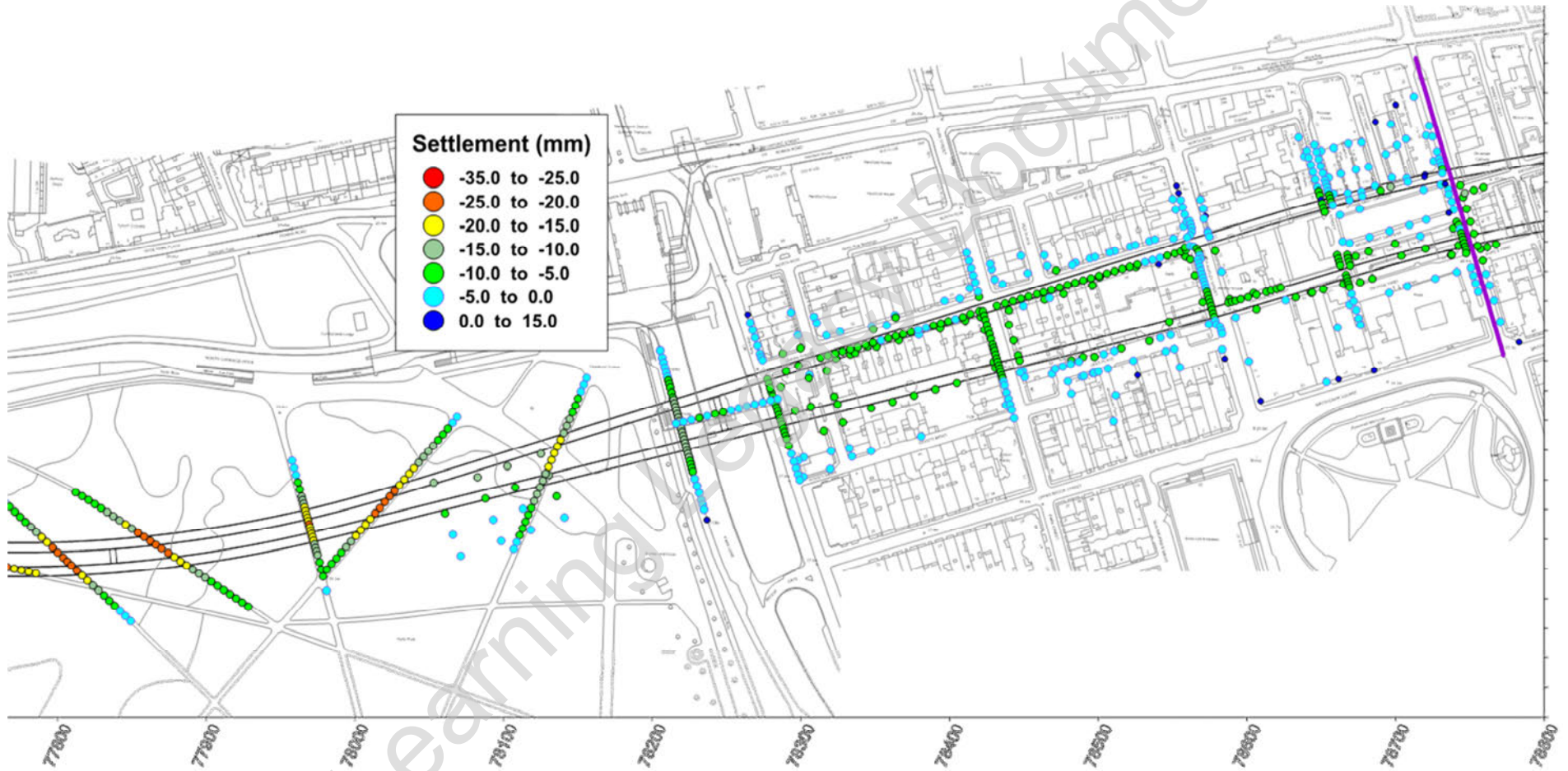
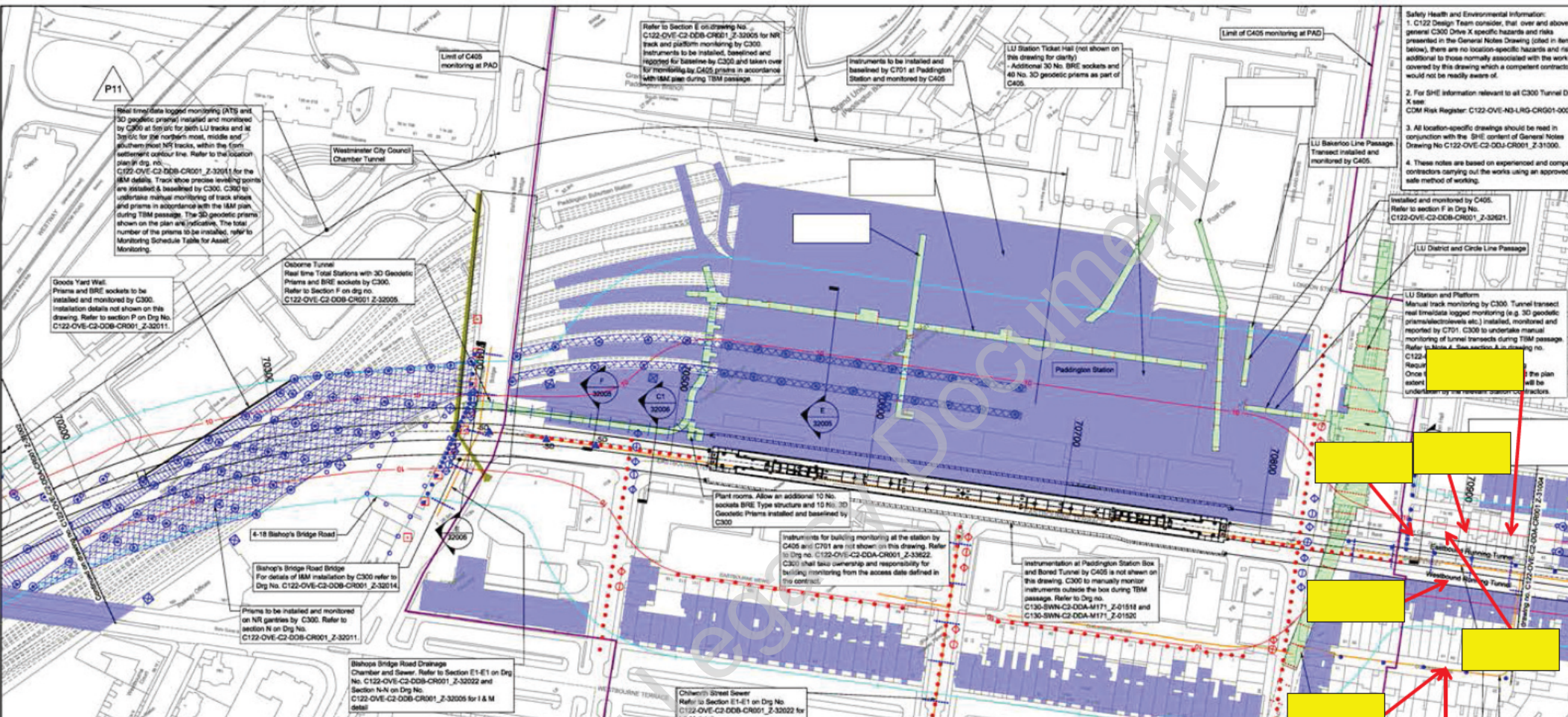


Figure 108: Final recorded settlements – BRE & PLP (east)



Safety Health and Environmental Information:
 1. C122 Design Team consider that over and above general C300 Drive X specific hazards and risks presented in the General Notes Drawing (listed in item below), there are no location-specific hazards and risks additional to those normally associated with the work covered by this drawing which a competent contractor would not be readily aware of.
 2. For SHE information relevant to all C300 Tunnel Drive X see CDM Risk Register: C122-OVE-N3-URG-CR01-0000
 3. All location-specific drawings should be read in conjunction with the SHE content of General Notes Drawing No C122-OVE-C2-DOB-CR001_Z-31000.
 4. These notes are based on experienced and competent contractors carrying out the works using an appropriate safe method of working.

Legend

Parties Responsible for the installation of the I & M

- By C300
- By Others
- General
- Tunnel Alignment
- Track shoe monitoring at 2m centres
- Track shoe monitoring at 3m centres

Settlement Contours

- 1mm Settlement Contour
- 10mm Settlement Contour

Existing Structures

- Structures with I & M Comments
- Buildings with damage category 3
- Listed Buildings
- Bored Tunnels
- Cut & Cover Tunnels
- Main Sewer (greater than Ø15in)
- Deep Tunnel assets

Instruments and Monitors

- Automated Total Station
- Basel Convergence System
- Electrolevel Beams
- Extensometer - Rod
- Inclinometer
- Inclinometer - Electrolevel
- Pneumator - Vibrating Wire
- 3D Geodetic Prisms
- Sockets - BRE Type - Structure
- Sockets - Precision Ground Levelling
- Spane Monitoring Point
- Monitoring Transect in Tunnels @ 10m c/c
- Deep Datum
- Shallow Datum - Utilities
- Internal monitoring Transect in TWUL asset @ 20m c/c

Schedule for Installation of I & M by C300 (Excluding Building Monitoring at Paddington Station Area)

Change	From	To	Total Number of Instruments	Instrument Type	Asset	Building Address
0000	0000	0000	14	Sockets - BRE Type - Structure	Westminster Chamber Tunnel	
Asset Monitoring						
Change	From	To	Total Number of Instruments	Instrument Type	Asset	Building Address
0000	0000	0000	2	3D Geodetic Prisms	Network Rail Tracks from Westminster Bridge	
0000	0000	0000	2	3D Geodetic Prisms	Network Rail Tracks from Westminster Bridge	
0000	0000	0000	2	3D Geodetic Prisms	London Underground Tracks from Westminster Bridge	
0000	0000	0000	2	Sockets - BRE Type - Structure	Goods Yard Wall	
0000	0000	0000	4	Sockets - BRE Type - Structure	Bishop's Bridge Road Bridge	
0000	0000	0000	4	Sockets - BRE Type - Structure	Bishop's Bridge Road Bridge	
0000	0000	0000	4	Sockets - BRE Type - Structure	Bishop's Bridge Road Sewer	
0000	0000	0000	4	Sockets - BRE Type - Structure	Bishop's Bridge Road Sewer	
0000	0000	0000	4	Sockets - BRE Type - Structure	Osborne Tunnel (including plant rooms)	
0000	0000	0000	4	Sockets - BRE Type - Structure	Osborne Tunnel (including plant rooms)	
0000	0000	0000	4	Sockets - BRE Type - Structure	Cherry Street Sewer	
0000	0000	0000	4	Sockets - BRE Type - Structure	Cherry Street Sewer	
0000	0000	0000	4	Sockets - BRE Type - Structure	Spring Street Sewer	
0000	0000	0000	4	Sockets - BRE Type - Structure	Spring Street Sewer	
0000	0000	0000	4	Sockets - BRE Type - Structure	Conduit Mews Sewer	
0000	0000	0000	4	Sockets - BRE Type - Structure	Conduit Mews Sewer	

Change	From	To	Total Number of Instruments	Instrument Type	Transect Type
0000	0000	0000	2	Inclinometer	E
0000	0000	0000	4	Extensometer - Rod	E
0000	0000	0000	4	Pneumator	E
0000	0000	0000	20	Shells - Precision Ground Levelling	E
0000	0000	0000	2	Inclinometer	C1
0000	0000	0000	4	Extensometer - Rod	E
0000	0000	0000	4	Extensometer - Rod	E
0000	0000	0000	11	Shells - Precision Ground Levelling	E
0000	0000	0000	11	Shells - Precision Ground Levelling	E

Number of Inclinometers	Number of Precision Ground Levelling Shells	Number of BRE Sockets	Number of 3D Geodetic Prisms	Number of Rod Extensometers	Number of Baseline Fastenings	Number of Vibrating Wire Pneumators	Total number
2	20	20	10	12	3	4	340

Rev	Date	Description	By	Check	App	Auth
P01	08/10/2020	Issued for Tender Purposes	AB	AK	RM	
P02	08/10/2020	Issued for Tender Purposes	AB	AK	RM	
P03	10/03/2019	Released for Tender Purposes	JF	AK	RM	
P04	20/05/2019	Released for Tender Purposes	AB	AK	RM	
P05	08/10/2020	Issued for Confirmed Set	JF	AK	RM	
P06	14/12/2020	Issued for Confirmed Set	AB	AK	RM	
P07	17/01/2021	Issued for Negotiation	JF	AK	RM	
P08	11/05/2021	Designer's Recommendations for Use by Contractors	JC	OC	PC	
P09	24/02/2021	Minimum Requirements for Instrumentation and Monitoring	JF	AK	RM	
P10	24/02/2021	Minimum Requirements for Instrumentation and Monitoring	AB	AK	RM	
P11	03/02/2012	Minimum Requirements for Instrumentation and Monitoring	GP	JA	RM	
P12	17/02/2012	Issued as FI for construction	GP	JA	RM	IF

Notes

- For instrumentation and monitoring general notes, monitoring frequencies and summary schedule, refer to Drg No. C122-OVE-C2-DOB-CR001_Z-31000, C122-OVE-C2-DOB-CR001_Z-30002 and C122-OVE-C2-DOB-CR001_Z-30005 respectively.
- Provision of manual monitoring of rail assets (LU & NR) made for the following at the frequencies given in the schedule:
 - (A) 2 man team monitoring track level (precise leveling).
 - (B) 2 man team monitoring tunnel transects (prisms / total stations).
 - (C) Transects at 10m centres.
 - (D) Track monitoring at 2m centres for LU.
 - (E) Track monitoring at 3m centres for NR.

Trackside and in-rail tunnel monitoring of 3rd Party assets will be undertaken during engineering hours or agreed possessions. CA05 shall make provision for protection of team and support staff for these works.
 At Paddington Station the running tunnels will be excavated prior to construction of the station box. Monitoring shown is for the purpose of 3rd party asset protection due to tunnel construction and is included in the schedule on drg no. C122-OVE-C2-DOB-CR001_30001.



Bored Tunnels (Alignment and Track)

Operator: Cve Anup & Partners Limited

Contractor: Crossrail General

File: Instrumentation and Monitoring Combined I & M

Route/Draw Plan Sheet 3 of 38

C300

Scale: 1:1000 @ A1

Drawing and CAD File No: C122-OVE-C2-DDA-CR001_Z-31003

Rev: C01

Author: G. POTTER

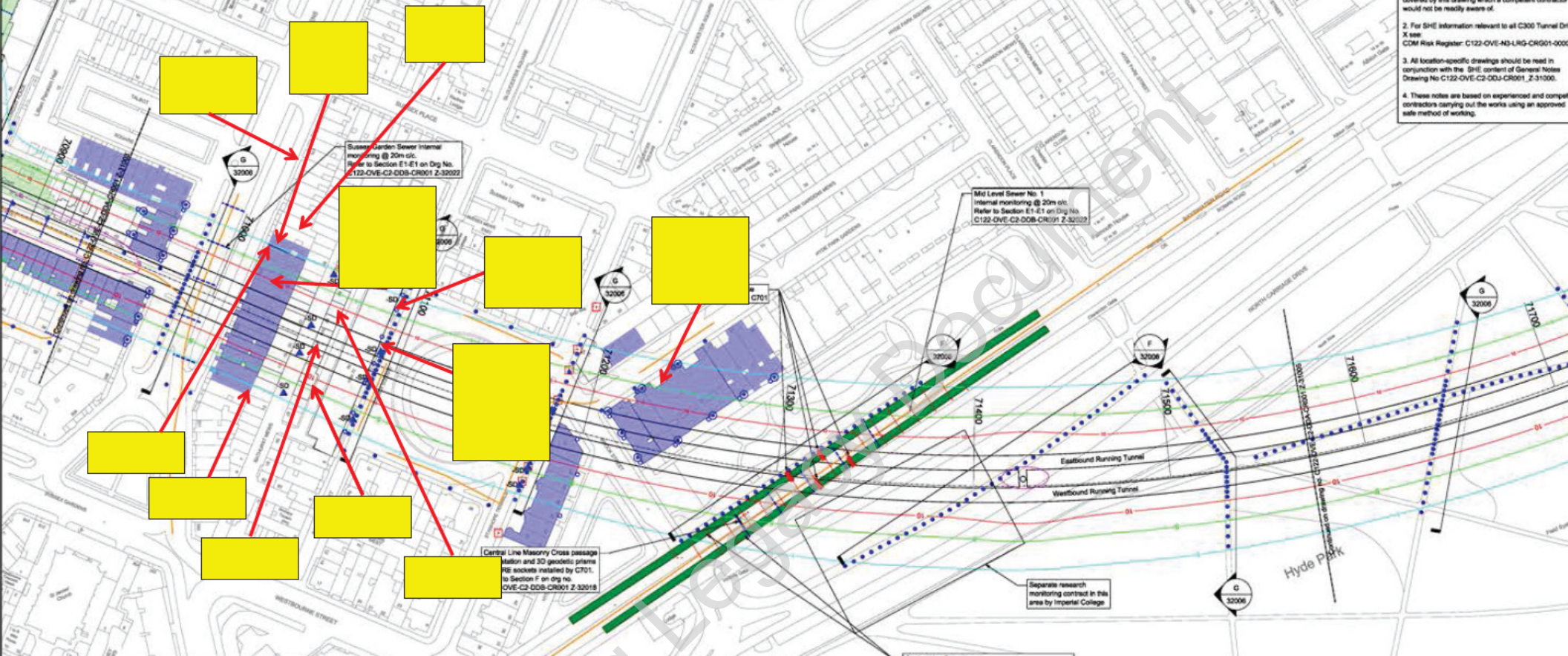
Drawn: J. APPEL

Rev: A. MCDONNELL

Rev: I. THOMSON

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Safety Health and Environmental Information:
 1. C122 Design Team consider that over and above the general C300 Drive X specific hazards and risks presented in the General Notes Drawing (noted in item below), there are no location-specific hazards and risks additional to those normally associated with the work covered by this drawing which a competent contractor would not be readily aware of.
 2. For SHE information relevant to all C300 Tunnel Drives see CDM Risk Register: C122-OVE-C2-DDA-CR001-2-31000
 3. All location-specific drawings should be read in conjunction with the SHE content of General Notes Drawing No C122-OVE-C2-DDA-CR001_2-31000.
 4. These notes are based on experienced and competent contractors carrying out the works using an approved safe method of working.



Legend

Parties Responsible for the installation of the I & M

- By C300
- By Others

General

- Tunnel Alignment
- Track shoe monitoring at 2m centres
- Track shoe monitoring at 3m centres

Settlement Contours

- 10mm Settlement Contour
- 15mm Settlement Contour

Existing Structures

- Structures with I & M Commitments
- Buildings with damage category 3
- Listed Buildings
- Bored Tunnels
- Cut & Cover Tunnels
- Mains Sewer (greater than Ø1.5m)

Instruments and Monitors

- Automated Total Station
- Basest Convergence System
- Electrolevel Beams
- Extensometer - Rod
- Inclinometer
- Inclinometer - Electrolevels
- Piezometer - Vibrating Wire
- 3D Geodetic Prisms
- Sockets - B&E Type - Structure
- Sluts - Precise Ground Levelling
- Spane Monitoring Point
- Monitoring Transact in Tunnels @ 10m c/c
- Deep Datum
- Shallow Datum - Utilities
- Internal monitoring Transact in TWUL asset @ 20m c/c

Central Line Tunnels
 Manual track monitoring by C300. Retro reflective targets installed, monitored and reported for baseline by C701. C300 to undertake manual monitoring of tunnel transacts during TBM passage. For details, refer to Note 13 of General Notes Drg No. C122-OVE-C2-DDA-CR001_2-31000. Refer to Section C on drg no. C122-OVE-C2-DDA-CR001_2-32005

Schedule of Building and Ground Monitoring Installation by C300

Change		Total Number of Instruments	Instrument Type	Asset	Building Address
From	To				
10000	11000	8	Sockets - B&E Type - Structure 3D Geodetic Prisms		
11000	11100	7	Sockets - B&E Type - Structure		
11100	11200	7	Sockets - B&E Type - Structure 3D Geodetic Prisms		
11200	11300	9	Sockets - B&E Type - Structure		

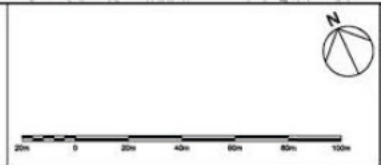
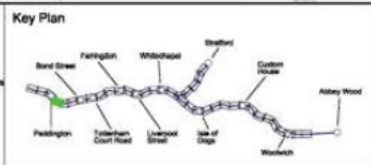
Change		Total Number of Instruments	Instrument Type	Transact Type	Number of B&E sockets	Number of 3D Geodetic Prisms	Number of Precise Ground Levelling Sluts	Number of Shallow Datum	Total Number
From	To								
10000	11000	23	Sluts - Precise Ground Levelling Shallow Datum	G					
11000	11100	27	Sluts - Precise Ground Levelling Shallow Datum	G					
11100	11200	8	Sluts - Precise Ground Levelling Shallow Datum	G					
11200	11300	29	Sluts - Precise Ground Levelling Shallow Datum	G					
11300	11400	36	Sluts - Precise Ground Levelling Shallow Datum	F					
11400	11500	36	Sluts - Precise Ground Levelling Shallow Datum	F					
11500	11600	27	Sluts - Precise Ground Levelling Shallow Datum	G					

Change		Total Number of Instruments	Instrument Type	Asset
From	To			
10000	11000	5	Sockets - B&E Type - Structure	Sussan Garden Sewer
11000	11400	16	3D Geodetic Prisms	Mid Level Sewer No. 1
11200	11600	16	3D Geodetic Prisms	

Rev.	Date	Description	By	Check	App	Auth
P02	20/11/2009	Issued for Tender Purposes	AB	AK	RM	
P03	12/03/2010	Revised for Tender Purposes	JC	AB	RM	
P04	26/04/2010	Revised for Tender Addendum Purposes	AB	AB	RM	
P05	18/05/2010	Issued for Confirmation	JF	AB	RM	
P06	14/10/2010	Issued for Confirmation	AB	AB	RM	
P07	13/01/2011	Issued for O&C Submission	JF	AB	RM	
P08	11/06/2011	Contractor's Recommendations for Use by Contractor	JA	GC	PC	
P09	24/05/2011	Minimum Requirements for Instrumentation and Monitoring	JF	AB	RM	
P10	03/03/2012	Minimum Requirements for Instrumentation and Monitoring	GP	JA	PC	
D01	17/02/2012	Issued as I1 for construction	GP	JA	RM	IT
P11	02/04/2012	Minimum Requirements for Instrumentation and Monitoring	GP	JA	PC	
C02	28/06/2012	Issued as I1 for construction	GP	JA	PC	IT

Notes

- For instrumentation and monitoring general notes, monitoring frequencies and summary schedule, refer to Drg. No. C122-OVE-C2-DDA-CR001_2-31000, C122-OVE-C2-DDA-CR001_2-32002 and C122-OVE-C2-DDA-CR001_2-30005 respectively.
- Schedule of the minimum provision for precise ground levelling based on assumptions of 5m spacing of studs within the 10mm settlement contour with a further stud approximately 10m beyond the 10mm settlement contour.



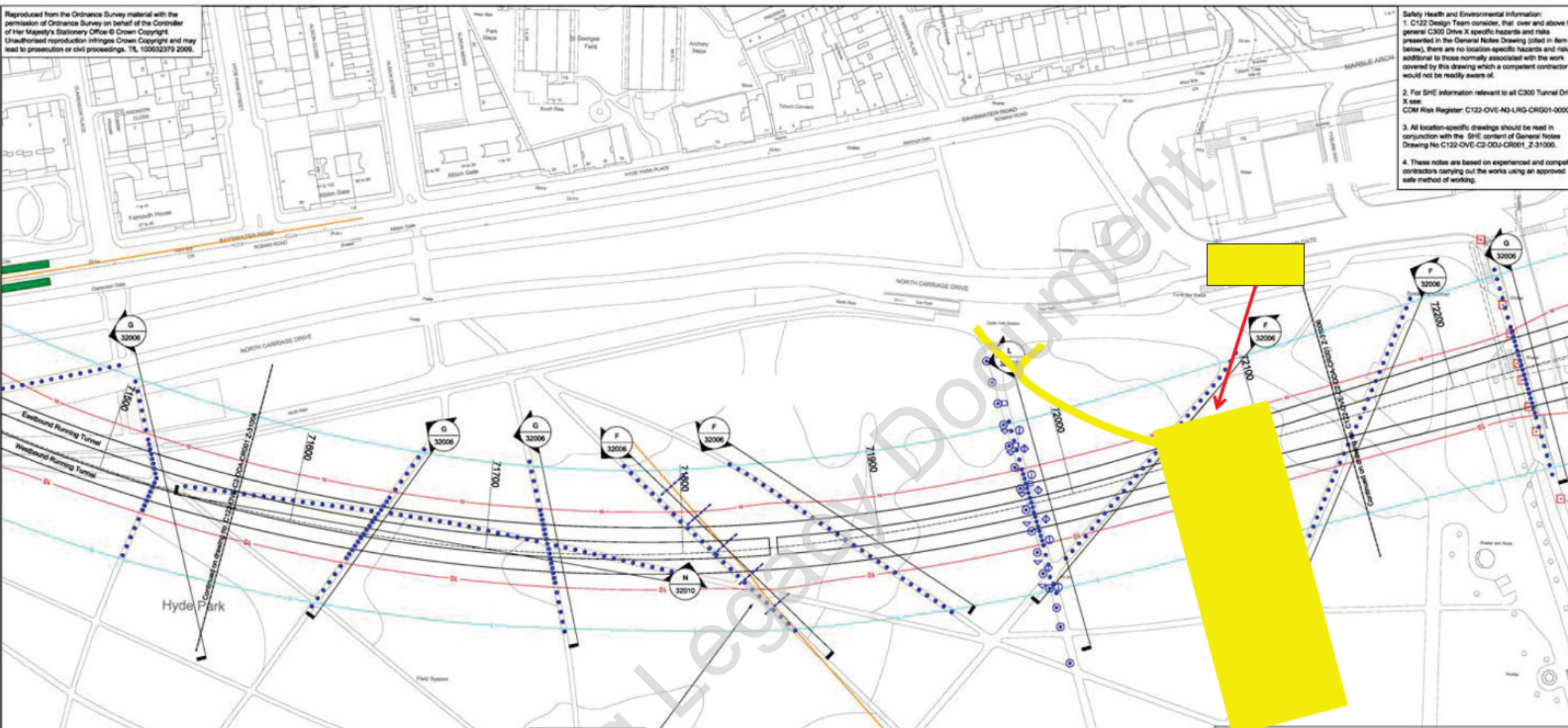
Client: Crossrail
Contract: General Crossrail (Alignment and Track)
Contractor: Ove Arup & Partners Limited
Location: Crossrail General
Title: Instrumentation and Monitoring Combined I & M
Route/line Plan Sheet 4 of 38 C300

Scale: 1:1000 @ A1
Drawing and CAD File No: C122-OVE-C2-DDA-CR001_2-31004
Sheet No: C02

Author: G. POTTER
Drawn: J. APTE
Rev: P. CHAMLEY
Appr: I. THOMSON

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Safety Health and Environmental Information:
 1. C122 Design Team consider that over and above general C300 Drive X specific hazards and risks presented in the General Notes Drawing (cited in item below), there are no location-specific hazards and risks additional to those normally associated with the work covered by this drawing which a competent contractor would not be readily aware of.
 2. For SH&E information relevant to all C300 Tunnel Drive X see CDM Risk Register: C122-OVE-N3-LRG-CR001-0000
 3. All location-specific drawings should be read in conjunction with the SH&E content of General Notes Drawing No C122-OVE-C2-DDJ-CR001_2-31000.
 4. These notes are based on experienced and competent contractors carrying out the works using an approved safe method of working.



Ranelagh Sewer
 Internal monitoring @ 20m o/c.
 Refer to Section E1-E1 on Dig No. C122-OVE-C2-DDJ-CR001_2-31002

Schedule of Building and Ground Monitoring Installation by C300

Change	Total Number of Instruments	Instrument Type	Transect Type
11500 - 11600	49	South - Precise Ground Levelling	M
11600 - 11700	28	South - Precise Ground Levelling	G
11700 - 11800	28	South - Precise Ground Levelling	G
11700 - 11800	28	South - Precise Ground Levelling	F
11800 - 12000	28	South - Precise Ground Levelling	F
11800 - 12000	15	3D Geodetic Prisms	
11800 - 12000	4	Strain Gauges	
11800 - 12000	4	Extensometer - Rod	
11800 - 12000	4	Piezometer	L
11900 - 12100	28	South - Precise Ground Levelling	G
12100 - 12200	27	South - Precise Ground Levelling	F

Change	Total Number of Instruments	Instrument Type	Asset
10900 - 11000	5	Sockets - BSE Type - Structure	Ranelagh Sewer
10900 - 11000	15	3D Geodetic Prisms	

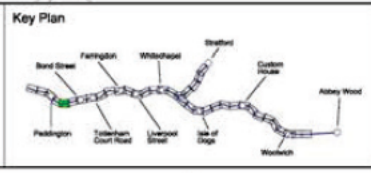
Number of Instrumentation	Number of Precise Ground Levelling Points	Number of Vibrating Wire Piezometers	Number of Rod Extensometers	Number of 3D Geodetic Prisms	Number of Strain Gauges	Number of BSE Sockets	Total Assessor
4	4	4	4	4	4	4	20

Legend

- Parties Responsible for the installation of the I & M**
 - By C300
 - By Others
- General**
 - Tunnel Alignment
 - Track shoe monitoring at 2m centres
 - Track shoe monitoring at 3m centres
- Settlement Contours**
 - 1mm Settlement Contour
 - 10mm Settlement Contour
- Existing Structures**
 - Structures with I & M Commitments
 - Buildings with damage category 3
 - Listed Buildings
 - Bored Tunnels
 - Cut & Cover Tunnels
 - Main Sewer (greater than Ø1.5m)
- Instruments and Monitors**
 - Automated Total Station
 - Basest Convergence System
 - Electrolevel Beams
 - Extensometer - Rod
 - Inclinometer
 - Inclinometer - Electrolevels
 - Piezometer - Vibrating Wire
 - 3D Geodetic Prisms
 - Sockets - BSE Type - Structure
 - Strain - Precise Ground Levelling
 - Strain Gauge
 - Sparse Monitoring Point
 - Monitoring Transect in Tunnels @ 10m o/c
 - Deep Datum
 - Shallow Datum - Utilities
 - Internal monitoring Transect in TWJL asset @ 20m o/c

Rev.	Date	Description	By	Chk	App	Auth
P01	06/11/2009	Issued for Tender Purposes	AB	AN	RM	
P02	20/11/2009	Issued for Tender Purposes	AB	AN	SR	
P03	10/03/2010	Revised for Tender Purposes	JC	AS	RM	
P04	28/04/2010	Revised for Tender Advertisement Purposes	AB	AS	RM	
P05	13/01/2011	Issued for OGI Submission	JF	AS	RM	
P06	11/03/2011	Designer's Recommendations for Use by Contractors	JC	GC	PC	
P07	14/05/2011	Minimum Requirements for Construction	JC	AS	SR	
P08	03/02/2012	Minimum Requirements for Construction	GP	JA	RM	
C01	17/02/2012	Issued as I1 for construction	BP	JA	RM	

Notes



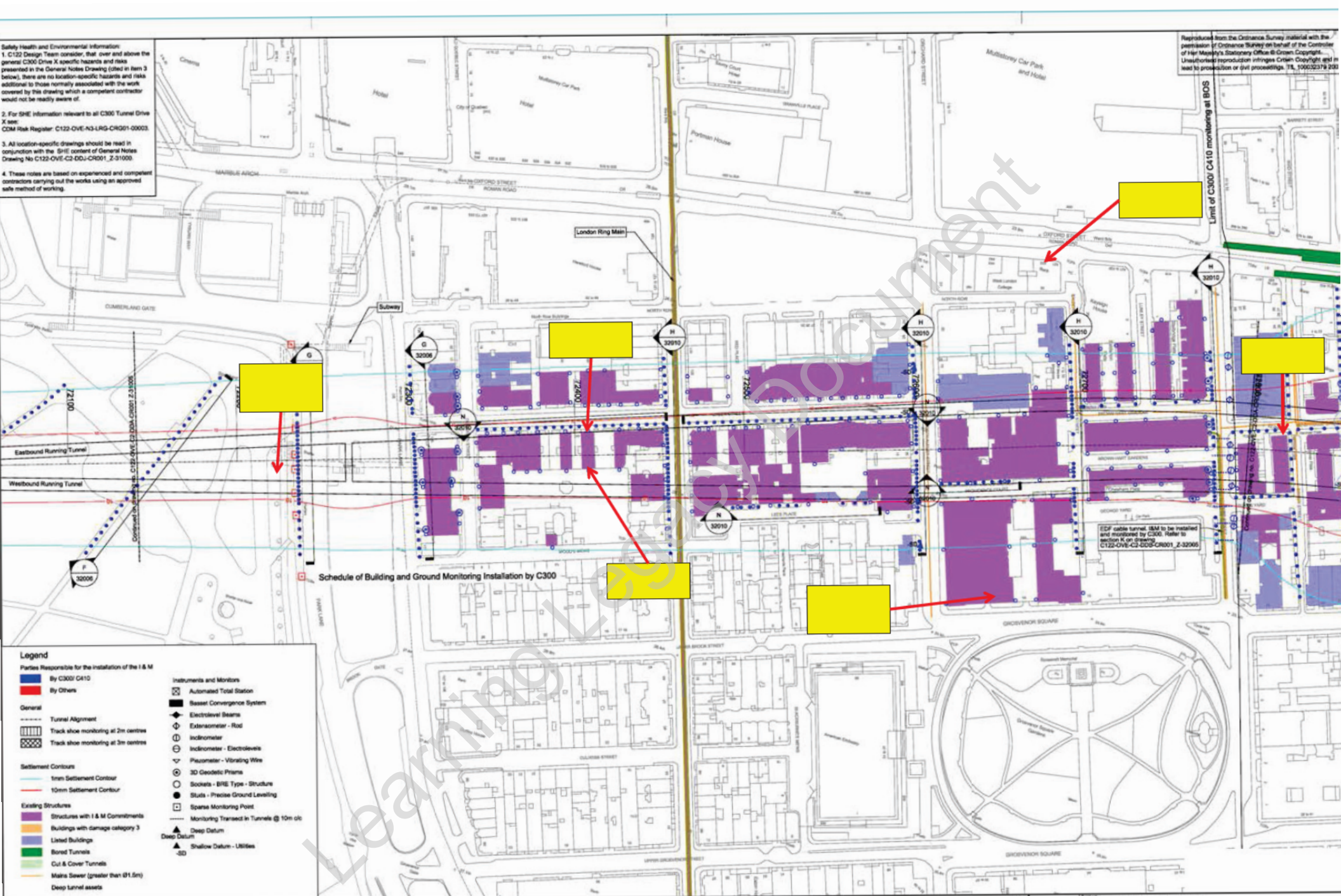
North Arrow

Crossrail
 Bored Tunnels (Alignment and Track)
 Operator: Ove Arup & Partners Limited
 Location: Crossrail General
 Title: Instrumentation and Monitoring Combined I & M
 Route/wise Plan Sheet 5 of 38
 C300
 Scale: 1:1000 @ A1
 Drawing and CAD Ref No: C122-OVE-C2-DDA-CR001_2-31005
 Date: C01

Safety Health and Environmental Information:

- C122 Design Team consider, that over and above the general C300 Drive X specific hazards and risks presented in the General Notes Drawing (cited in item 3 below), there are no location-specific hazards and risks additional to those normally associated with the work covered by this drawing which a competent contractor would not be readily aware of.
- For SHE information relevant to all C300 Tunnel Drive X see:
COM Risk Register: C122-OVE-N3-LRG-CR001-00003.
- All location-specific drawings should be read in conjunction with the Brief content of General Notes Drawing No C122-OVE-C2-DDA-CR001_Z-31000.
- These notes are based on experienced and competent contractors carrying out the works using an approved safe method of working.

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Schedule of Building and Ground Monitoring Installation by C300

Legend

Parties Responsible for the installation of the I & M

- By C300/ C410
- By Others

General

- Tunnel Alignment
- Track shoe monitoring at 2m centres
- Track shoe monitoring at 3m centres

Settlement Contours

- 10mm Settlement Contour
- 10mm Settlement Contour

Existing Structures

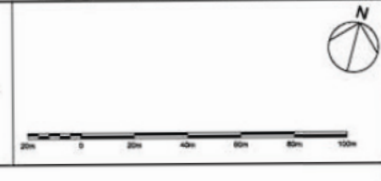
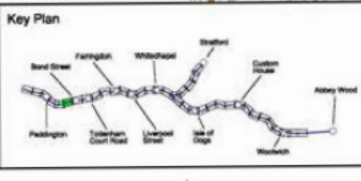
- Structures with I & M Comments
- Buildings with damage category 3
- Linked Buildings
- Bored Tunnels
- Cut & Cover Tunnels
- Mains Sewer (greater than Ø1.5m)
- Deep Tunnel assets

Instruments and Monitors

- Automated Total Station
- Basest Convergence System
- Electrolevel Beams
- Extensometer - Rod
- Inclinometer
- Inclinometer - Electrolevel
- Piezometer - Vibrating Wire
- 3D Geodetic Prisms
- Sockets - BRF Type - Structure
- Studs - Precise Ground Levelling
- Spars Monitoring Point
- Monitoring Transient in Tunnels @ 10m c/c
- Deep Datum
- Shallow Datum - Utilities

Notes

NO	DATE	DESCRIPTION	BY	CHKD	APP	AUTH
P01	20/11/2009	Issued for Tender Purposes	AB	AK	RM	
P02	20/11/2009	Issued for Tender Purposes	AB	AK	RM	
P03	12/03/2010	Released for Tender Purposes	JC	AS	RM	
P04	26/04/2010	Released for Tender Advertisement Purposes	AB	AS	RM	
P05	14/10/2010	Issued for Combined Bid	JF	AS	RM	
P06	11/05/2011	Designer's Recommendations for Use by Contractors	JO	CC	PC	
P07	24/06/2011	Minimum Requirements for Instrumentation and Monitoring	JO	AS	RM	
P08	25/01/2012	Minimum Requirements for Instrumentation and Monitoring	GP	JA	RM	
P09	03/02/2012	Minimum Requirements for Instrumentation and Monitoring	GP	JA	RM	
C01	11/02/2012	Issued as fit for construction	GP	JA	RM	IT



Crossrail

General: Bored Tunnels (Alignment and Track)

Operator: Ove Arup & Partners Limited

Lead: Crossrail General

Title: Instrumentation and Monitoring Combined I & M

Route-wide Plan Sheet 6 of 38

C300

Scale: 1:1000 @ A1

Drawing and CAD file No: C122-OVE-C2-DDA-CR001_Z-31006

Rev: C01

By: J. GROTTER

Chk: J. APTEID

App: A. MCCORM

App: I. THOMSON