C300/410

Western Tunnels & Caverns Project

Close-out Report

FISHER STREET WORKS ~ Fisher Street Grout Shaft Close-out report

CRL Document No. **C300-BFK-C4-RGN-CRT00_ST005-51233**

Contract MDL reference: C14.020

1. Contractor Document Submittal History

Revision	Date	Prepared by	Checked by	Approved by	Reason for Issue
3.0	19/02/16	[redacted]	[redacted]	[redacted]	For CRL Acceptance
		[redacted]	[redacted]	[redacted]	

2a. Stakeholder Review Required? YES ☐ NO ☒

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

Purpose of submission: For no objection ☐ For information ☐

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

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

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

2b. Review by Stakeholder (if required):

Stakeholder Organisation	Job Title	Name	Signature	Date	Acceptance
					☐
					☐

3. Acceptance by *Crossrail:*

***Crossrail* Review and Acceptance Decal**

This decal is to be used for submitted documents requiring acceptance by *Crossrail*.

☒	Code 1.	Accepted. Work May Proceed
☐	Code 2.	Not Accepted. Revise and resubmit. Work may proceed subject to incorporation of changes indicated
☐	Code 3.	Not Accepted. Revise and resubmit. Work may not proceed
☐	Received [redacted] is confirmed	

Reviewed/Accepted by: (signature) [redacted] Print Name: [redacted] Position: [redacted] Date: 01/06/16

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Contents

1. Purpose and Scope

A number of summary reports (or written submissions) are required by the Works Information within the Compensation Grouting (KC21) and Instrumentation and Monitoring (KX10) Materials and Workmanship Specifications. The relevant Clauses are reproduced in Figure 1.1. A list of Reference Documents is given in Appendix 1.

The requirements that are addressed in this report are:

- Summary of pre-treatment, concurrent grouting and grout jacking records
- Summary of construction activities
- Comparison of measured movements with predicted movements
- Comparison of measured movements with Specification limits
- Proposal to de-commission the Grout Shaft and associated automatic monitoring

As required by the Compensation Grouting Specification KC21 Clause KC21.3220(c), a written submission is required to justify the de-commissioning of compensation grouting facilities a minimum of 3 months after the completion of construction. Comparisons are made to the Compensation Grouting Performance Requirements defined in Specification for the Control of Ground Movement Clause 3.2.5.1 and 3.2.5.2.

This report refers to the de-commissioning of the Grout Shaft at Fisher Street (Figure 1). All BFK excavation works potentially causing settlement within the plan extent of the compensation grouting arrays at Fisher Street Shaft were completed by early July 2014.

This report aims to summarise the relevant construction, compensation grouting and monitoring information for the Grout Shaft at Fisher Street Shaft and provide justification for the decommissioning of the shaft.

The requirements of KC21.3228(e) & (f) not fulfilled by this report are:

- H&S file – submitted separately for construction and a further file will be submitted after de-commissioning.
- Grout shaft & array construction – submitted separately.

The requirements of KX10.2013 and KX10.2014 not fulfilled by this report are:

- Updated as-built record and status for all instrumentation
- Justification for de-commissioning instrumentation other than the hydrostatic levelling cells (HLCs).

The HLCs have been used for construction control during compensation grouting works and a separate “close-out” report is not required, since the 2mm/year criterion does not apply. Examples of data from the HLC in the area are included in Section 2.2.

The “as-built record and status” will be supplied as co-ordinates and digital data for incorporation into UCIMS.

Table 1.1 Extracts from Works Information

KC21.3220 Compensation Grouting - General Requirements

c) The grouting facilities shall be maintained in place for a minimum of three months after the end of excavations or other construction activities which could produce settlement within the zone of compensation grouting. The grouting facilities shall be maintained for a further period until such time that the *Contractor* can demonstrate, by written submission, to the satisfaction of the *Project Manager*, that the specified criteria on movement specified in Volume 2C, *Specification* for the Control of Ground Movements will not be exceeded as a result of post-construction long term settlement. Automatic monitoring can be decommissioned at the same time as the grouting facilities whereas precise levelling points will be maintained in place and monitored until the *Contractor* can demonstrate compliance with the specified criteria for the cessation of monitoring to the satisfaction of the *Project Manager*.

KC21.3228 Reporting

e) Within one month of the completion of concurrent grouting the *Contractor* will supply a summary report of the grout shaft and array construction, pre-treatment and concurrent grouting, site H&S file, ground movement monitoring, construction activities and a comparison of observed behaviour with both predicted movements and the *Specification* limits on movement. This report is to be updated one month after the completion of any episodes of grout jacking.

f) A final version of the report will be prepared to incorporate the justification for de-commissioning, as required by Compensation Grouting - general requirements, and as-built records of the reinstatement of grout shafts and arrays including H&S closeout reporting.

KX10.2113 Final Report

Within three months after completion of the Works the *Contractor* shall issue a final report providing an updated as-built record and status for all instrumentation. The report shall include a summary of the observed movements for each monitoring area (relative to the construction works) and appropriate *Drawings*. The report shall be submitted to the *Project Manager* in an approved format.

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.

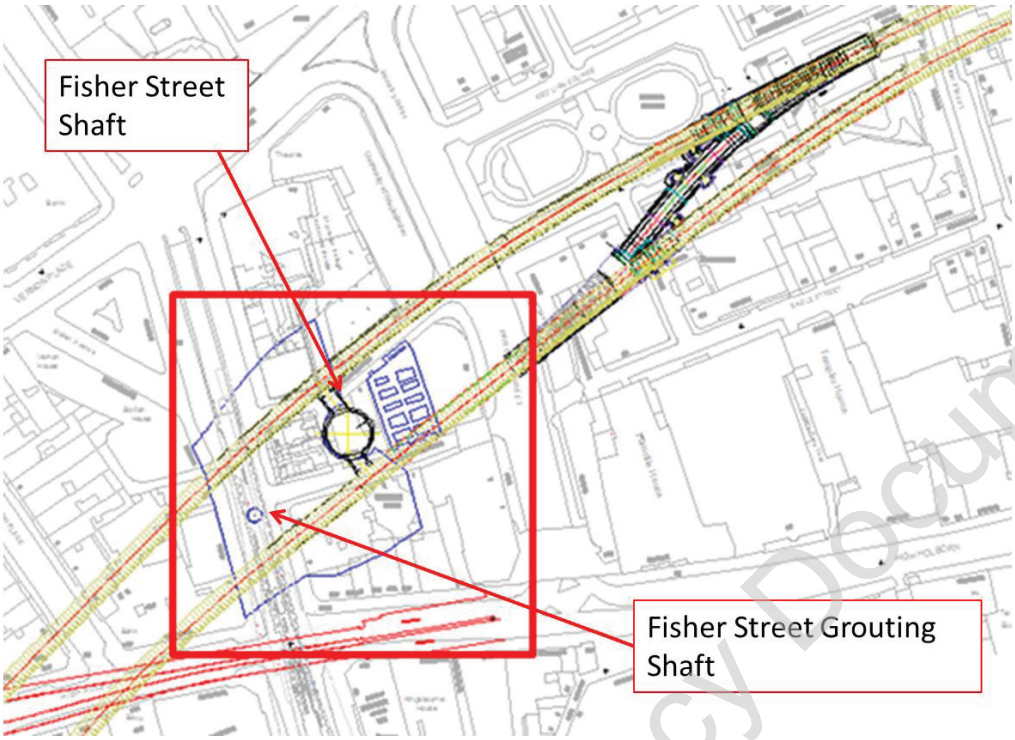


Figure 1: Location. General overview of the works

2. Main Works related to the Grouting Shaft

2.1. Excavation

The grout shaft at Fisher Street, located within the Kingsway Tram Tunnel, was excavated between 11/06/2012 and 12/07/2012.

2.2. TAMs installation

The installation of the TAMs was carried out between 06/08/2012 and 20/09/2012. Details of the TAM installation progress and a copy of the as-built drawing are included in Appendices 2 and 3.

2.3. Pre-Treatment injections

The pre-treatment injections consisted of 3 passes (Passes1, 2 and 3) carried out over 10 shifts between 10/10/2012 and 01/11/2012. A total of 29,126 litres (or 29.1 m^3) of grout was injected during the pre-treatment phase. The cumulative volume of grout injected with time is illustrated in Figure 2.

Figure 3 illustrates the distribution of the grout injected through contours of the total grout intensity and the locations of the ports injected. The grout intensity is the equivalent thickness of grout injected into the ground in millimetres. The methodology used to generate these contours is described in Appendix 4.

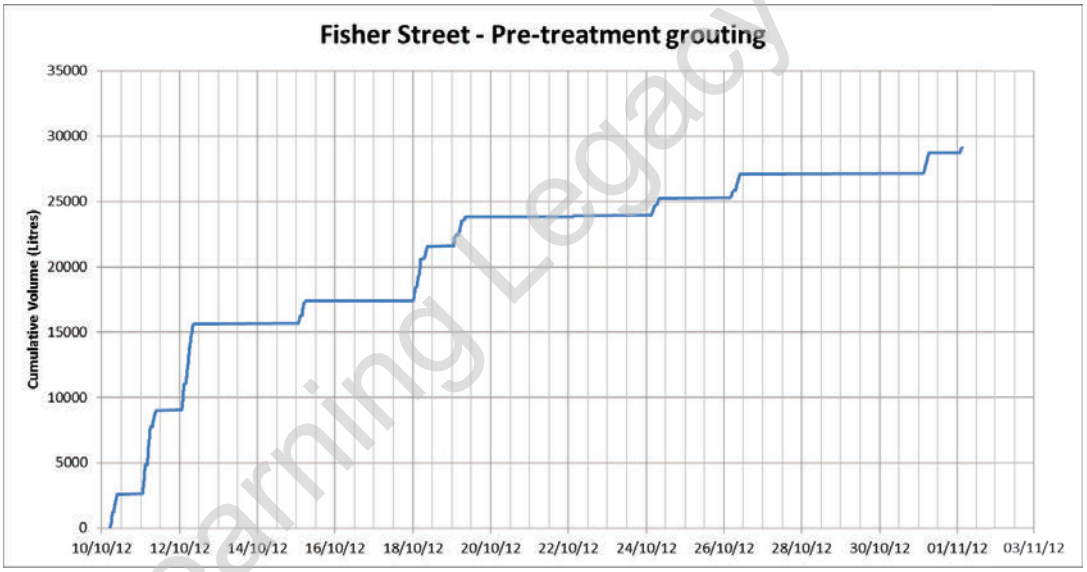


Figure 2 Cumulative grout volume vs. time (Pre-treatment)

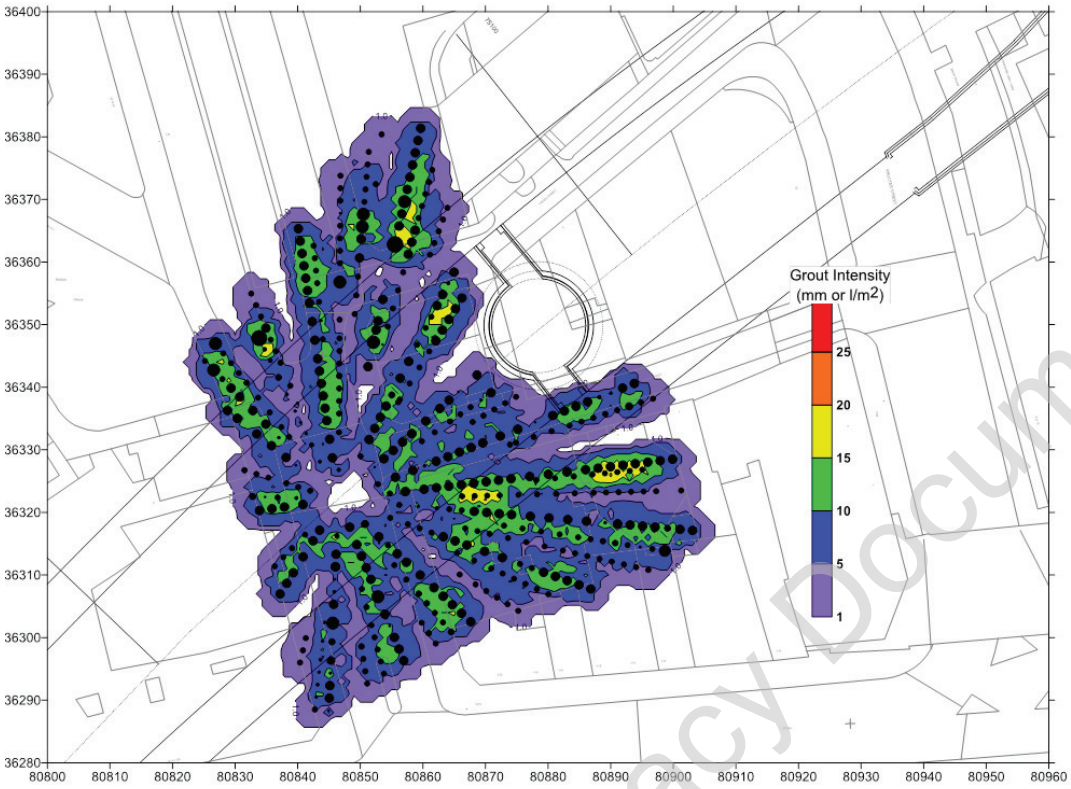


Figure 3 Pre-treatment grouting intensity

2.4. Construction works

The dates of the main construction activities potentially generating settlement within the plan extent of the grouting arrays are given in Table 1.

Activity	Start	Finish	Comments
Shaft & OSD piling	26/09/2012	16/11/2012	
Shaft excavation within piles	30/05/2013	12/07/2013	Ring beam from 20/06/13
Shaft excavation - SCL	15/07/2013	06/09/2013	Stopped for WB TBM 24 & 25/07/2013
WB TBM	08/07/2013	28/07/2013	TBM stopped 11/07/13 to 23/07/13
EB TBM	01/10/2013	05/10/2013	
IA1	27/03/2014	03/04/2014	
IA2	13/12/2013	12/01/2014	

Table 1 Main construction activities at FIS

It is noteworthy that refurbishment of 2-6 Southampton Row commenced prior to the end of construction in late 2013 and continued after completion of BFK works. The refurbishment included underpinning of some internal foundations which generated some further settlement of the building.

2.5. Concurrent Grouting and Grout Jacking

No concurrent grouting or grout jacking episodes were carried out from this Grout Shaft. As at Bond Street and Tottenham Court Road, concurrent grouting was not carried out with the TBM drives, with an alternative strategy adopted with pre- and post- grout jacking episodes to be undertaken as required. The measured settlements and the calculated volume loss settlements were used to determine the likelihood of any exceedance of the Compensation Grouting Performance Requirements. These assessments were presented and agreed at CTC meetings. Due to the good volume loss performance of the TBMs and the small movements generated by the shaft excavation, no grout jacking either before or after the TBM drives was deemed necessary.

The monitoring results are presented in the following Section 3.

3. Summary of the observed ground movements

3.1. Predicted Movements

The settlements used to assess the impact of the works used in the assessment of impact of the excavation works in the compensation grouting area have been re-produced as a contour in Figure 4. The settlements were calculated using simple empirical methods.

The maximum settlement from the TBM drives is about -13mm and adjacent to the shaft just under -40mm.

The monitored settlements are summarised in a comparable contour plot is Figure 5: the maximum settlement is approximately -22mm adjacent to the shaft over the WB TBM tunnel. At the western edge of the grouting arrays, the maximum settlement is -7mm.

The actual movements recorded are significantly less than the predicted values, particularly adjacent to the shaft.

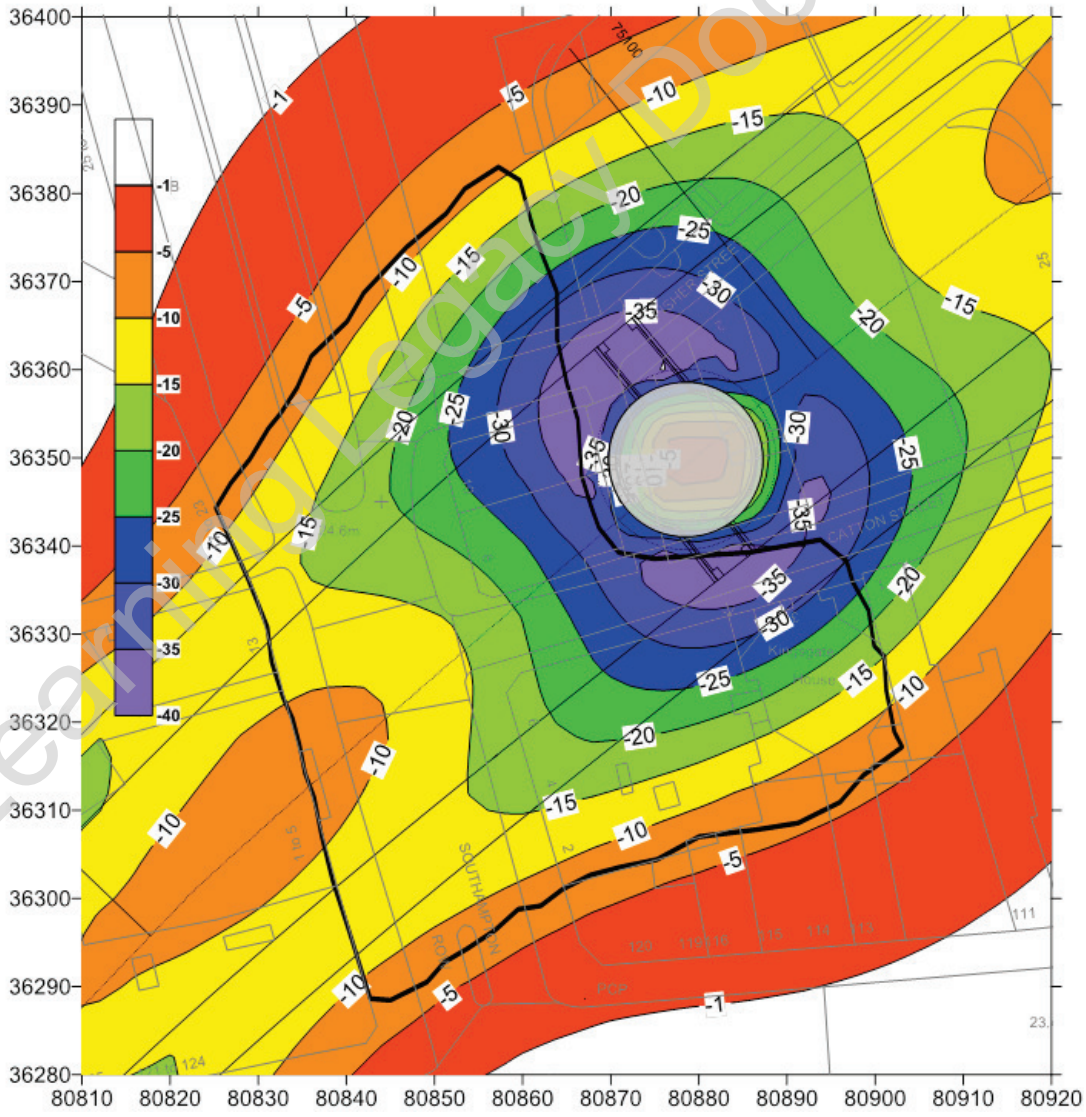


Figure 4 Calculated volume loss and shaft excavation settlements

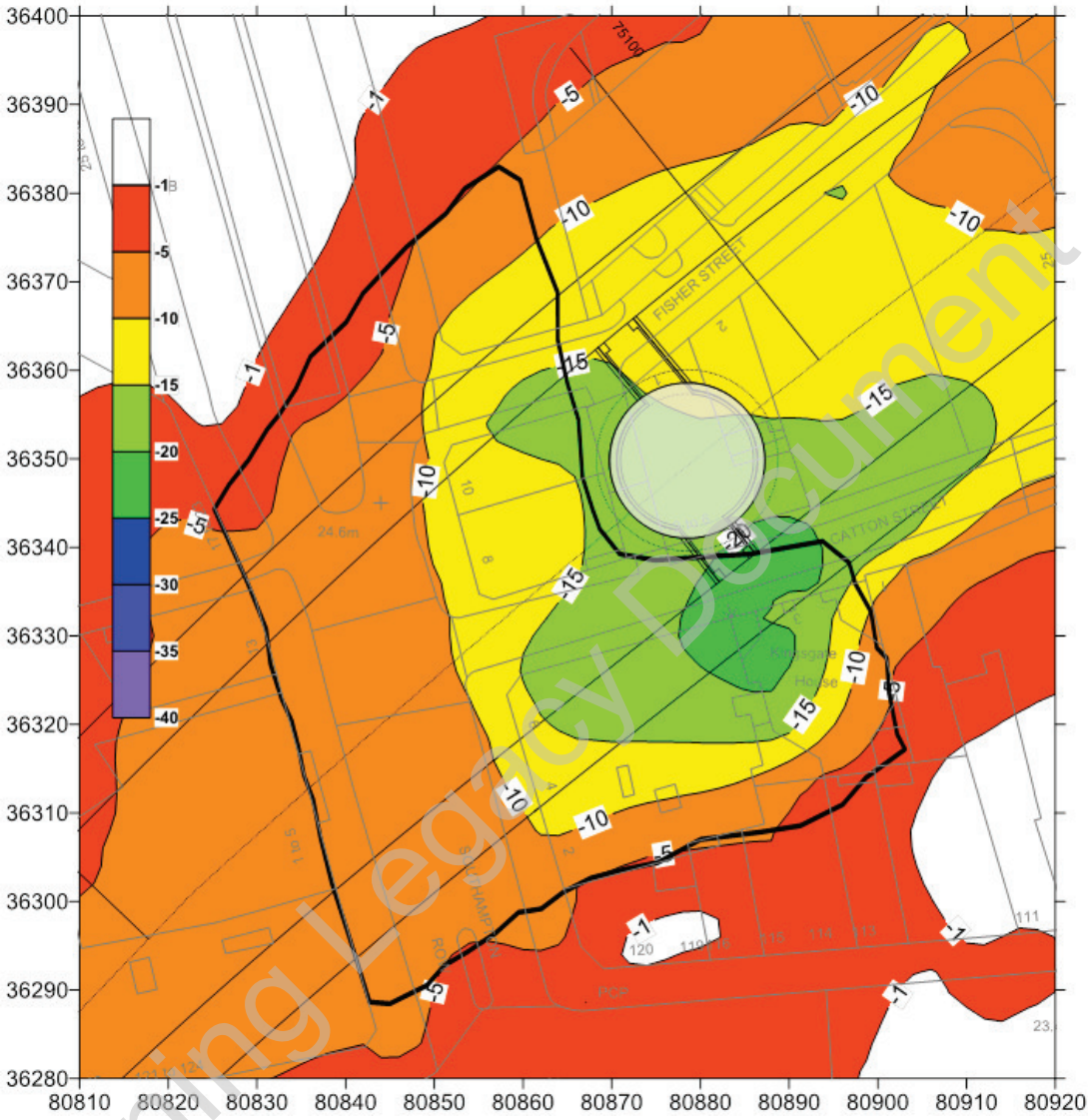


Figure 5 Observed settlements in May 2014 after the end of construction

3.2. HLCs blocks data

This section presents monitoring results from HLCs around the extent of the compensation grouting area. The HLCs "blocks" legend is presented in Figure 6 below.

The maximum heave due to pre-treatment grouting did not exceed 3mm. The monitoring time plots presented below include annotation indicating the timing of execution of the main works in the Fisher Street Shaft area.

Figures 7 and 8 show examples of HLC data from the period of Pre-treatment grouting. Figures 9 to 13 show data over the full construction period for each of the HLC blocks.

3.2.1. Data

Figure 6: Location of HLC blocks

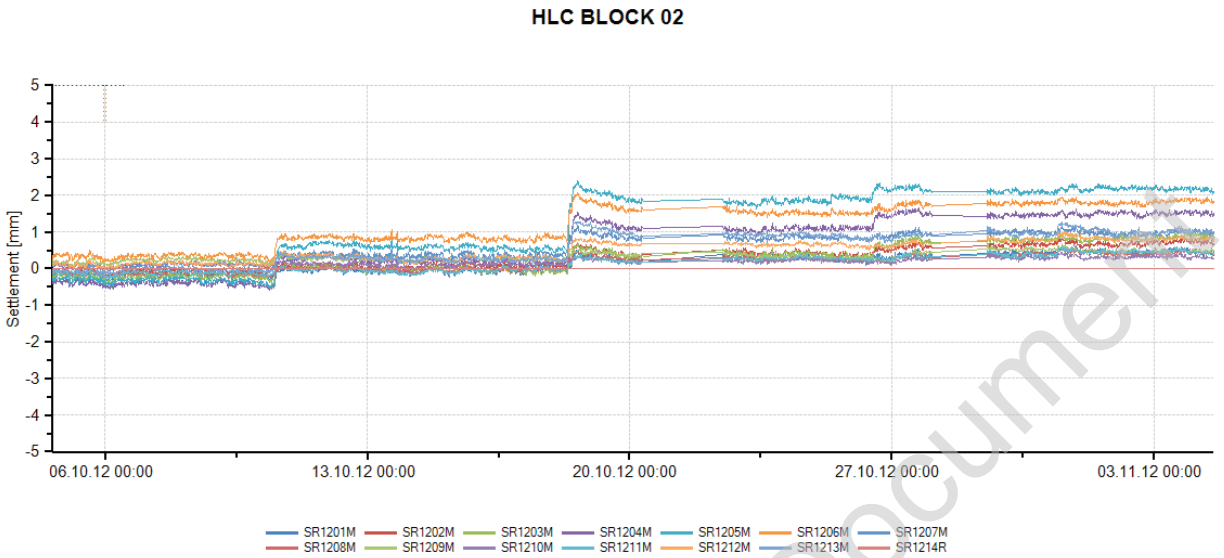


Figure 7: heave due to pre-treatment injections on Block 02.

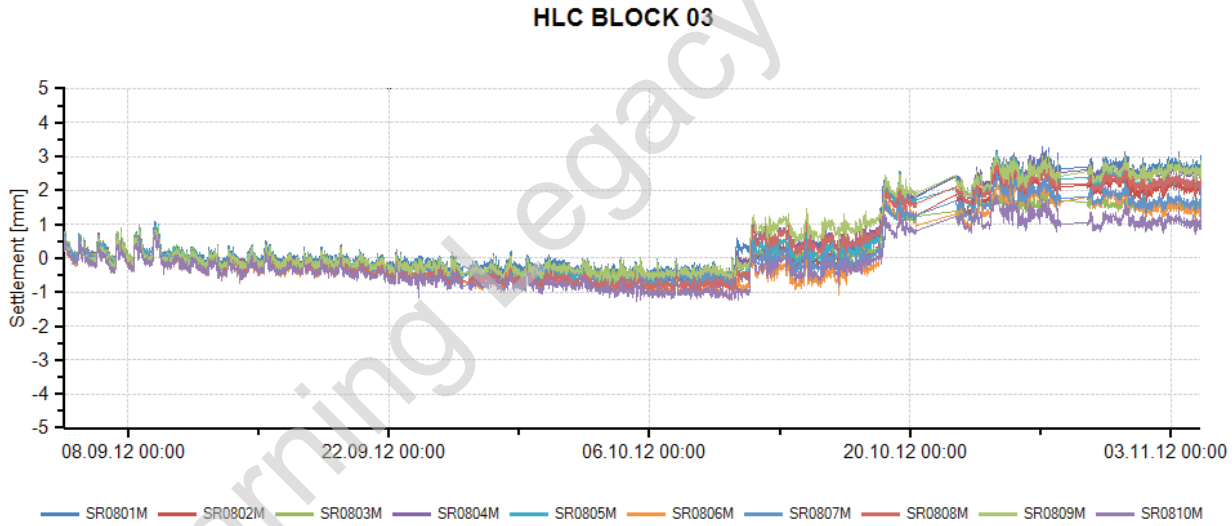
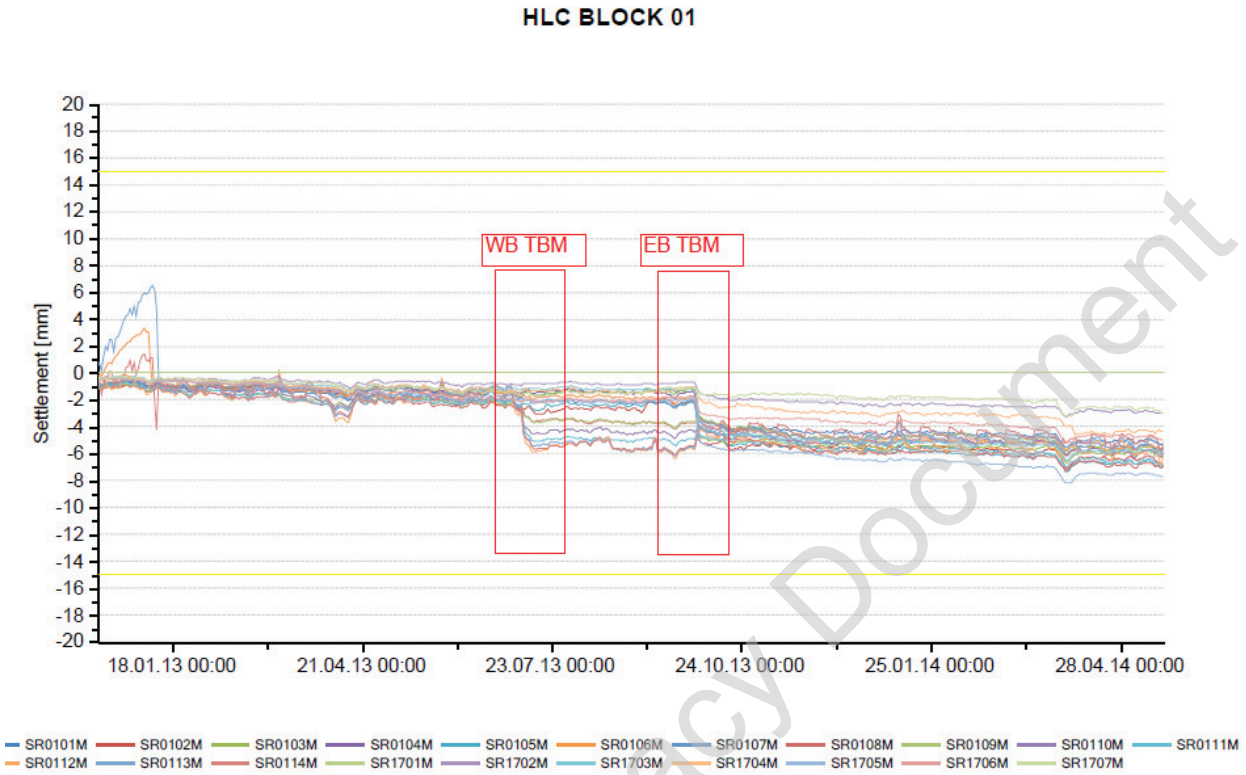


Figure 8: heave due to pre-treatment injections on Block 03.



Project: Routewide: TCR-FAR
Reference Date: none Date of Measurement: 19.05.2014 14:30

Figure 9: data time-plots for Block 1

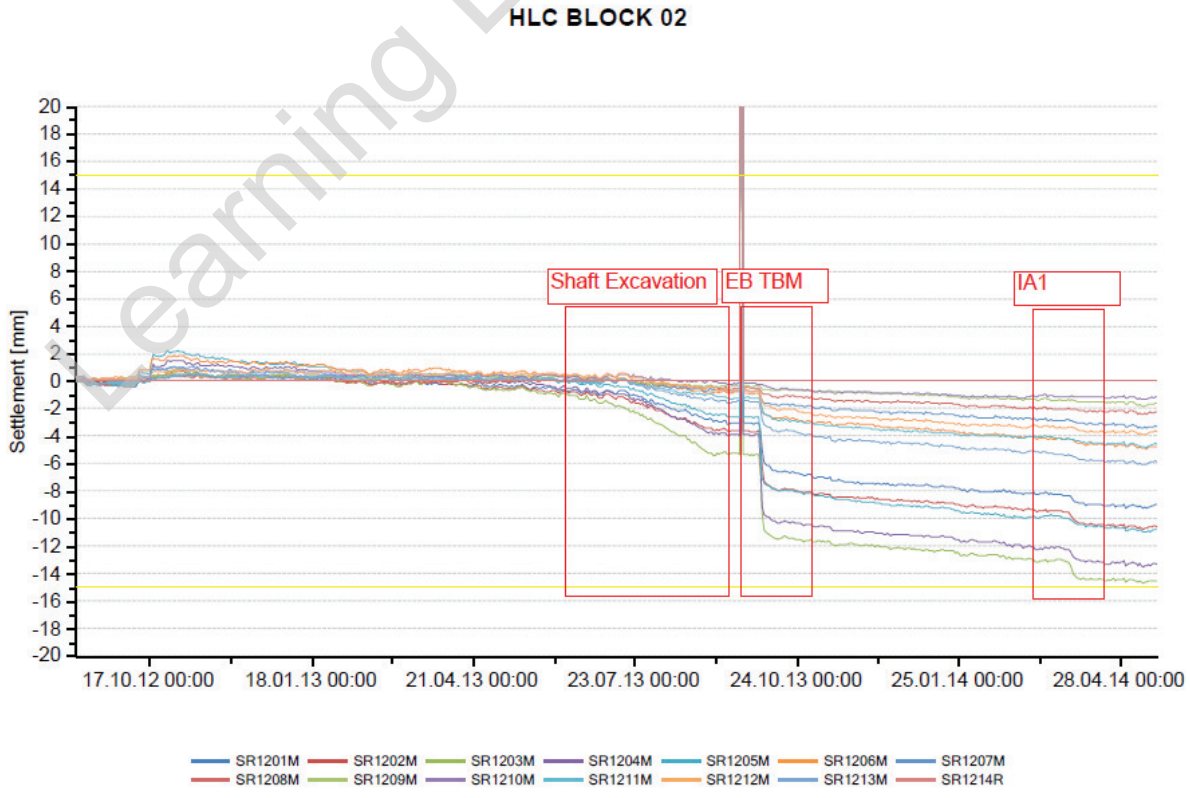
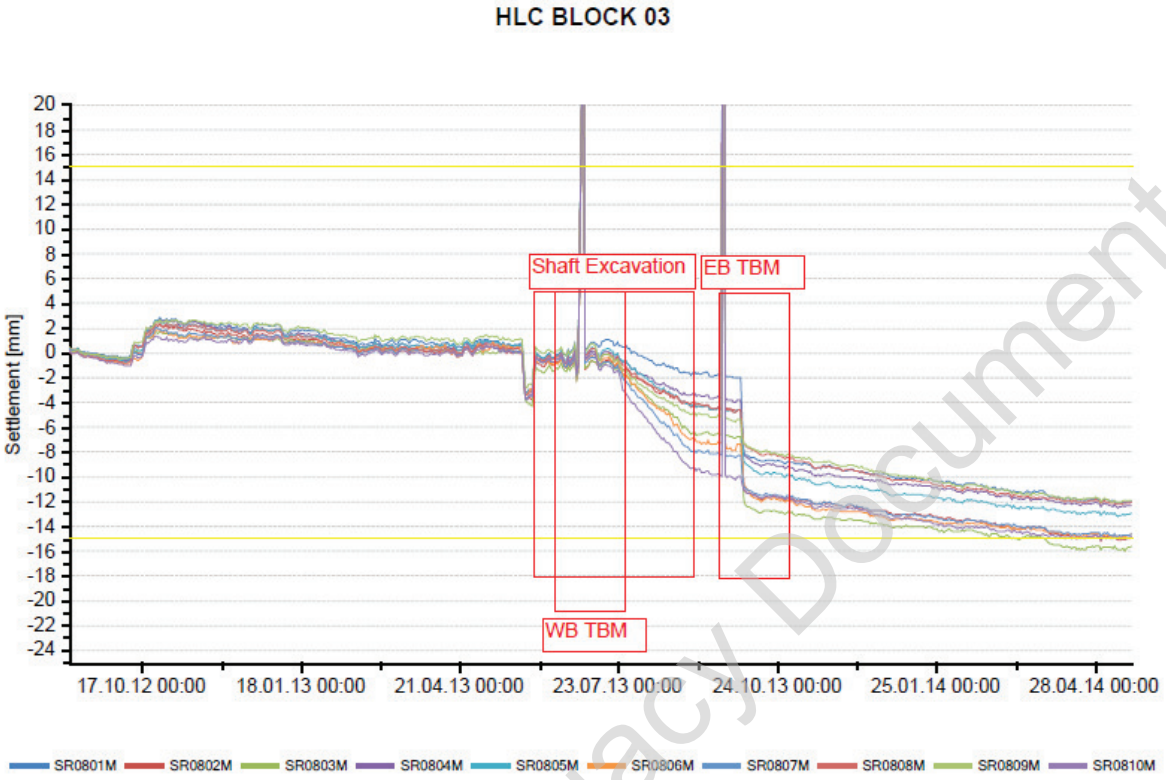


Figure 10: data time-plots for Block 2



N.B the settlement & heave event immediately prior to the shaft excavation and the heave spikes showin ~20mm heave are due to instrumentation issues and do not represent real movements

Figure 11: data time-plots for Block 3

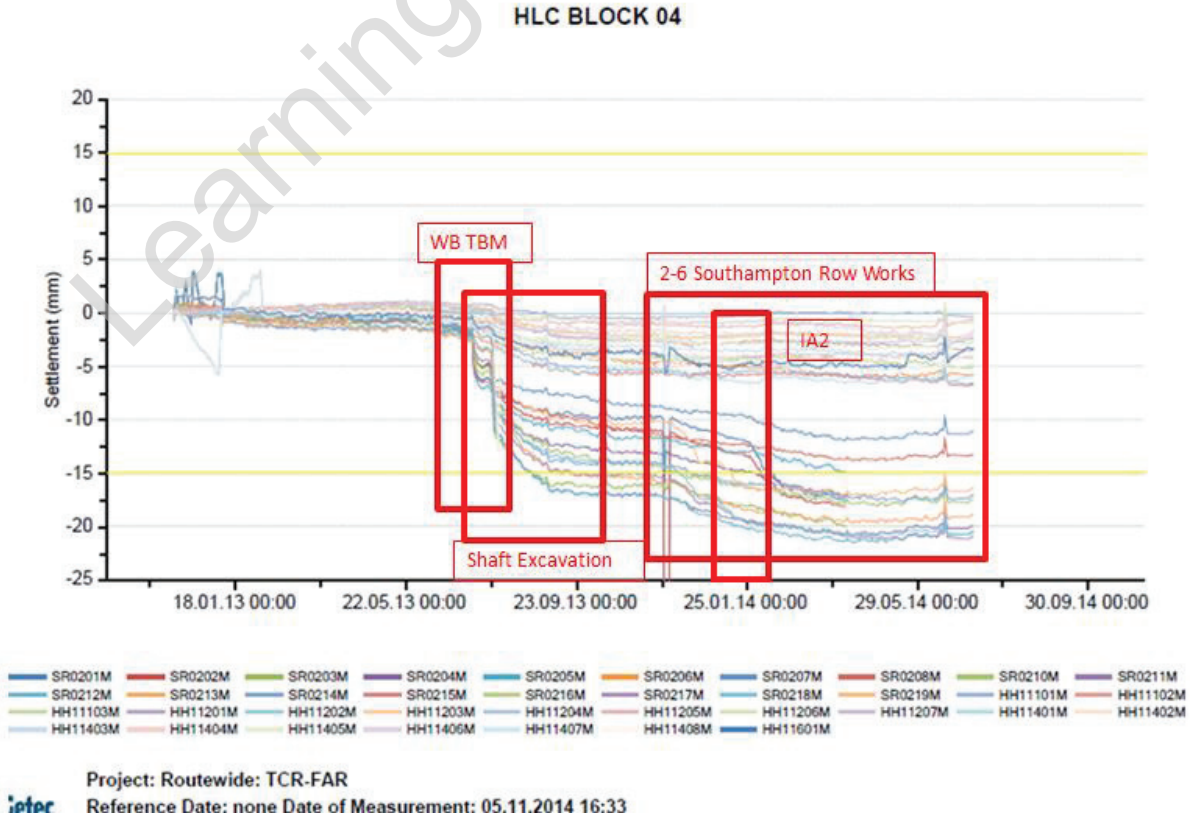
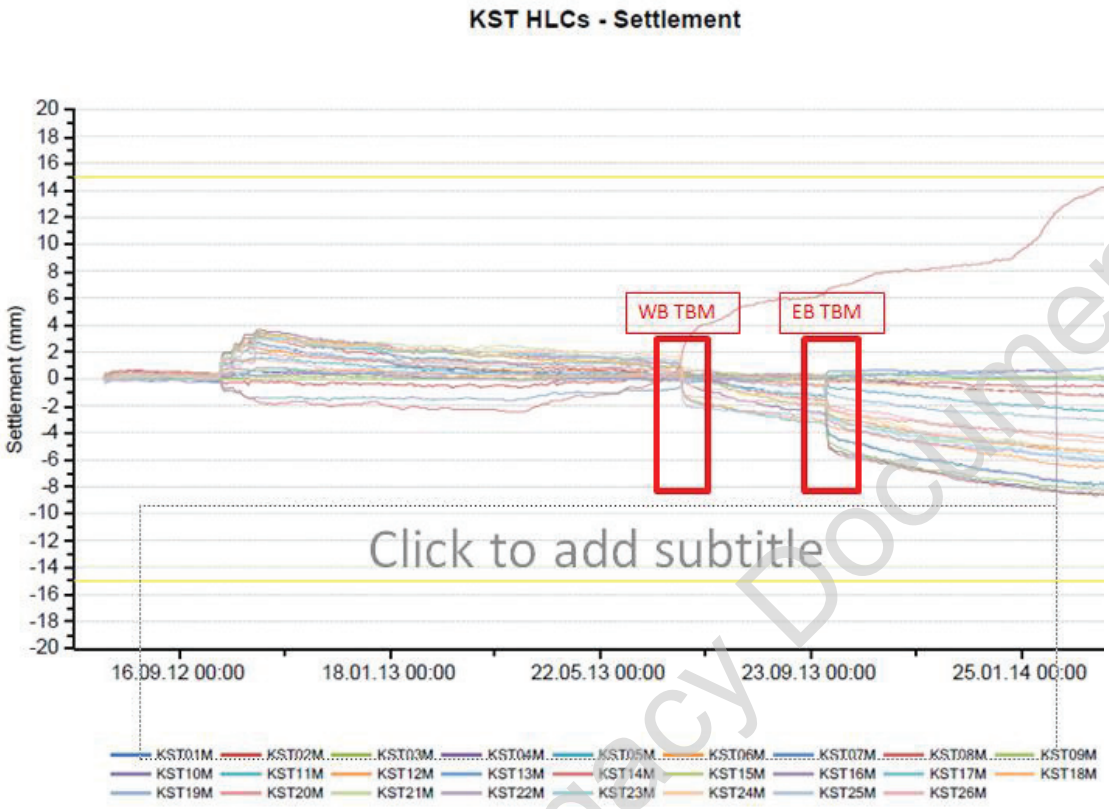


Figure 12: data time-plots for Block 4



N.B the heave shown by one sensor is due to instrumentation issues and does not represent real movement

Figure 13: data time-plots for KST.

3.2.2. Comments

The maximum settlement measured by the HLCs arrays on the above assets is approx. 22mm (Block 4). This results from a number of works in the area, whose effects are clearly visible and highlighted in the charts. It should be noted that Block 1 and KST are the only assets affected by the passage of both WB and EB TBMs and show a maximum settlement of ~7mm.

The time-plots are showing stabilising settlement trend. The associated risk is considered negligible.

3.3. Catton Street BREs and PLPs

3.3.1. Data

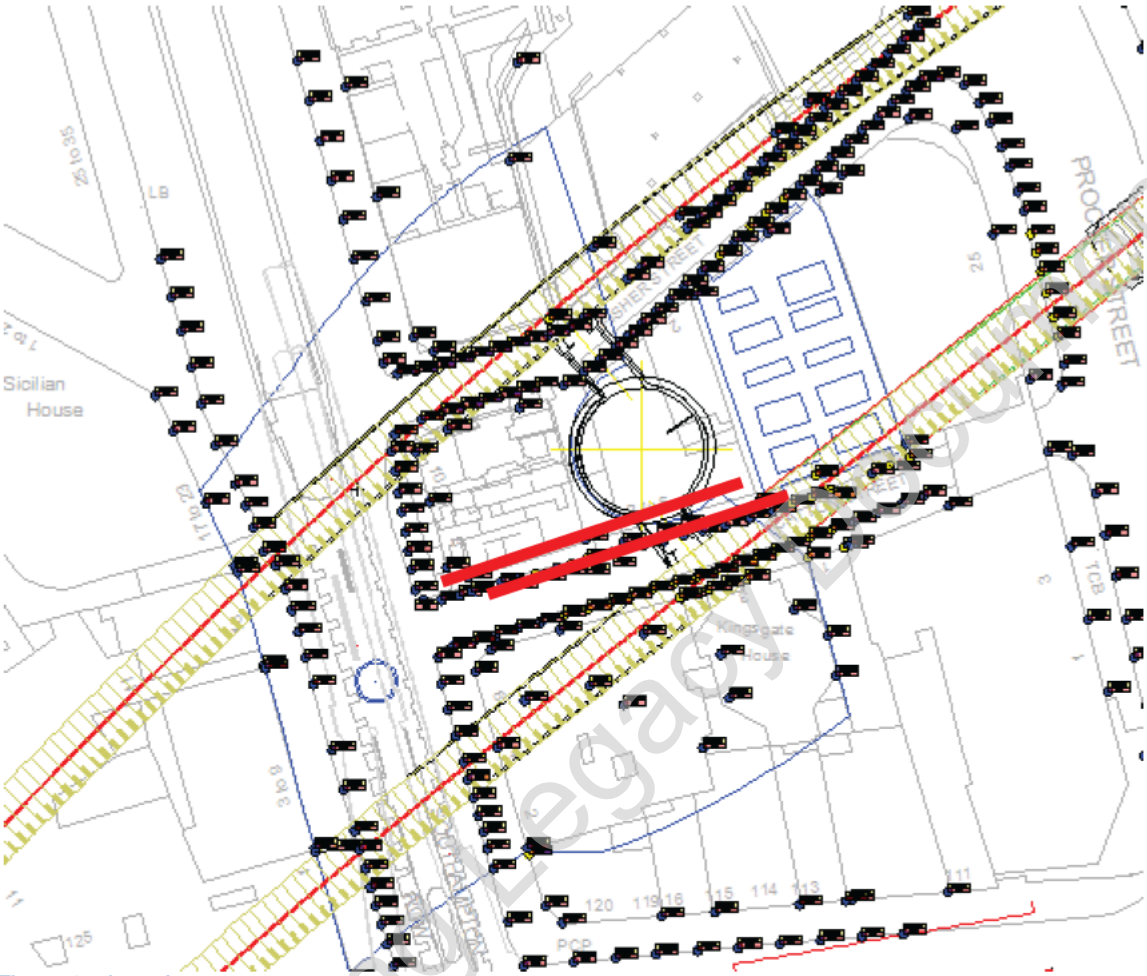


Figure 14: Location

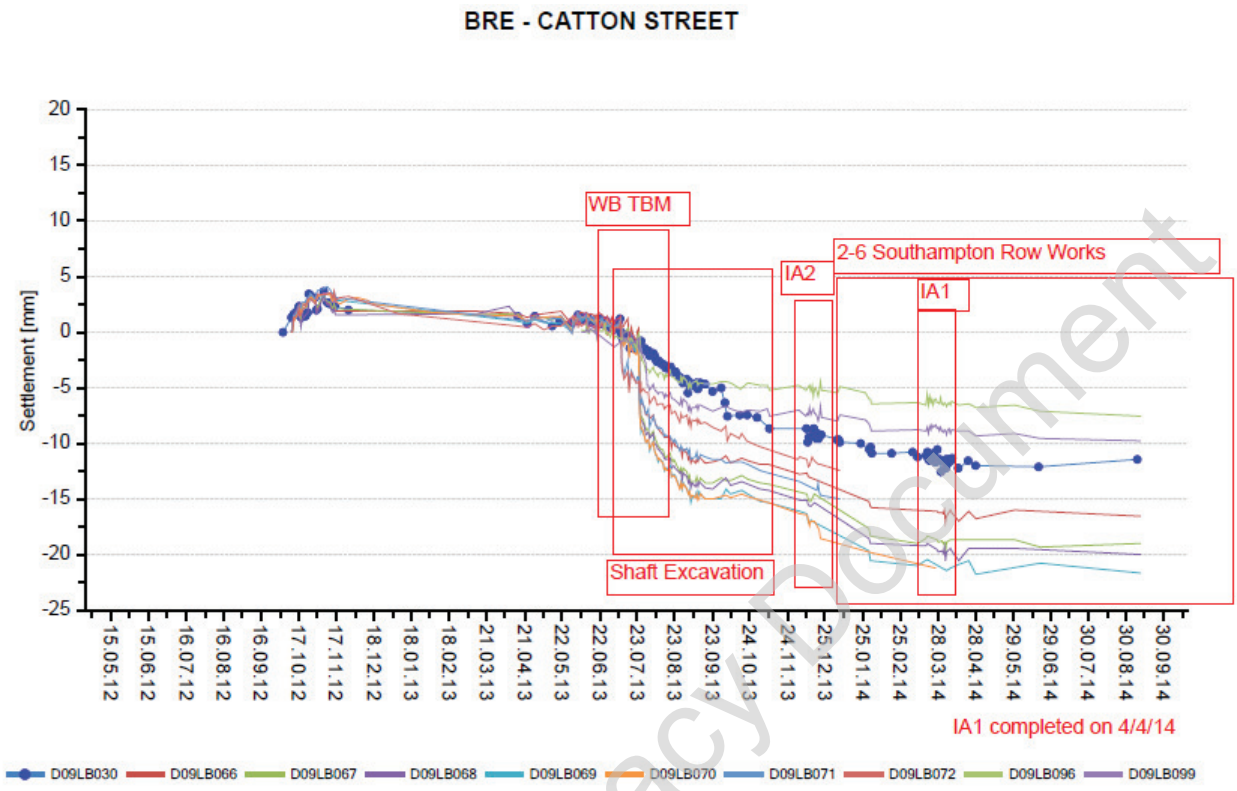


Figure 15: data time-plots (general)

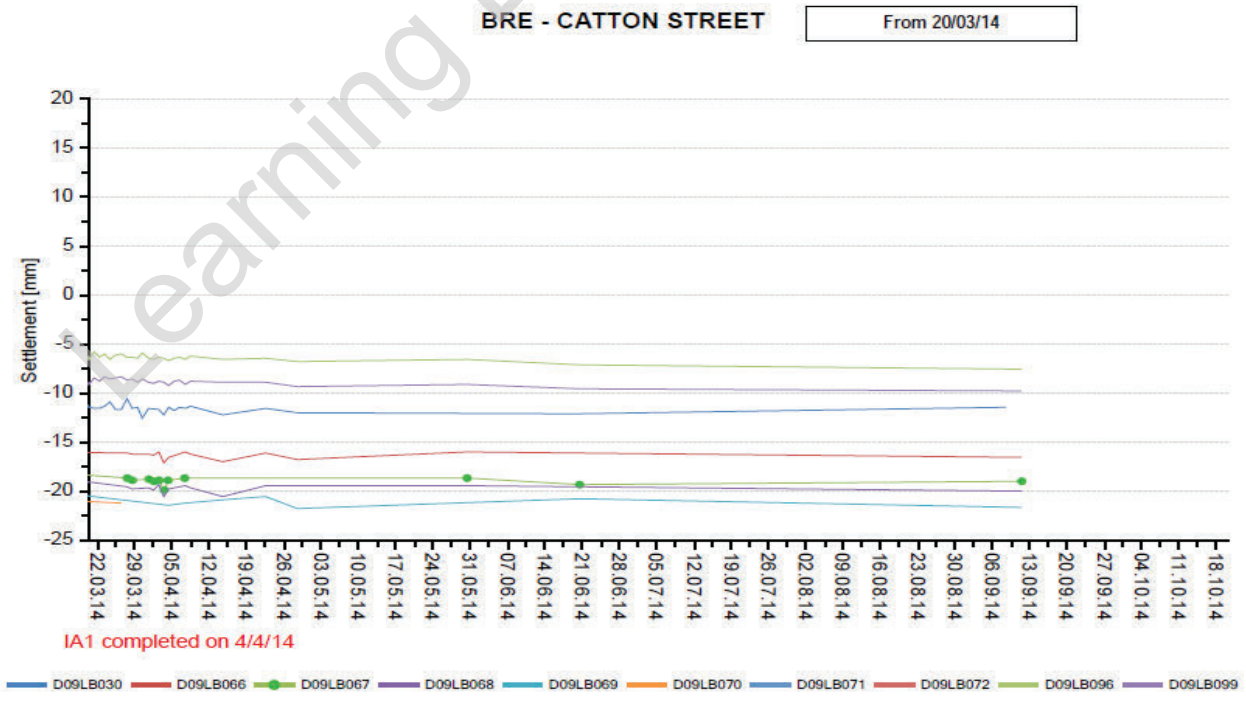


Figure 16: data time-plots (long-term period)

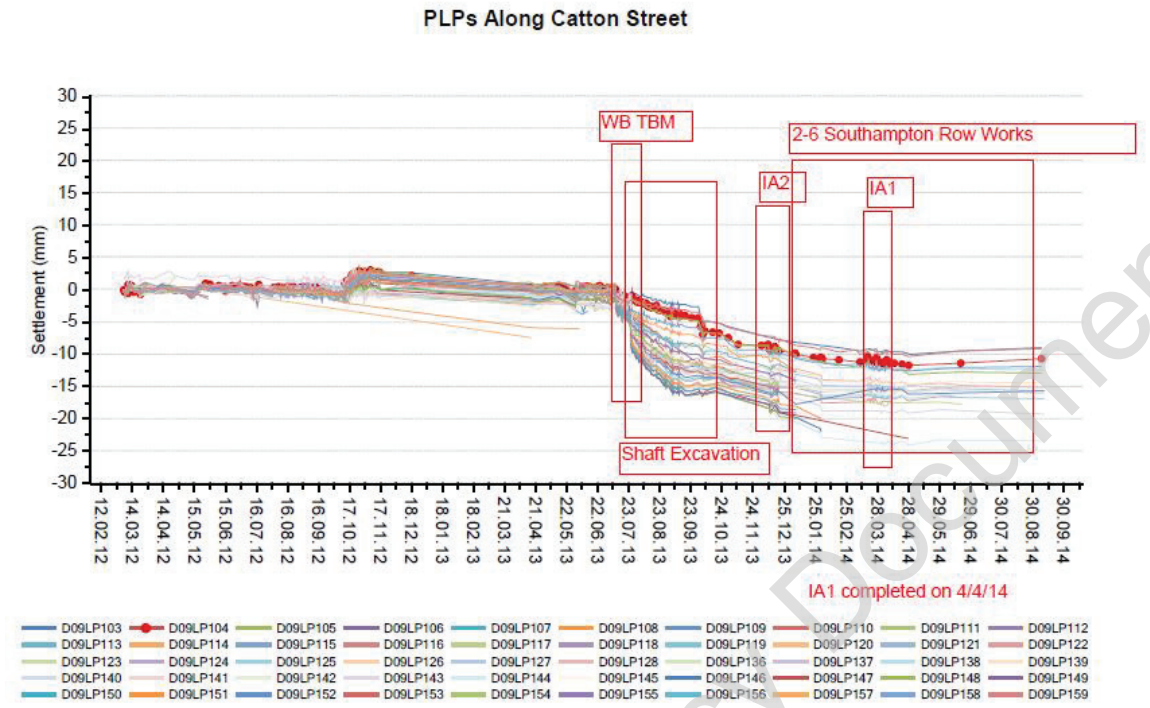


Figure 17: data time-plots (general)

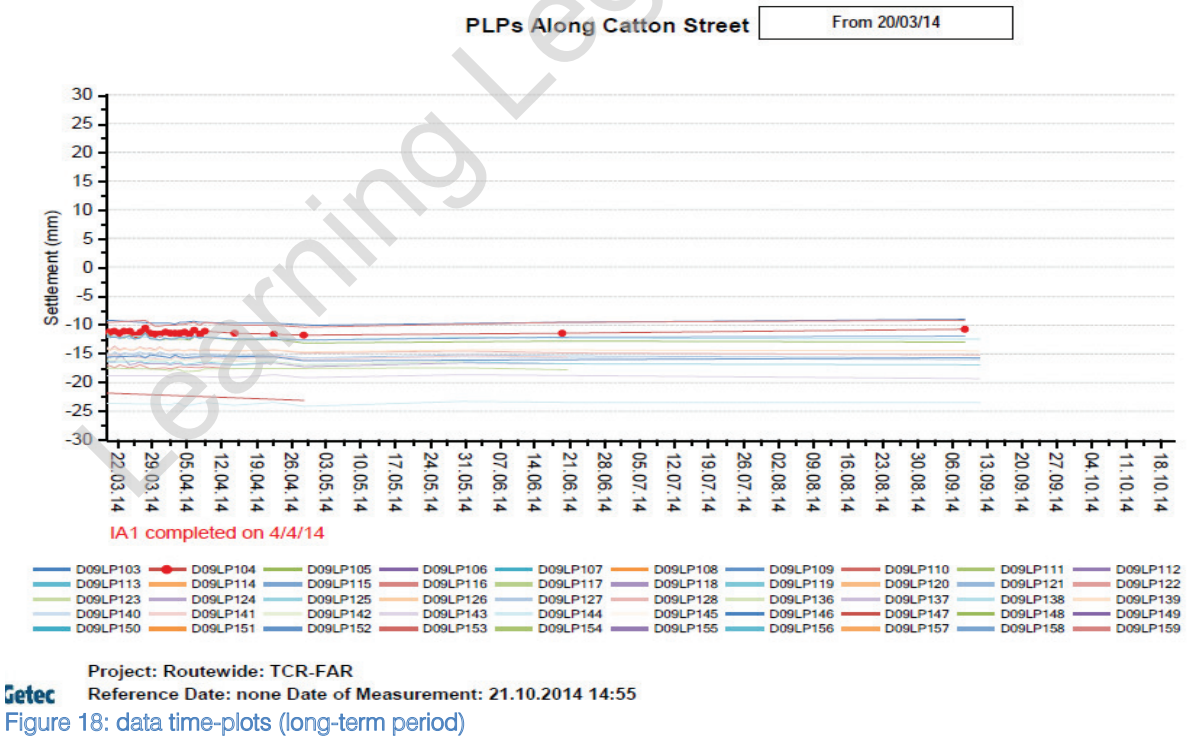


Figure 18: data time-plots (long-term period)

3.3.2. Comments

The points along Catton Street settled up to approx. 22mm. The settlements result from a number of construction activities in the area, including the refurbishment of 2-6 Southampton Row. The durations of each activity are annotated in the charts, allowing the associated movements to be discerned.

The time-plots are generally showing stability on the long term readings. The associated risk is considered negligible.

3.4. Fisher Street PLPs and BREs

3.4.1. Data

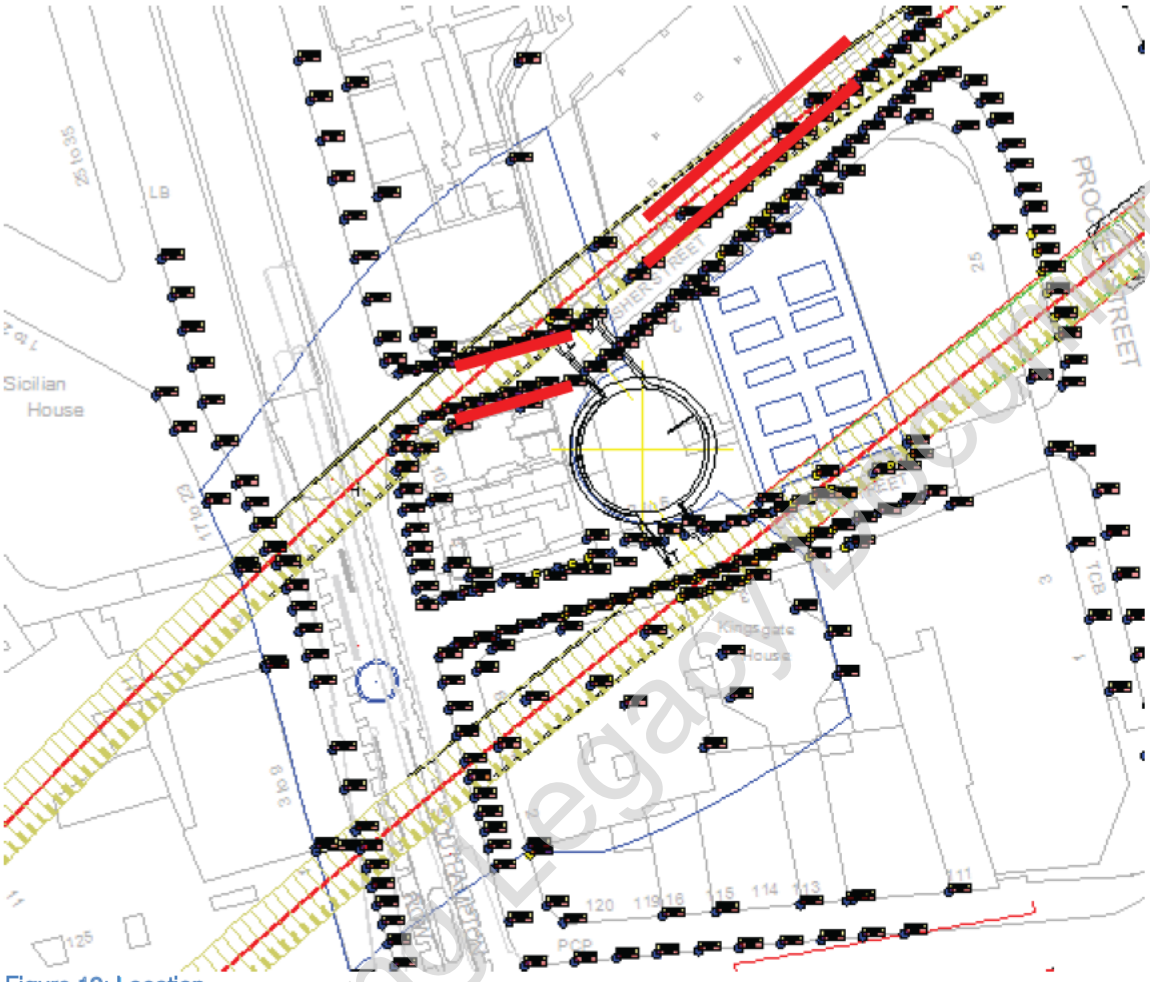


Figure 19: Location

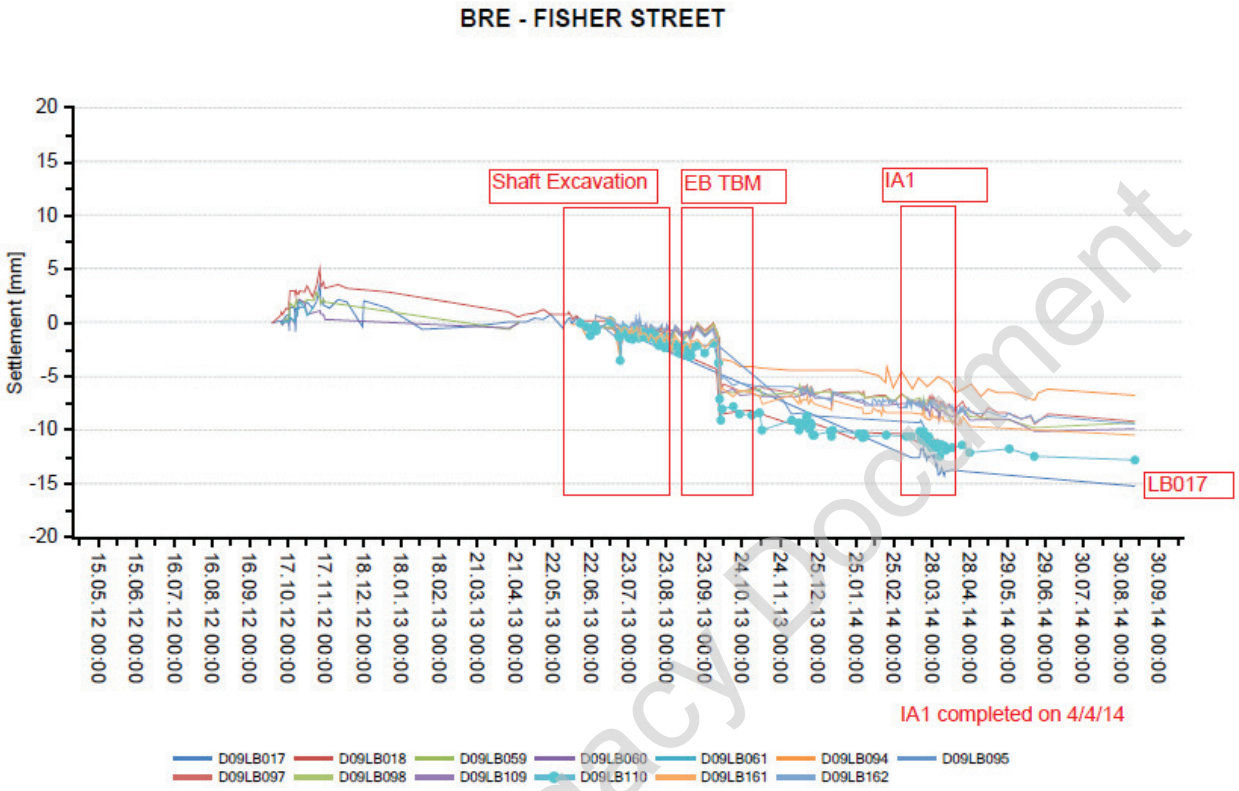


Figure 20: data time-plots (general)

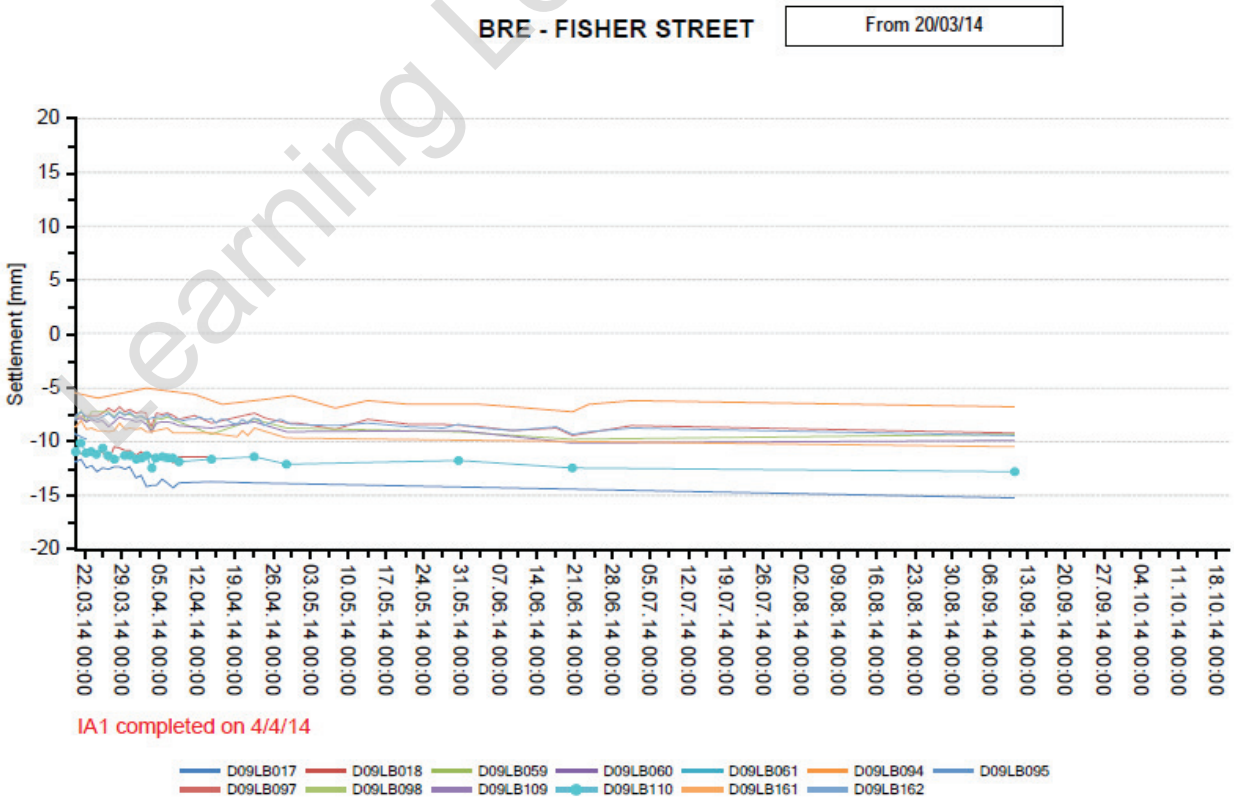


Figure 21: data time-plots (long-term period)

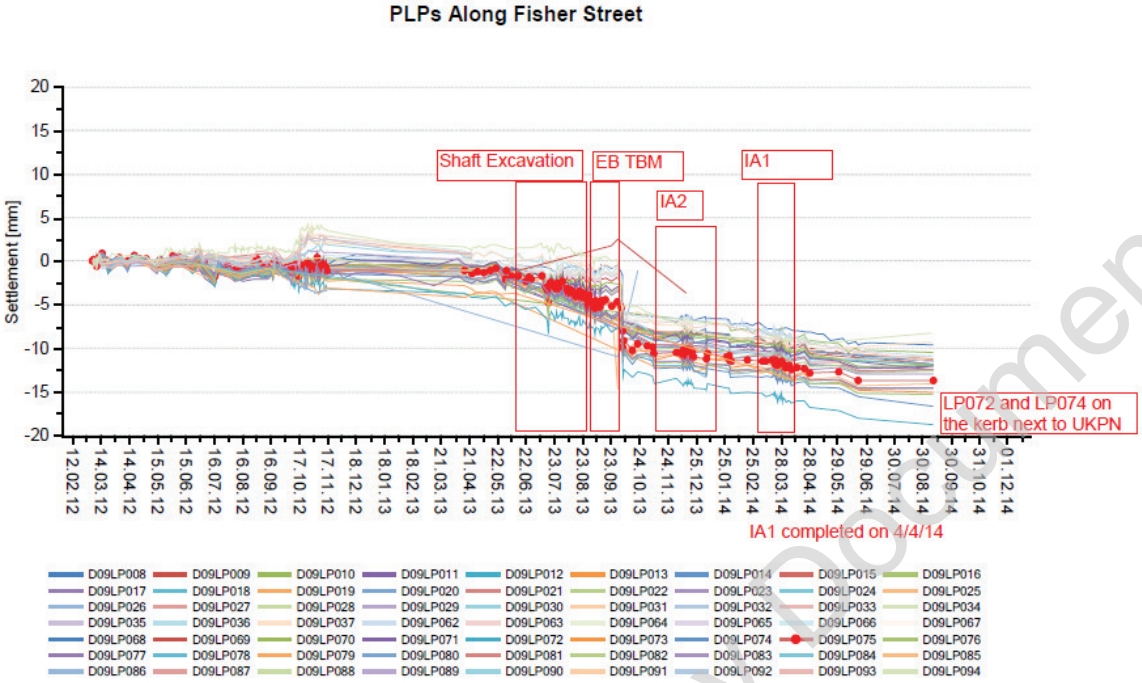


Figure 22: data time-plots (general)

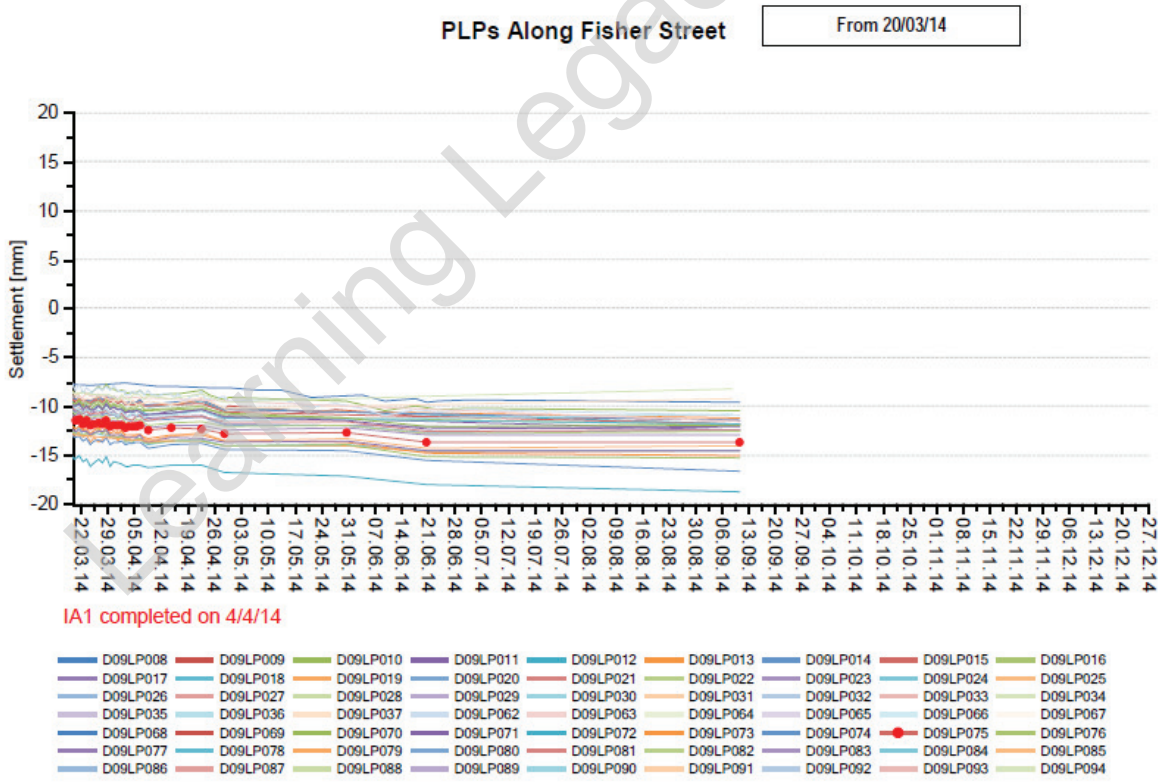


Figure 23: data time-plots (long-term period)

3.4.2. Comments

The points along Fisher Street settled up to approx. 20mm. This results from a number of works in the area, whose effects are clearly visible and highlighted in the charts. There is no effect from WB TBM passage.

The time-plots are generally showing stability on the long term readings. The associated risk is considered negligible.

3.5. High Holborn PLPs and BREs

3.5.1. Data

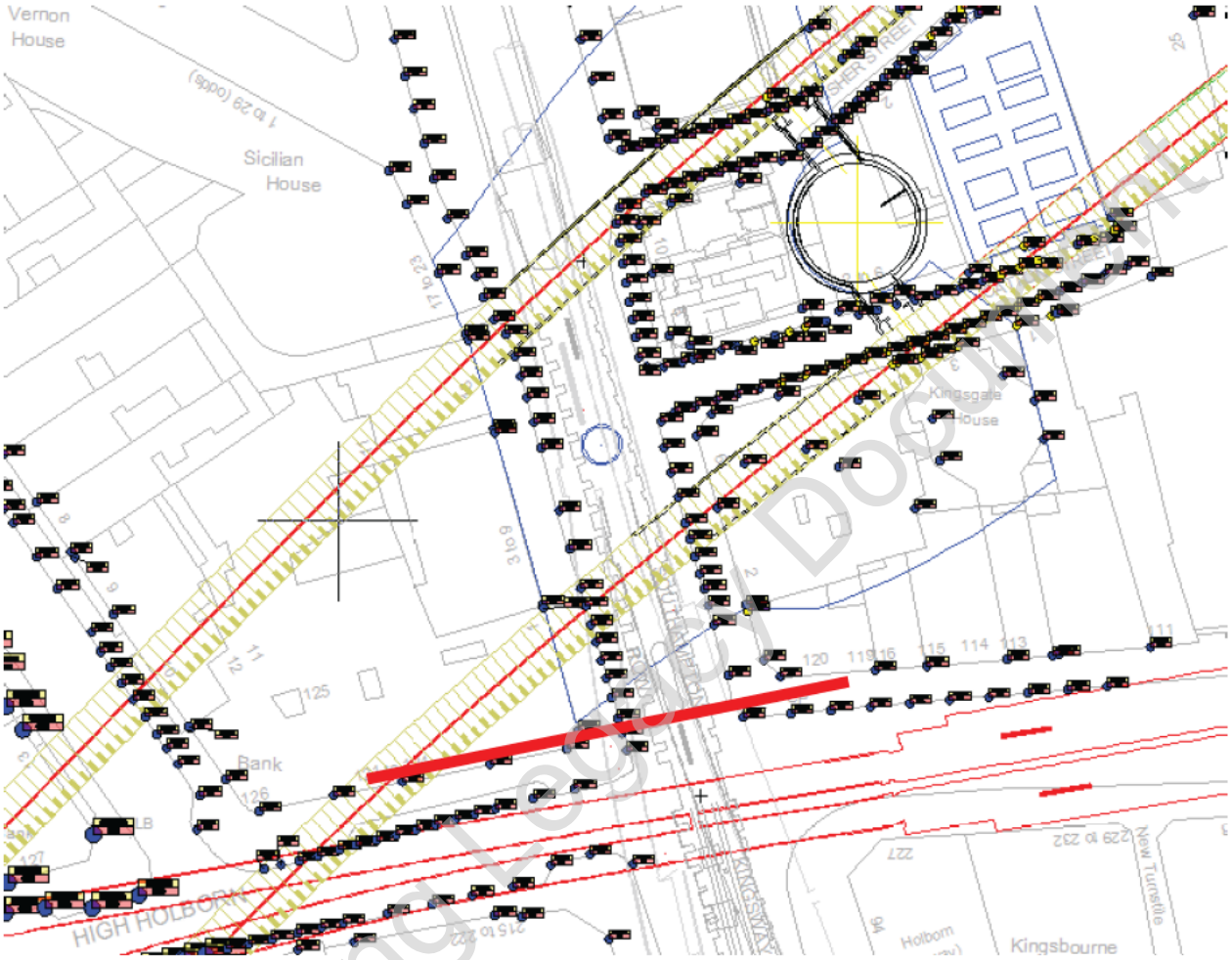


Figure 24: Location

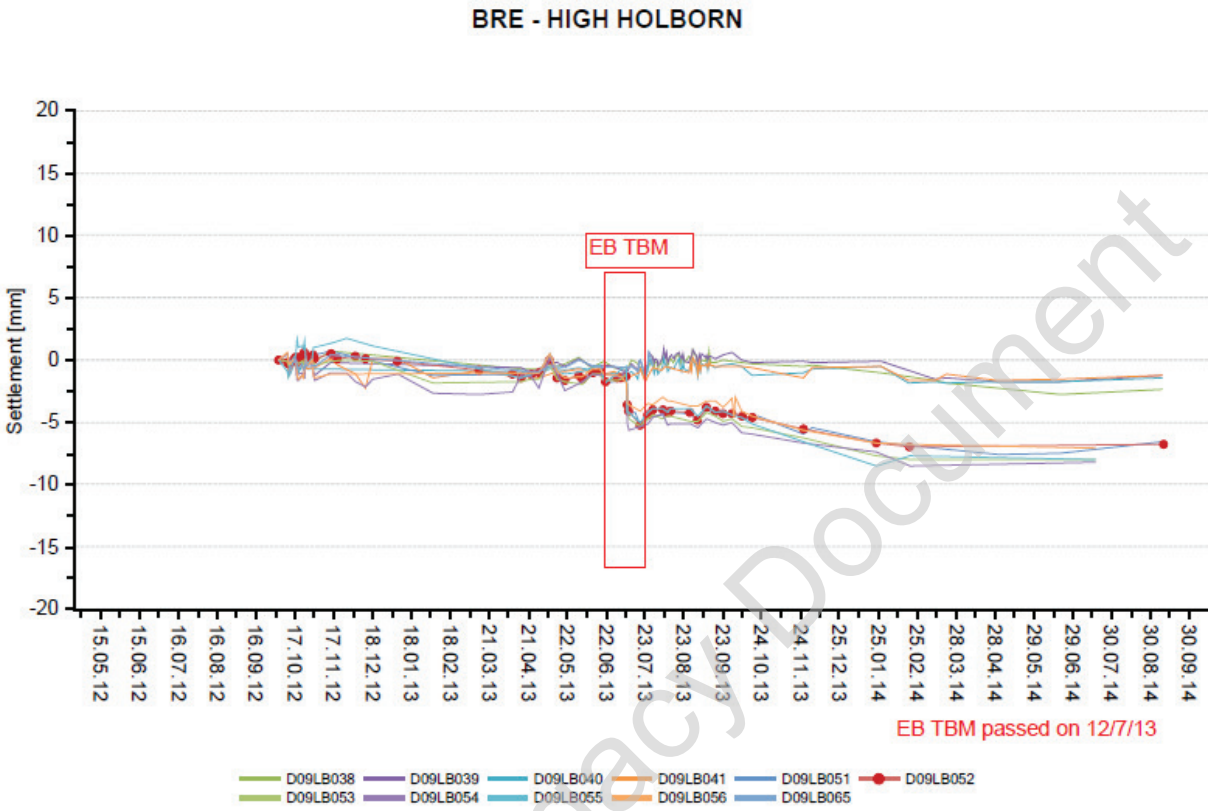


Figure 25: data time-plots (general)

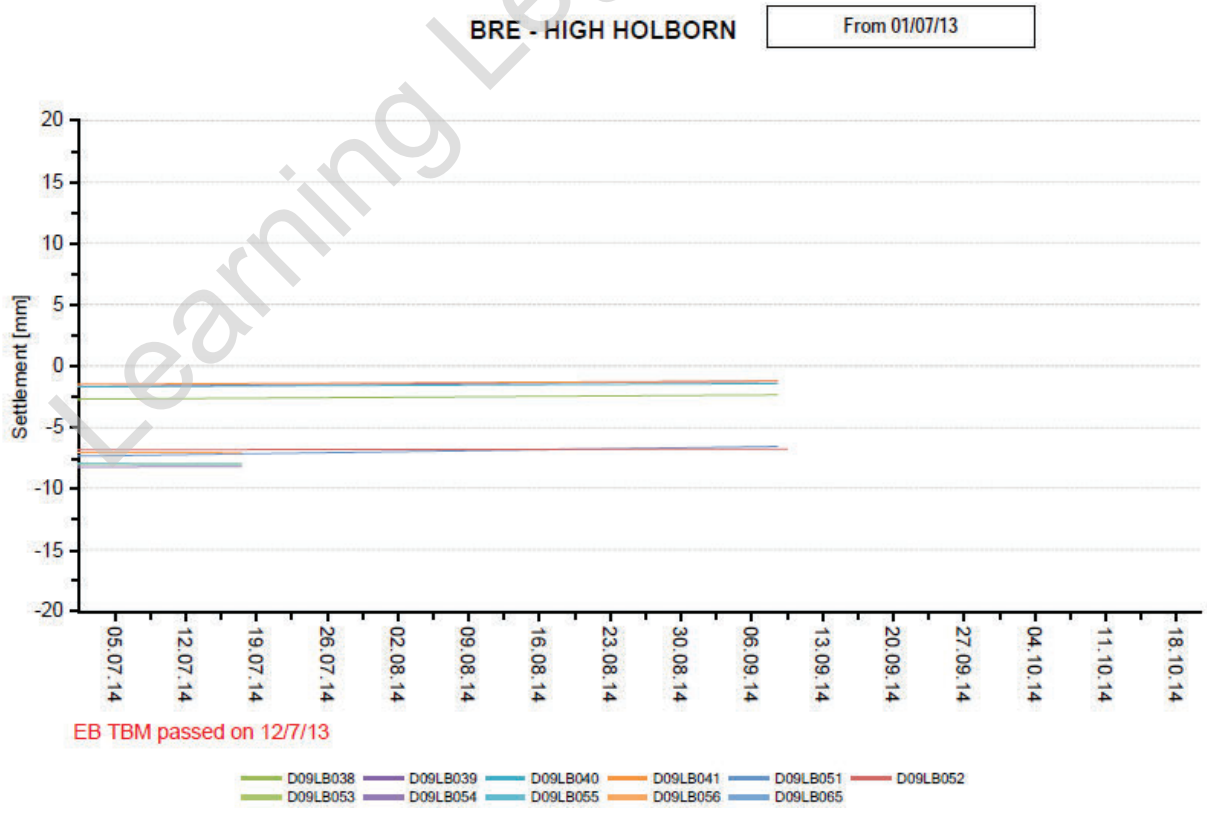


Figure 26: data time-plots (long-term period)

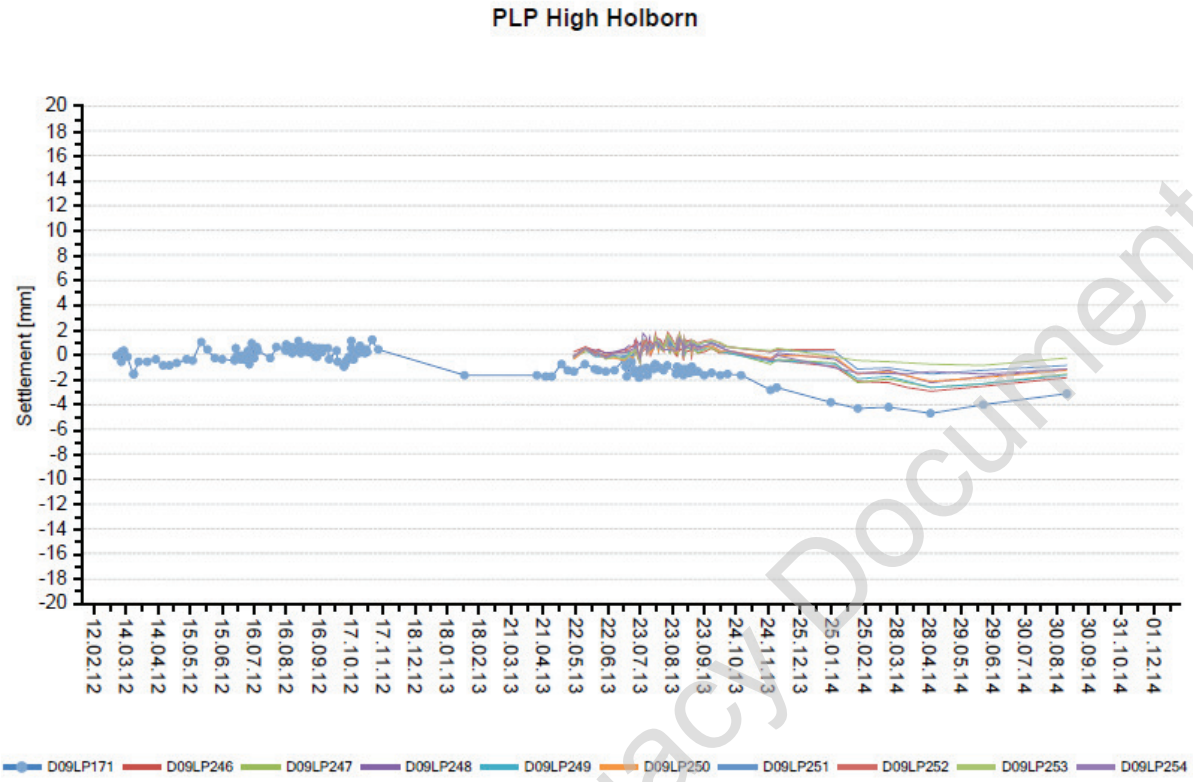


Figure 27: data time-plots (general)

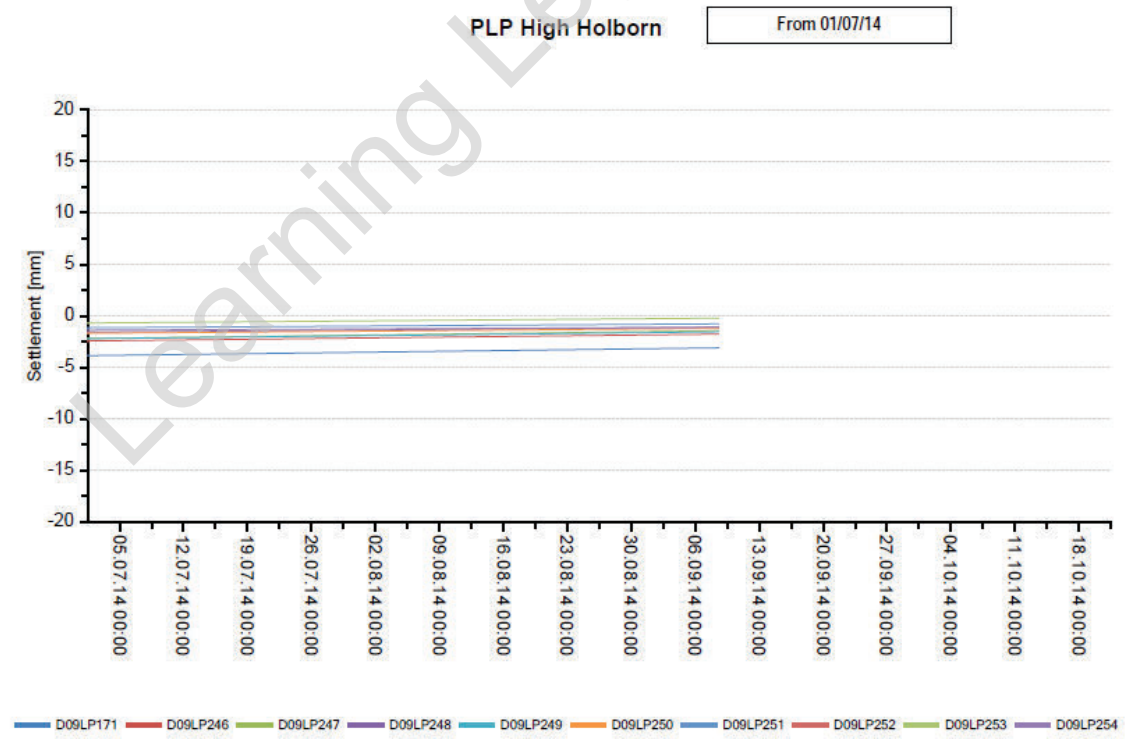


Figure 28: data time-plots (long-term period)

3.5.2. Comments

The points along High Holborn are outside the grouting area and settled up to approx. 7mm.

The time-plots are generally showing stability on the long term readings. The associated risk is considered negligible.

3.6. Kingsway Tram Tunnel (KTT) BREs

3.6.1. Data

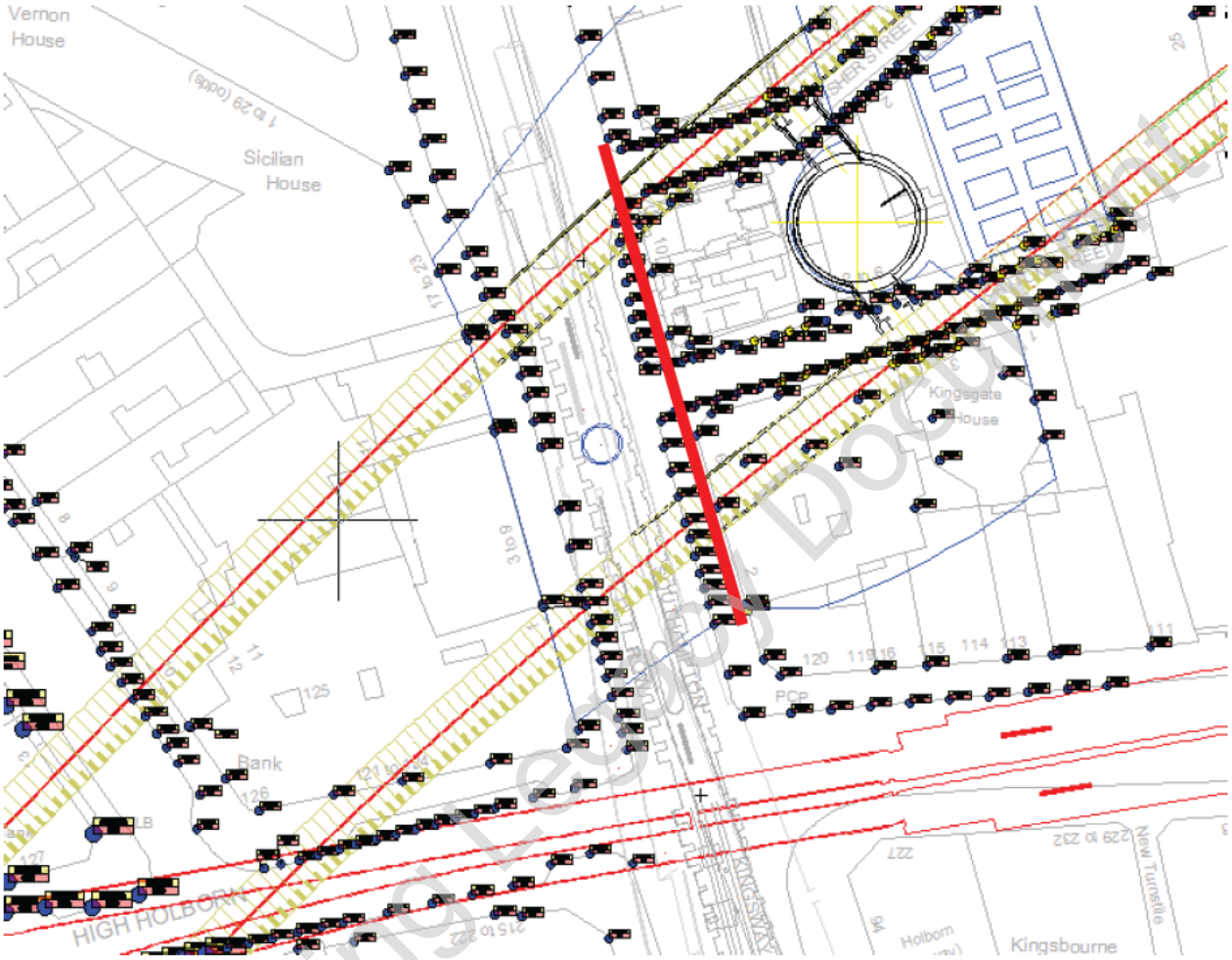


Figure 29: Location

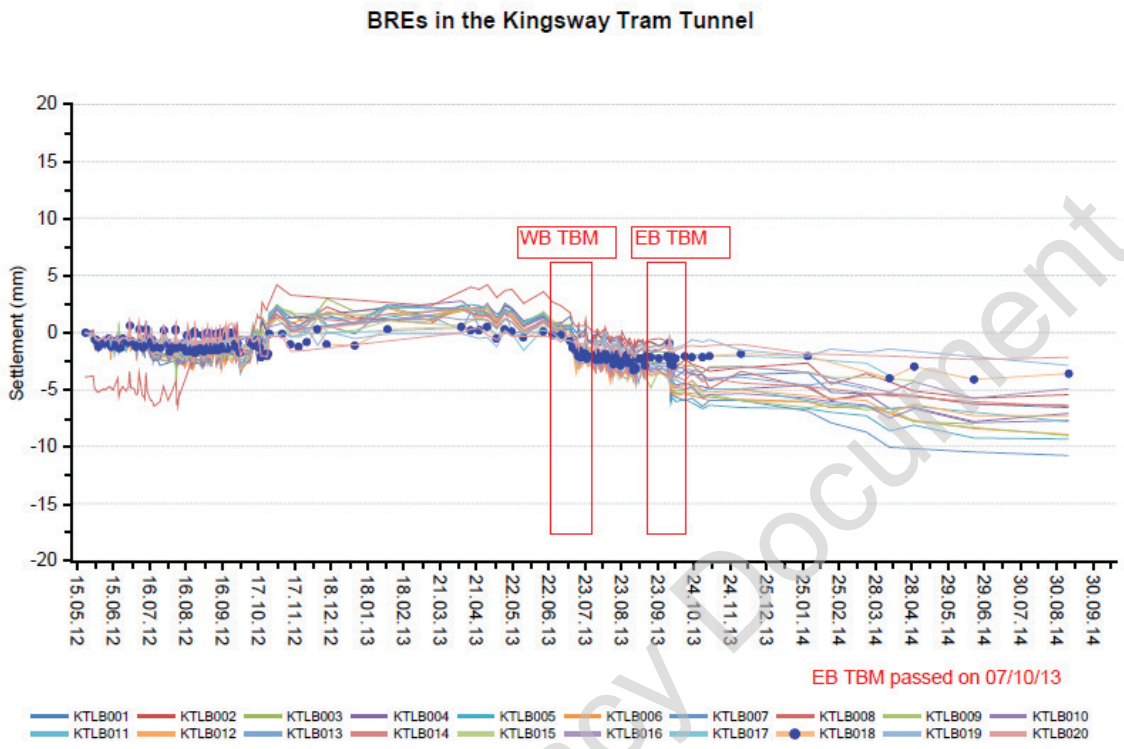


Figure 30: data time-plots (general)

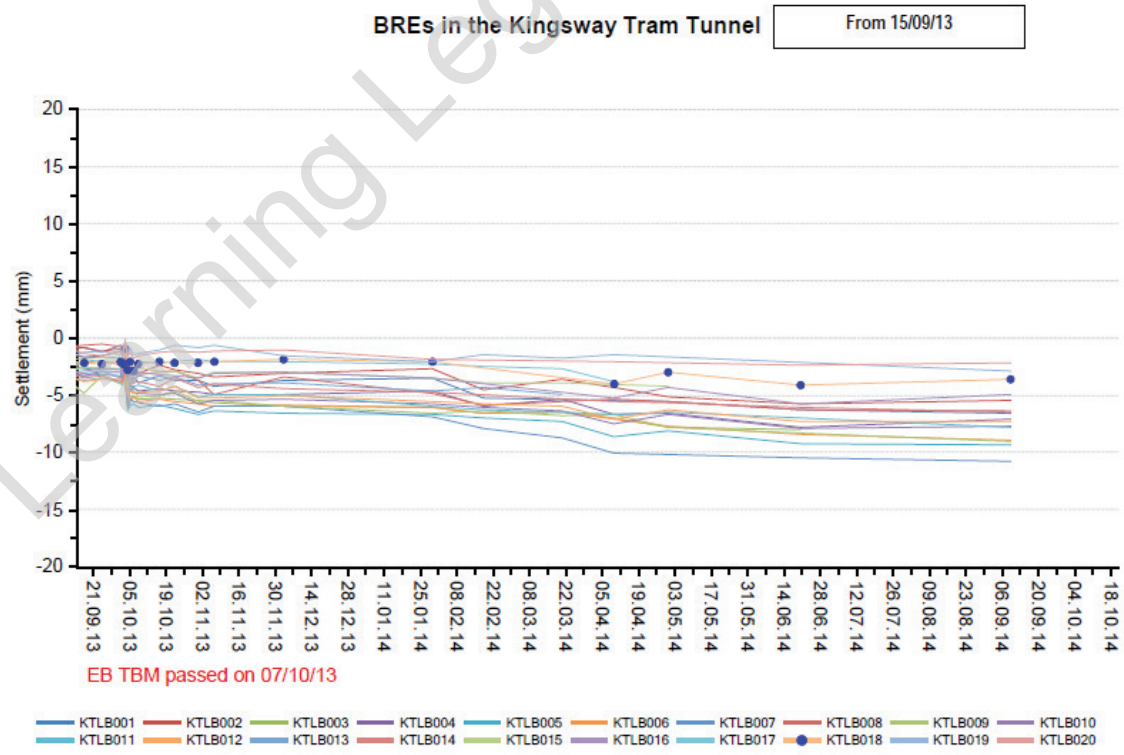


Figure 31: data time-plots (long-term period)

3.6.2. Comments

The points (BREs) inside the KTT settled up to approx. 11mm. The effects of both WB and EB TBMs are visible from the settlement time-plots.

The time-plots are generally showing stability on the last readings. The associated risk is considered negligible.

3.7. Southampton Row BREs and PLPs

3.7.1. Data

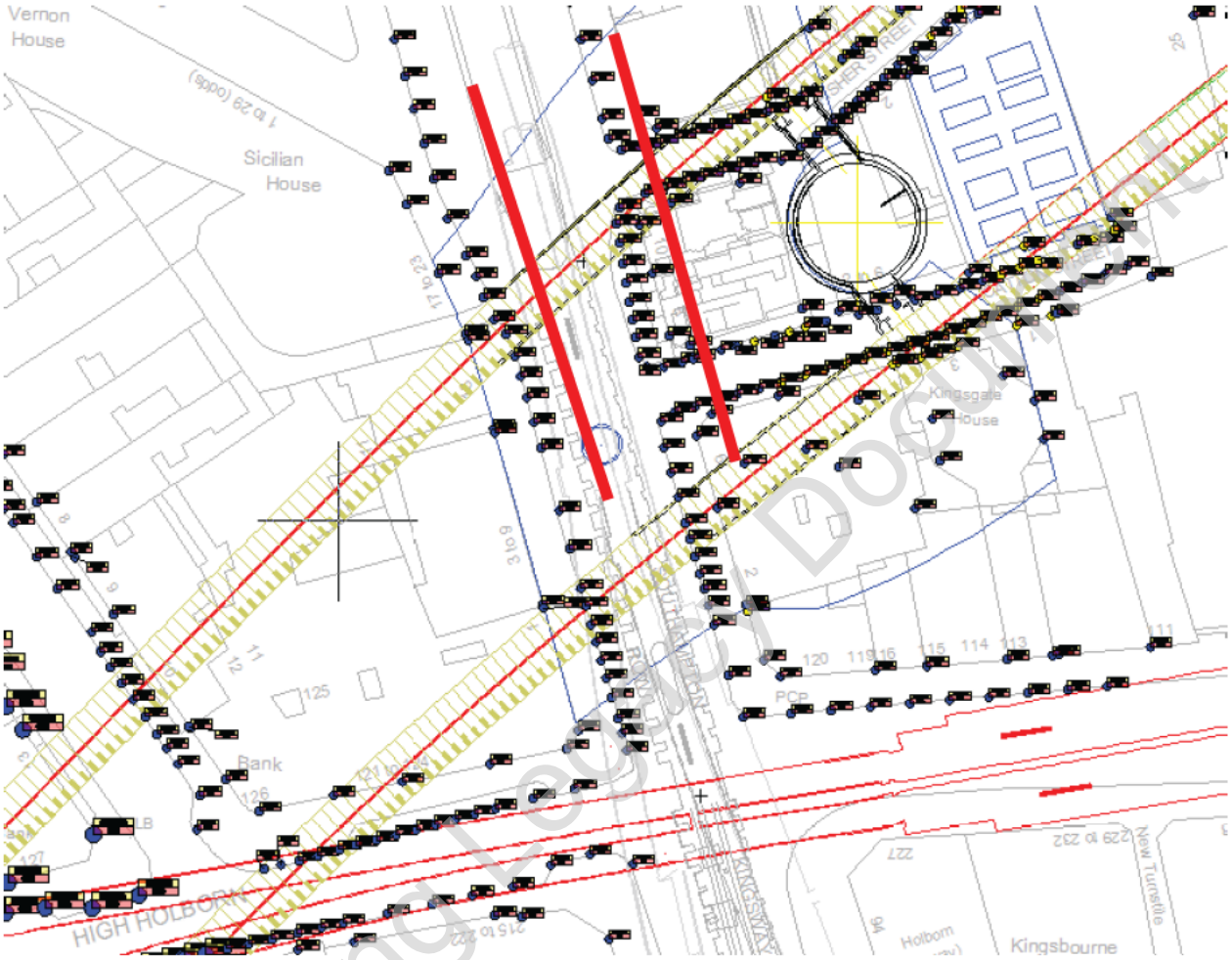


Figure 32: Location

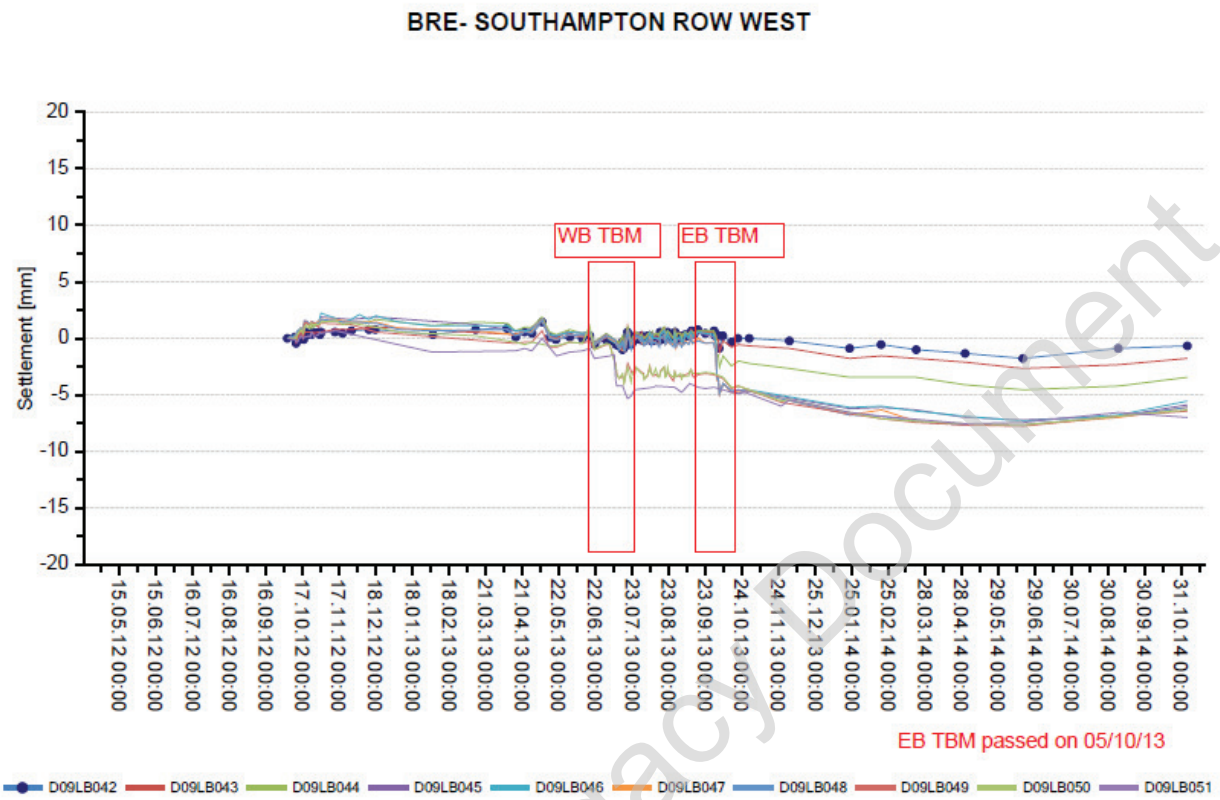


Figure 33: data time-plots (general)

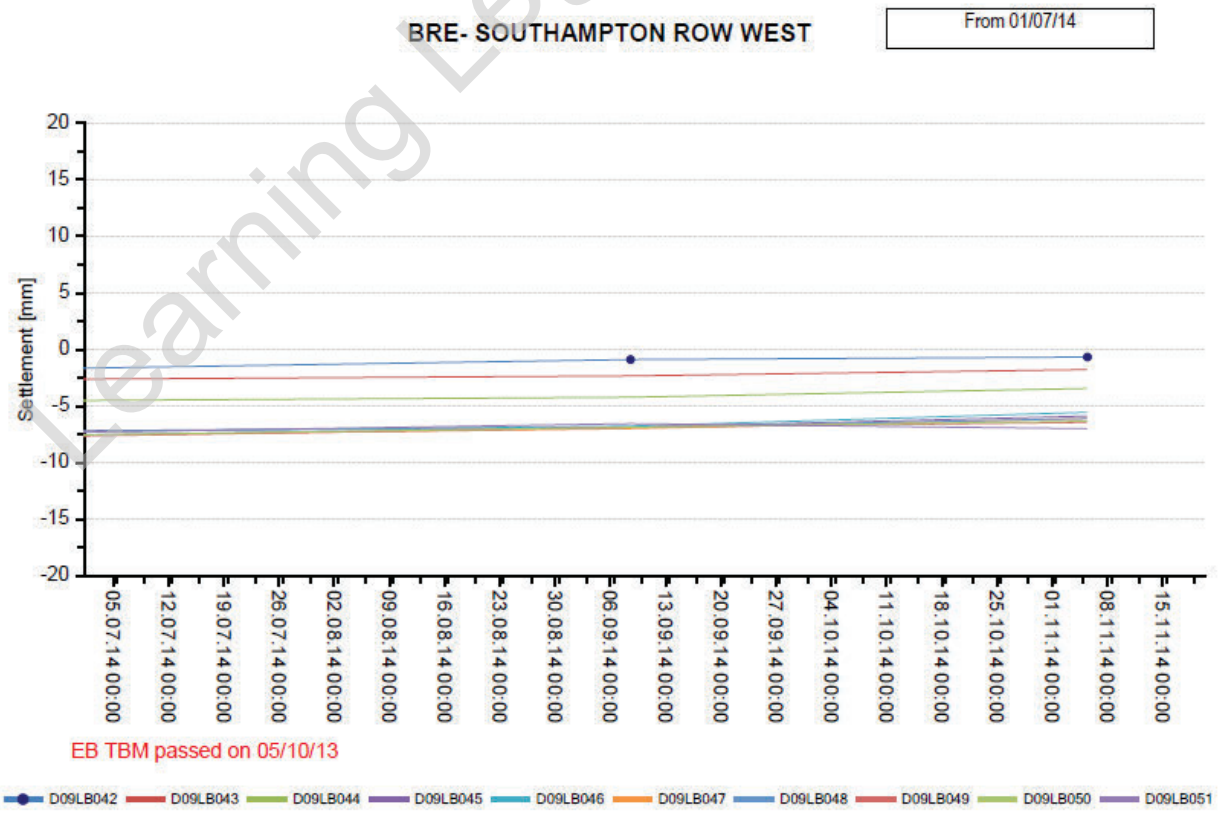


Figure 34: data time-plots (long-term period)

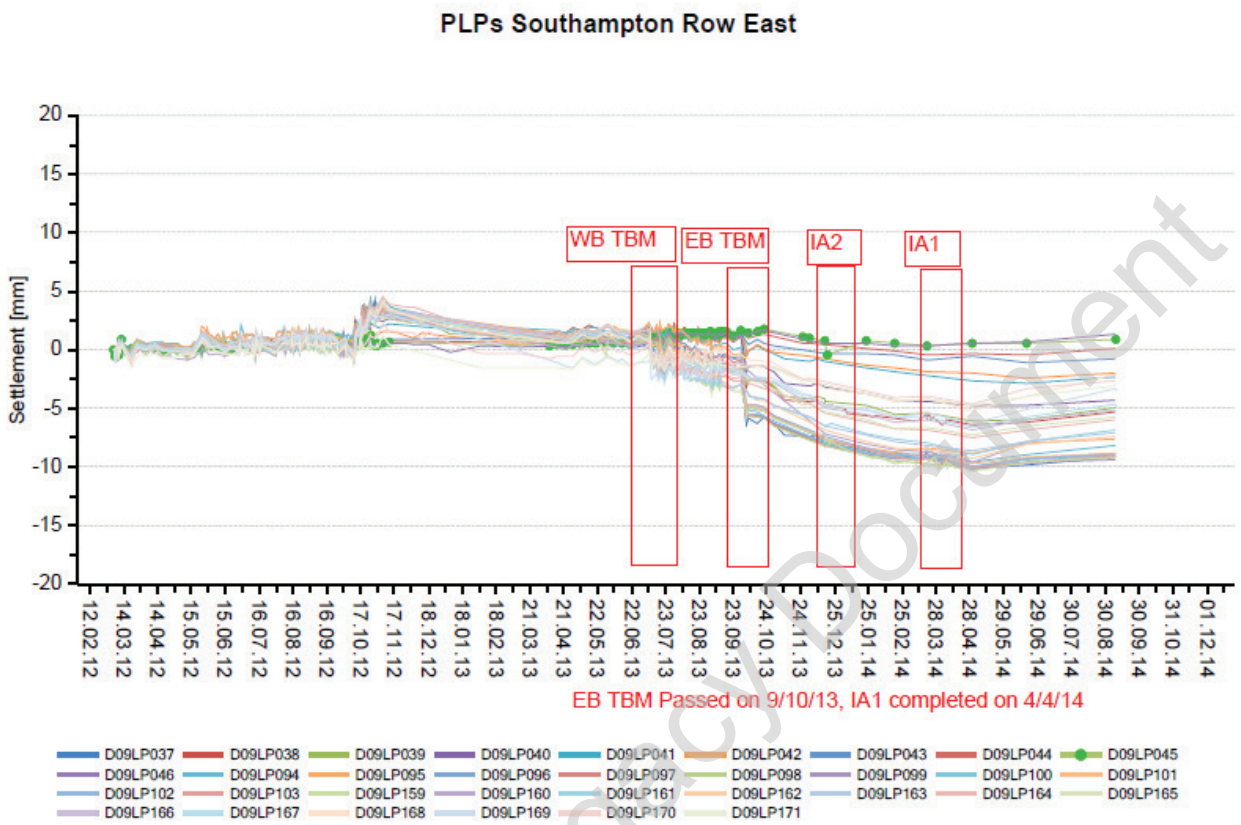


Figure 35: data time-plots (general)

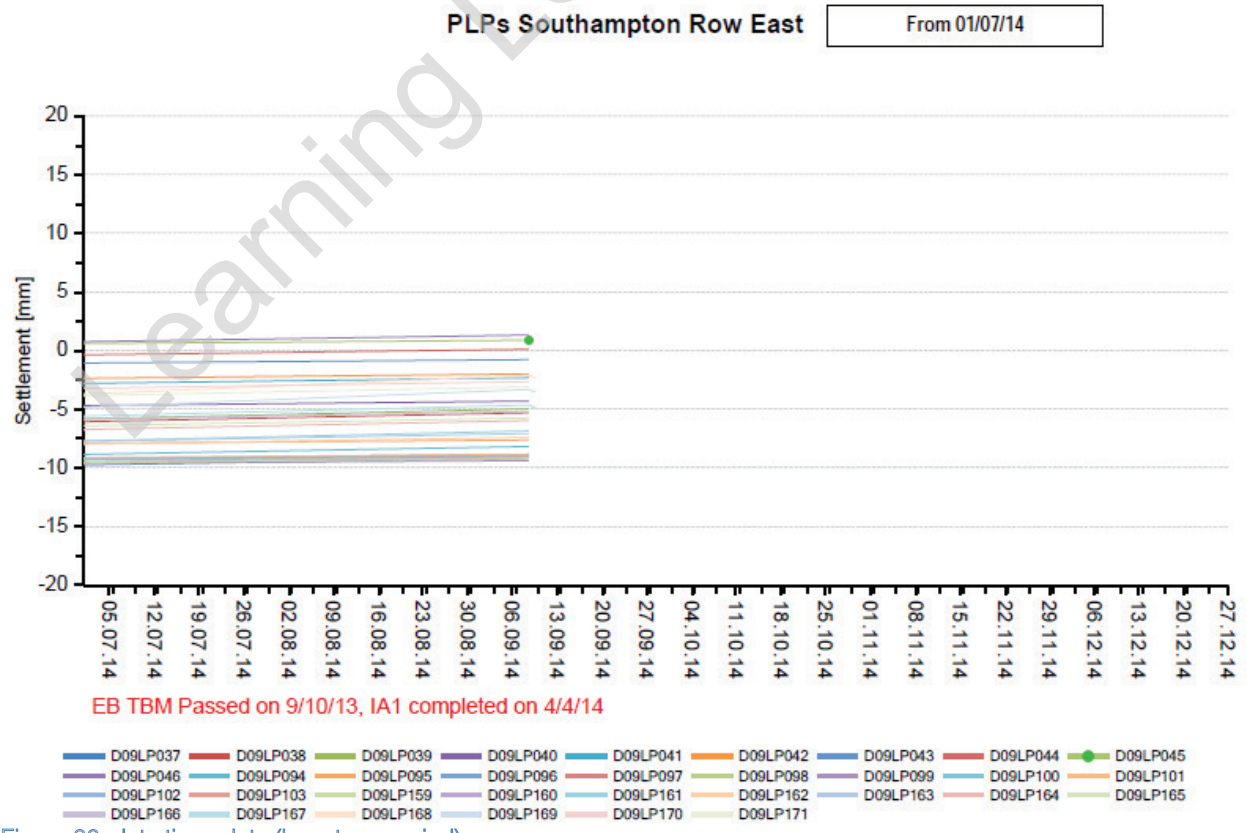


Figure 36: data time-plots (long-term period)

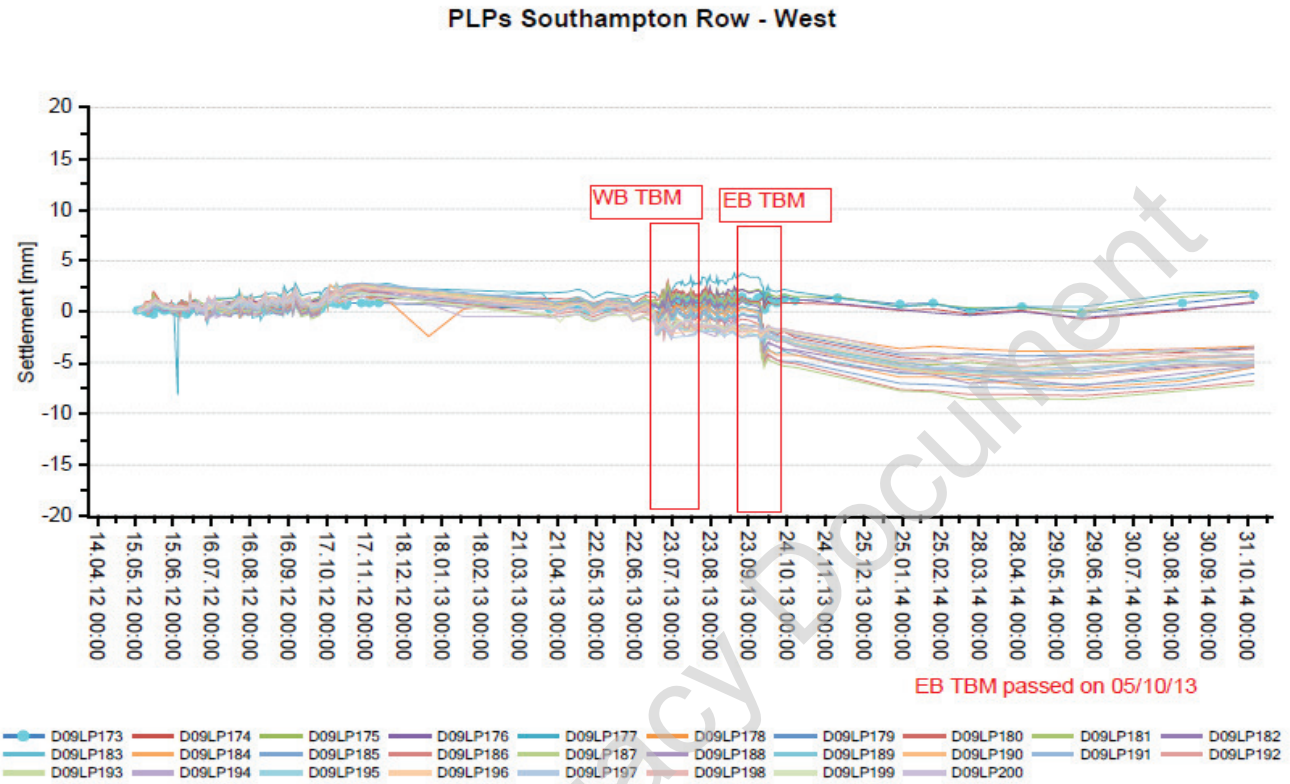


Figure 37: data time-plots (general)

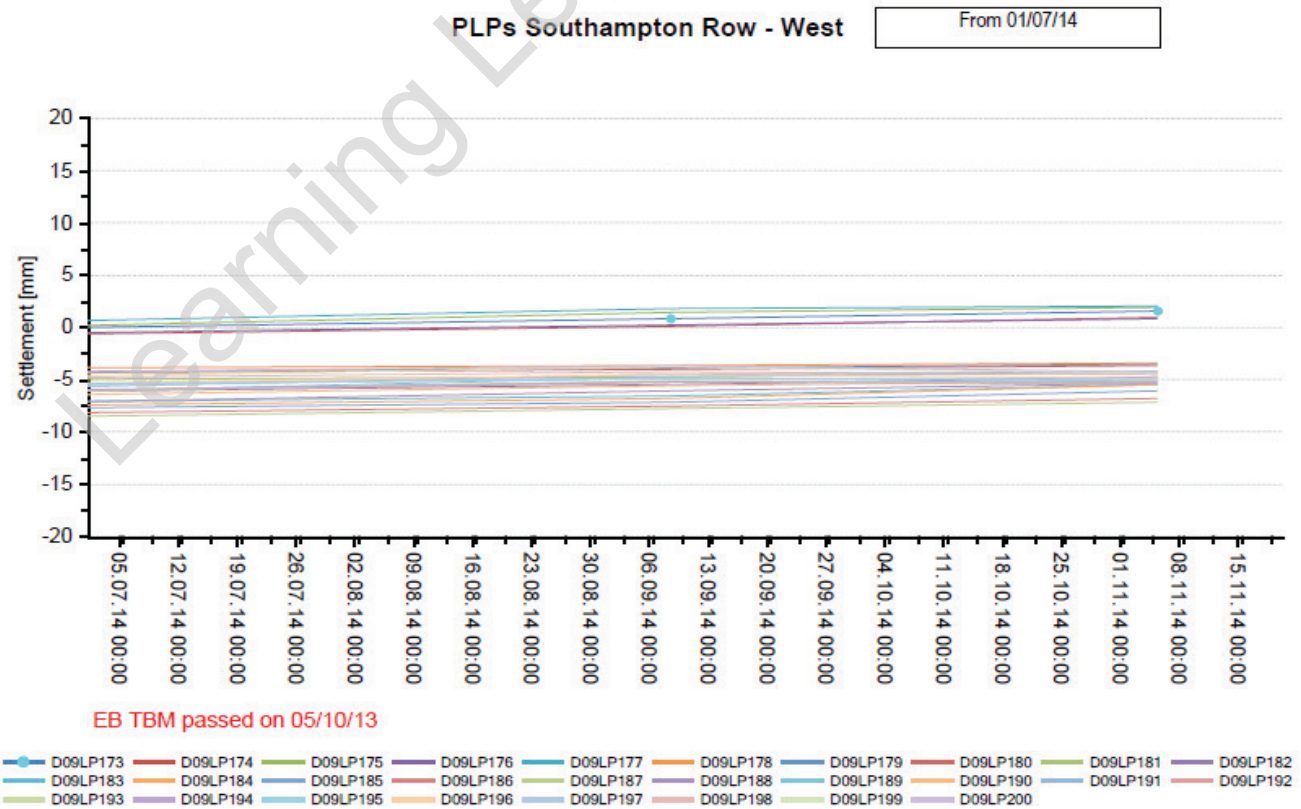


Figure 38: data time-plots (long-term period)

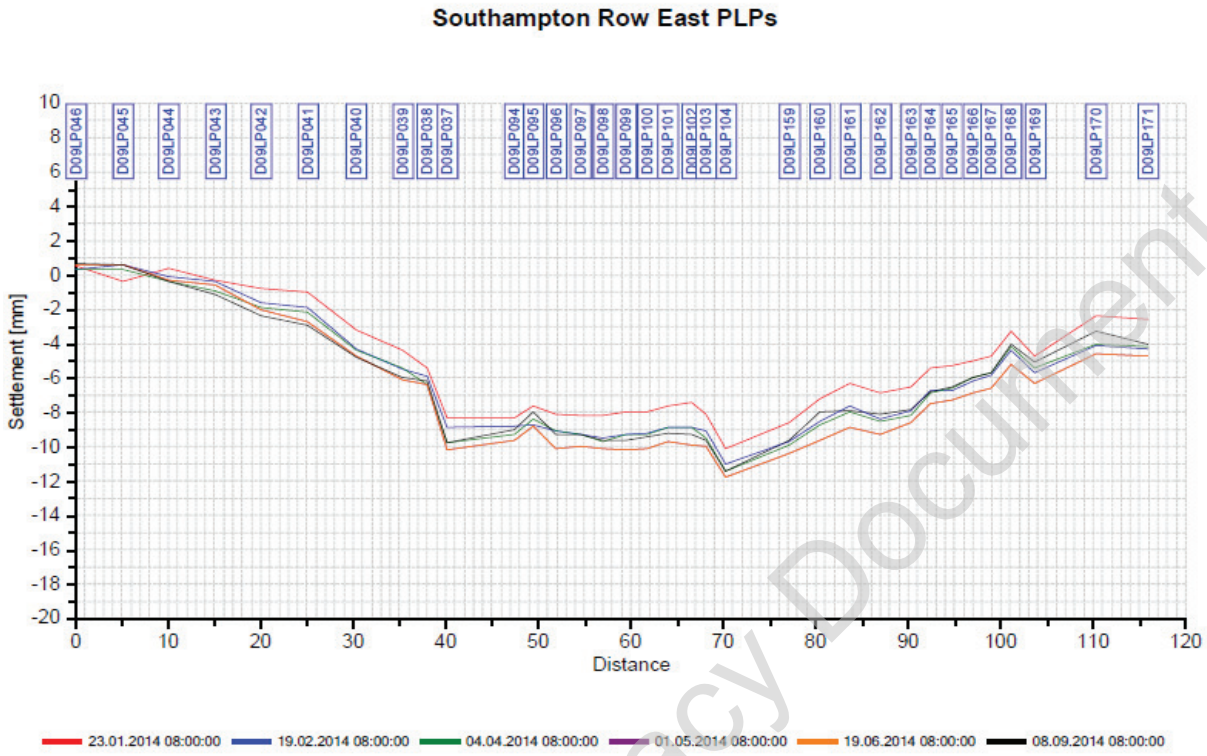


Figure 39: Cut

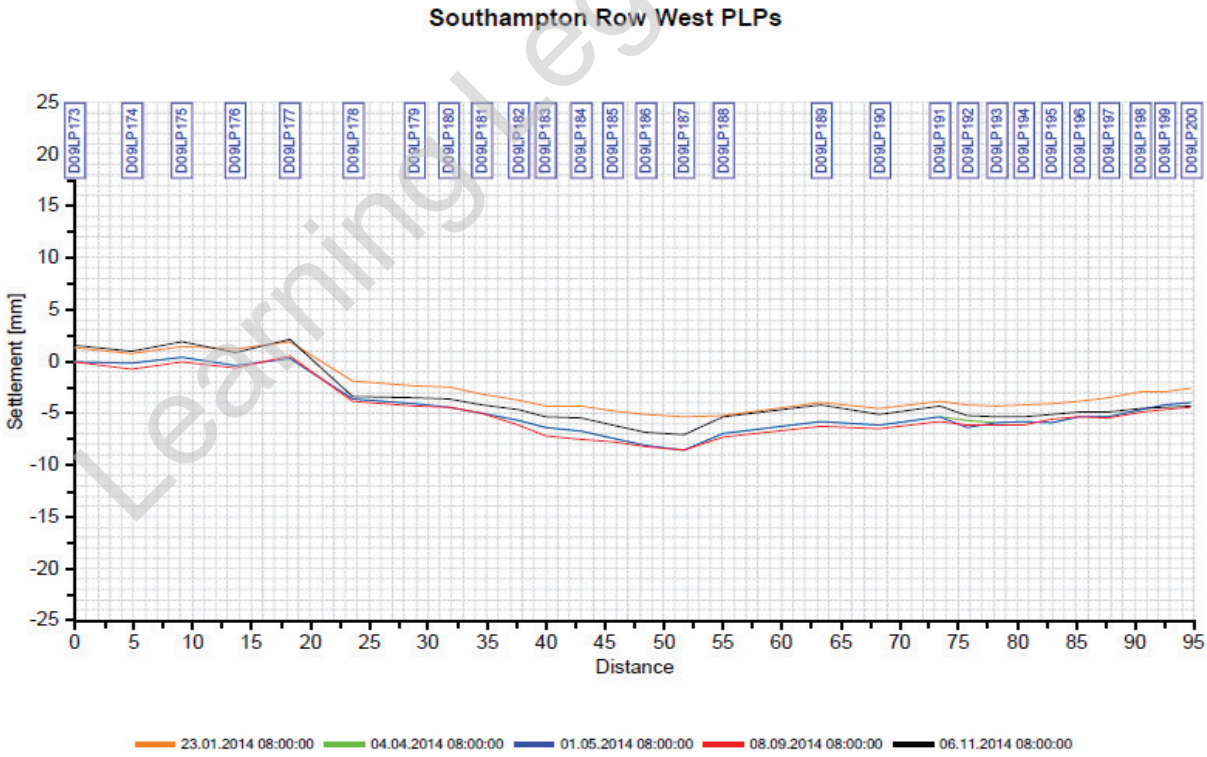


Figure 40: Cut

3.7.2. Comments

The points along Southampton Row settled up to approx. 10mm. The effects of both WB and EB TBMs are visible from the settlement time-plots.

The time-plots are generally showing stability on the last readings. The associated risk is considered negligible.

Appendix 1. Reference Documents

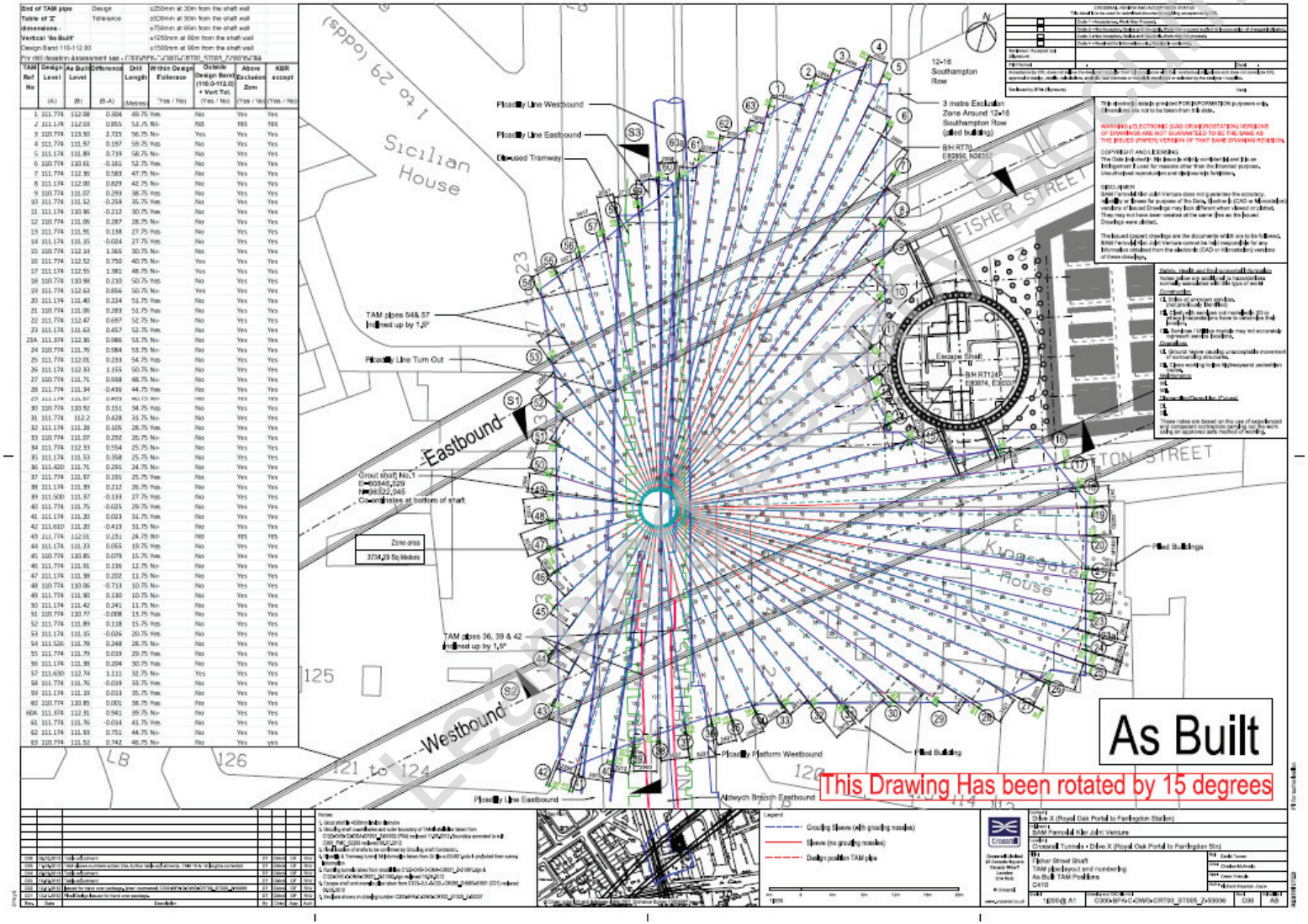
Code	Document
C300-BFK-C4-STP-CRT00_ST005- 50166	MANAGEMENT PLAN FOR THE CONTROL OF GROUND MOVEMENTS: ADDENDUM 37: TBM Drive 9 - Fisher Street
C122-OVE-C2-RGN-CRG01-50076	Instrumentation & Monitoring Plan C300 Running Tunnels Ground Movement And Asset Protection
C122-OVE-U-RGN-CRG01-50003	Instrumentation and Monitoring Plans: Thames Water Assets: Drive X (C300) Instrumentation Plan for large or Deep Sewers

Appendix 2. Details of Tam installation

Hole No.	Start Drilling	Complete Drilling	TaM Installation	Sock Grouted	Sleeve Grouted Phase I	Design Drill Length (m)	Actual Drilled length (m)
F1/49	6.8.12 DS	6.8.12 DS	6.8.12 DS	6.8.12 DS	12.8.12 DS	10.75	10.75
F1/37	6.8.12 DS	6.8.12 NS	6.8.12 NS	6.8.12 NS	17.8.12 DS	25.75	25.75
F1/58	6.8.12 NS	7.8.12 DS	7.8.12 DS	7.8.12 DS	12.8.12 DS	33.75	33.75
F1/46	7.8.12 DS	7.8.12 DS	7.8.12 DS	7.8.12 DS	12.8.12 DS	12.75	12.75
F1/59	7.8.12 NS	8.8.12 DS	8.8.12 DS	8.8.12 DS	12.8.12 DS	35.75	35.75
F1/47	8.8.12 DS	8.8.12 DS	8.8.12 DS	8.8.12 DS	12.8.12 DS	11.75	11.75
F1/50	8.8.12 DS	8.8.12 DS	8.8.12 DS	8.8.12 DS	12.8.12 DS	11.75	11.75
F1/38	8.8.12 DS	8.8.12 NS	8.8.12 NS	8.8.12 NS	17.8.12 NS	26.75	26.75
F1/60	8.8.12 NS	8.8.12 NS	8.8.12 NS	8.8.12 NS	12.8.12 DS	38.75	38.75
F1/48	9.8.12 DS	9.8.12 DS	9.8.12 DS	9.8.12 DS	17.8.12 NS	10.75	10.75
F1/39	10.8.12 DS	13.8.12 DS	13.8.12 DS	13.8.12 DS	17.8.12 NS	27.74	27.74
F1/55	13.8.12 DS	14.8.12 NS	14.8.12 NS	14.8.12 NS	17.8.12 NS	29.75	29.75
F1/43	14.8.12 NS	14.8.12 NS	14.8.12 NS	14.8.12 NS	17.8.12 NS	24.75	24.75
F1/52	14.8.12 NS	14.8.12 NS	14.8.12 NS	14.8.12 NS	17.8.12 NS	15.75	15.75
F1/40	14.8.12 NS	14.8.12 NS	14.8.12 NS	14.8.12 NS	17.8.12 DS	29.75	29.75
F1/61	14.8.12 NS	14.8.12 NS	14.8.12 NS	14.8.12 NS	17.8.12 NS	41.75	41.75
F1/42	14.8.12 NS	15.8.12 DS	15.8.12 DS	15.8.12 DS	17.8.12 NS	31.74	31.74
F1/16	15.8.12 DS	15.8.12 NS	15.8.12 NS	15.8.12 NS	17.8.12 DS	46.75	**40.75**
F1/34	15.8.12 NS	15.8.12 NS	15.8.12 NS	15.8.12 NS	17.8.12 DS	25.75	25.75
F1/19	15.8.12 NS	16.8.12 NS	16.8.12 NS	16.8.12 NS	17.8.12 DS	51.75	**50.75**
F1/7	16.8.12 NS	16.8.12 NS	16.8.12 NS	16.8.12 NS	17.8.12 NS	47.75	47.75
F1/31	16.8.12 NS	17.8.12 DS	17.8.12 DS	17.8.12 DS	17.8.12 DS	31.75	31.75
F1/13	20.8.12 DS	20.8.12 NS	20.8.12 NS	20.8.12 NS	23.8.12 NS	27.75	27.75
F1/1	20.8.12 NS	20.8.12 NS	20.8.12 NS	20.8.12 NS	23.8.12 NS	49.75	49.75
F1/22	20.8.12 NS	21.8.12 DS	21.8.12 DS	21.8.12 DS	23.8.12 NS	52.75	52.75
F1/4	21.8.12 DS	21.8.12 NS	21.8.12 NS	21.8.12 NS	23.8.12 NS	59.75	59.75
F1/28	21.8.12 NS	21.8.12 NS	22.8.12 DS	22.8.12 DS	23.8.12 NS	44.75	44.75
F1/25	22.8.12 DS	22.8.12 NS	22.8.12 NS	22.8.12 NS	23.8.12 NS	54.75	54.75
F1/26	22.8.12 NS	22.8.12 NS	22.8.12 NS	22.8.12 NS	23.8.12 NS	50.75	50.75
F1/44	28.8.12 ds	28.8.12 ds	28.8.12 ds	28.8.12 ds	3.9.12 ds	19.75	19.75
F1/14	28.8.12 ds	28.8.12 ds	28.8.12 ds	28.8.12 ds	3.9.12 ds	27.75	27.75
F1/62	28.8.12 ns	28.8.12 ns	28.8.12 ns	28.8.12 ns	3.9.12 ds	44.75	44.75
F1/41	28.8.12 ns	29.8.12 ds	29.8.12 ds	29.8.12 ds	3.9.12 ds	31.75	31.75
F1/11	29.8.12 ds	29.8.12 ds	29.8.12 ds	29.8.12 ds	3.9.12 ds	30.75	30.75
F1/56	29.8.12 ns	29.8.12 ns	29.8.12 ns	29.8.12 ns	3.9.12 ds	30.75	30.75
F1/35	29.8.12 ns	29.8.12 ns	29.8.12 ns	29.8.12 ns	3.9.12 ds	25.75	25.75
F1/20	30.8.12 ds	30.8.12 ds	30.8.12 ds	30.8.12 ds	3.9.12 ds	51.75	51.75
F1/53	30.8.12 ds	30.8.12 ds	30.8.12 ns	30.8.12 ns	3.9.12 ds	20.75	20.75
F1/2	30.8.12 ns	30.8.12 ns	31.8.12 ds	31.8.12 ds	3.9.12 ds	53.75	53.75

Hole No.	Start Drilling	Complete Drilling	TaM Installation	Sock Grouted	Sleeve Grouted Phase I	Design Drill Length (m)	Actual Drilled length (m)
F1/32	3.9.12 ds	3.9.12 ns	3.9.12 ns	3.9.12 ns	8.9.12 ds	28.75	28.75
F1/5	3.9.12 ns	4.9.12 ds	4.9.12 ds	4.9.12 ds	8.9.12 ds	58.75	58.75
F1/29	4.9.12 ds	4.9.12 ds	4.9.12 ds	4.9.12 ds	8.9.12 ds	40.75	40.75
F1/8	5.9.12 ds	5.9.12 ds	5.9.12 ds	5.9.12 ds	8.9.12 ds	42.75	42.75
F1/23	5.9.12 ds	5.9.12 ns	5.9.12 ns	5.9.12 ns	8.9.12 ds	52.75	52.75
F1/63	5.9.12 ns	6.9.12 ds	6.9.12 ds	6.9.12 ds	8.9.12 ds	46.75	46.75
F1/17	6.9.12 ds	6.9.12 ns	6.9.12 ns	6.9.12 ns	8.9.12 ds	48.75	48.75
F1/51	6.9.12 ns	6.9.12 ns	6.9.12 ns	6.9.12 ns	8.9.12 ds	13.75	13.75
F1/45	6.9.12 ns	7.9.12 ds	7.9.12 ds	7.9.12 ds	8.9.12 ds	15.75	15.75
F1/33	7.9.12 ds	7.9.12 ds	7.9.12 ds	7.9.12 ds	8.9.12 ds	26.75	26.75
F1/21	10.9.12 ds	10.9.12 ns	10.9.12 ns	10.9.12 ns	14.9.12 ns	51.75	51.75
F1/9	10.9.12 ns	10.9.12 ns	10.9.12 ns	10.9.12 ns	14.9.12 ns	38.75	38.75
F1/57	10.9.12 ns	11.9.12 ds	11.9.12 ds	11.9.12 ds	14.9.12 ns	32.74	32.74
F1/27	11.9.12 ds	11.9.12 ns	11.9.12 ns	11.9.12 ns	14.9.12 ns	48.75	48.75
F1/12	11.9.12 ns	11.9.12 ns	11.9.12 ns	11.9.12 ns	14.9.12 ns	28.75	28.75
F1/54	11.9.12 ns	12.9.12 ds	12.9.12 ds	12.9.12 ds	14.9.12 ns	28.74	28.74
F1/36	12.9.12 ns	12.9.12 ns	12.9.12 ns	12.9.12 ns	14.9.12 ns	24.74	24.74
F1/24	12.9.12 ns	12.9.12 ns	12.9.12 ns	12.9.12 ns	14.9.12 ns	53.75	53.75
F1/3	12.9.12 ns	13.9.12 ds	13.9.12 ds	13.9.12 ds	14.9.12 ns	56.75	56.75
F1/30	13.9.12 ds	13.9.12 ns	13.9.12 ns	13.9.12 ns	14.9.12 ns	34.75	34.75
F1/18	14.9.12 ds	17.9.12 ds	17.9.12 ds	17.9.12 ds	18.9.12 ns	50.75	50.75
F1/6	17.9.12 ns	17.9.12 ns	17.9.12 ns	17.9.12 ns	18.9.12 ns	52.75	52.75
F1/10	18.9.12 ds	18.9.12 ds	18.9.12 ds	18.9.12 ds	18.9.12 ns	35.75	35.75
F1/15	18.9.12 ds	18.9.12 ds	18.9.12 ds	18.9.12 ds	18.9.12 ns	30.75	30.75
F1/23A	19.9.12 ds	19.9.12 ns	19.9.12 ns	19.9.12 ns	20.9.12 ds	53.75	53.75
Fl/60A	19.9.12 ns	19.9.12 ns	19.9.12 ns	19.9.12 ns	20.9.12 ds	39.75	39.75

Appendix 3. As-built drawing of Tam array



Appendix 4. Grout Intensity Contours

Assumptions used to produce contour plots of grout intensity

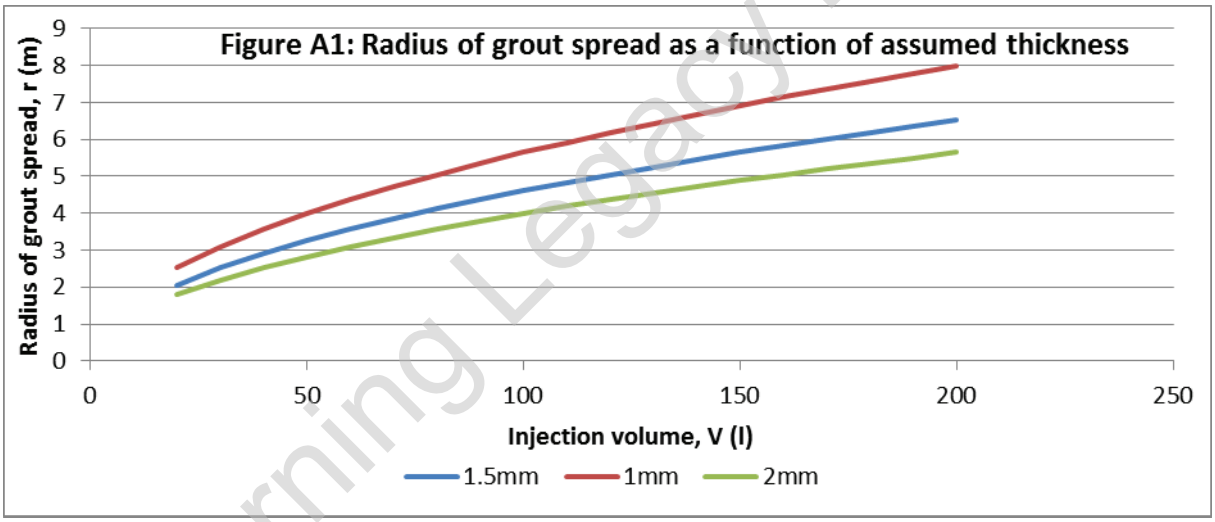
A method of producing a visualisation of the quantity and distribution of grout injected during compensation grouting is useful in interpreting performance. For each injection the volume and the location of the port used are known. The model used is intended to approximate the distribution of grout within the ground at the level of injection not to estimate the potential heave / settlement reduction from the grouting. Of course the actual distribution of grout in the ground cannot be determined since this is governed by the stress conditions at the time of injection which are constantly changing during the construction process. It is known that in London Clay that the grout enters the ground by hydrofracturing along pre-existing fissures, but the direction of travel is not fully known.

The model used adopts the simple assumption that the grout spreads uniformly in all directions radially from the point of injection to form a disc of uniform thickness, t. The radius, r, to which the grout spreads from each individual injection point, is therefore a function of the grout volume, V, according to the relationship:

$$V = \pi r^2 t$$

Or, rearranging:

$$r = \sqrt{\left(\frac{V}{\pi t}\right)}$$



Observation of grout in the ground suggests that a thickness of 1 – 2mm is predominantly achieved. All of the plots included in this report are based on an assumed thickness of 1.5mm. Figure A1 shows the variation in radius for thicknesses of 1.0, 1.5 and 2.0mm.

The contribution of each injection within a specified data set are summed at each node within a grid. This grid file is then contoured within Surfer.