C300/410
Western Tunnels & Caverns Project
Report

Grouting Summary & I &M Final Report - BOS GS3

CRL Document No. **C300-BFK-C4-RGN-CRT00_ST005-51214**

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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.

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2b. Review by Stakeholder (if required):

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Acceptance [redacted]e designer/supplier from full compliance with their contractual obligations and does not constitute *Crossrail* approval of design, details, calculations, analyses, test methods or materials developed or selected by the designer/supplier.

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APPENDICES

1. PURPOSE OF THIS REPORT

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 Table 1.1.

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 Grout Shaft 3 and associated monitoring at Bond Street Station

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.

All BFK excavation (tunnelling) works within the plan extent of the compensation grouting arrays from Bond Street Station Grout Shaft 3 were completed by early July 2014. No grout jacking episodes were implemented after completion of tunnelling. An abridged version of this report was issued in October 2014, 3 months after the end of tunnelling (C300-CCM-09101), to justify de-commissioning of the grout shaft: this report was accepted by CRL and the grout shaft was subsequently de-commissioned. Excavation of the Eastern Ticket Hall (ETH) was ongoing at that time and was not completed until January 2016.

This report aims to summarise the relevant construction, compensation grouting and monitoring information for Grout Shaft 3 at Bond Street Station and includes manual monitoring up to October 2015 when any further manual monitoring was de-scoped under C300-PMI-1858. The purpose of this report is therefore to fully document the justification for the decommissioning of the shaft and also to provide a close-out report for all instrumentation in the GS3 area, with the exception of the networked ATS monitoring of prisms (see C300-BFK-C4-RGN-CRT00_ST005-51208).

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

- H&S file – submitted separately for construction and 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: this will be supplied as co-ordinates and digital data for incorporation into UCIMS.

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 GS3 area are included in Appendix C.

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.

2. CONSTRUCTION WORKS PROGRESS

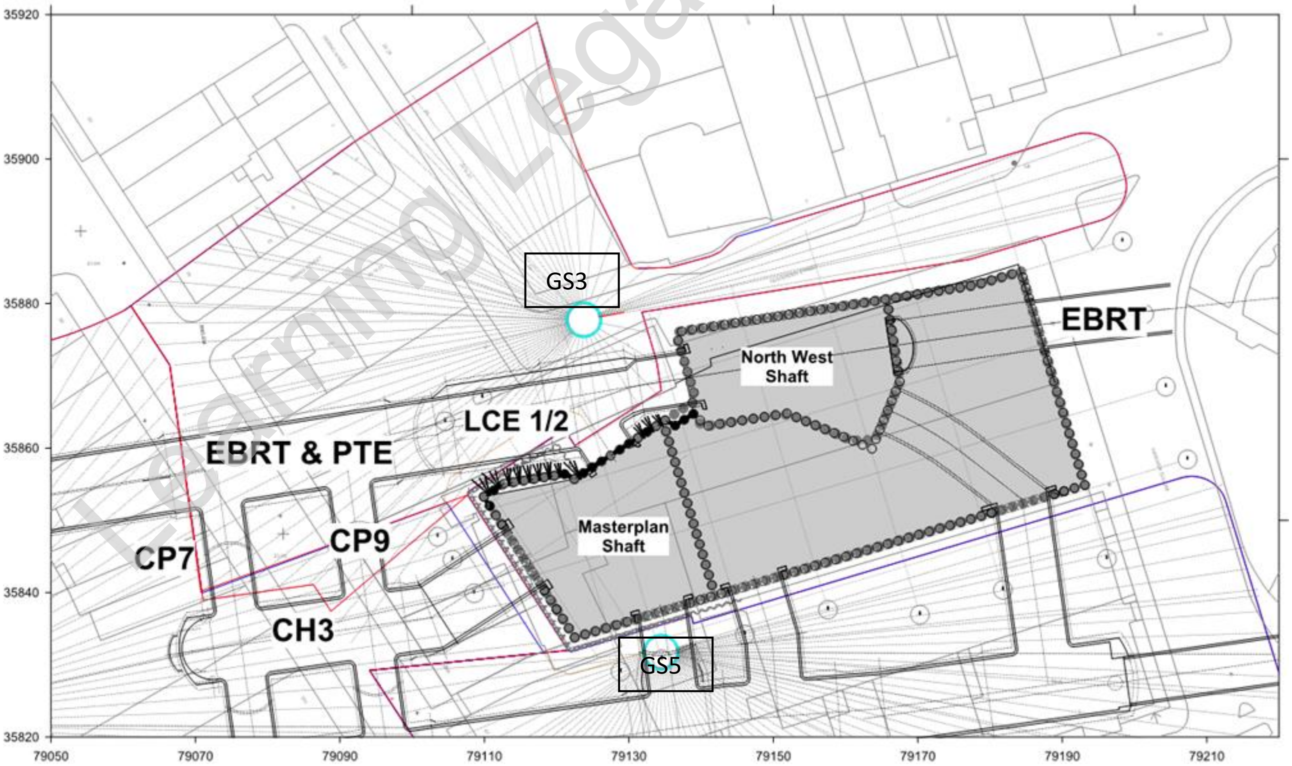
2.1. Tunnels

Table 2.1 and Figure 2.1 show the tunnel construction works undertaken within the footprint of the compensation grouting arrays installed from Grout Shaft 3 at Bond Street Station. Tunnel excavation commenced with the pilot tunnel for LCE1 in February 2013 and was completed with the excavation of CP9 stub from the PTE in July 2014. To facilitate comparison of monitoring data with construction activities 7 periods (A to G) have been assigned. Tunnelling was completed in 4 of these periods (B, C, D & E) as shown in Table 2.1. The main construction activities in each period are summarised in Table 2.2. Grout Shaft 3 de-commissioning was commenced at the beginning of Period G.

Table 2.1. Progress of works in BOS GS3 area and Construction Periods.

Periods	Start Date	End Dates	Main Works
A	22/09/2011	14/02/2013	Bonhams Redevelopment, ETH piling, excavation of NW & Masterplan Shafts, GS3 Shaft Sinking, GS3 Drilling, Pre-treatment grouting, grout jacking.
B	25/03/2013	29/05/2013	LCE1/2 Pilot to Ch. 33.0; LCE1/2 enlargement to Ch. 33.0, Concurrent Grouting
C	30/05/2013	03/08/2013	EBRT, CH3, Grout Jacking
D	04/08/2013	01/05/14	CP7, CP9, Grout Jacking (ETH excavation)
E	02/05/14	10/07/2014	PTE, CP7(out of PTE), CP9 (out of PTE), Concurrent grouting, Grout Jacking (ETH excavation)
F	11/07/14	21/10/2014	ETH Excavation below level -2
G	21/10/14	13/10/2015	ETH Excavation below level -3 ongoing at end of BFK monitoring

Figure 2.1. Tunnels within extent of grout array from Grout Shaft 3



2.2. Other construction works

Works by BFK prior to the commencement of tunnelling in GS3 area included:

- Drilling for installation of TaMs
- Pre-treatment grouting
- Grout jacking

Works by Others prior to the start of tunnelling included:

- Sinking of Grout Shaft 3
- Demolition for ETH
- Piling for ETH
- Excavation of the North west and Masterplan shafts
- Bonham's Underpinning and Excavation works

Works by Others during tunnelling with the potential to generate ground movements comprised:

- Excavation of ETH to Level -1 (17/01/14 – 30/03/14)
- Excavation of ETH to Level -2 (27/05/14 – 18/07/14)
- Bonham's re-development

Works by Others after completion of tunnelling include:

- Excavation of ETH to Level -3 (27/08/14 – January 2015)
- Excavation of ETH to Level -4 (completed May 2015)
- Excavation of ETH to Level -5 (completed October 2015, base slab to January 2016)

2.3. Compensation Grouting

The volume of grout injected from GS3 is plotted against time on Figure 2.2 together with a plot of when each of the tunnels was constructed. Figure 2.2 shows that pre-treatment comprised approximately 35m^3 injected prior to tunnelling, concurrent grouting approximately 100m^3 and grout jacking almost 80m^3. Concurrent grouting was undertaken with all tunnels except Cross Passages 7 and 9, and the EBRT. A VE proposal was implemented to avoid any delays to the running tunnel drive which allowed grouting to be undertaken pre- and post- tunnelling – the volume of grout associated with this is included under grout jacking. CP7 and CP9 are short length tunnels and the extent of the exclusion zones over the tunnel face, as defined in the SCoGM, rendered concurrent grouting impractical.

Figures 2.3 to 2.5 show contours of the total grout intensity for each of the three types of grouting (pretreatment, concurrent and jacking respectively) and a cumulative total of all grout injected from GS3 is shown in Figure 2.6. 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 A. Comparison of the contour plots of grout intensity with observed settlements is discussed in Section 3. The exclusion zone adjacent to the ETH and a similar 3m exclusion zone around the grout shaft are clearly evident in the contours.

Figure 2.2 Volume of grout injected from GS3 by grouting type.

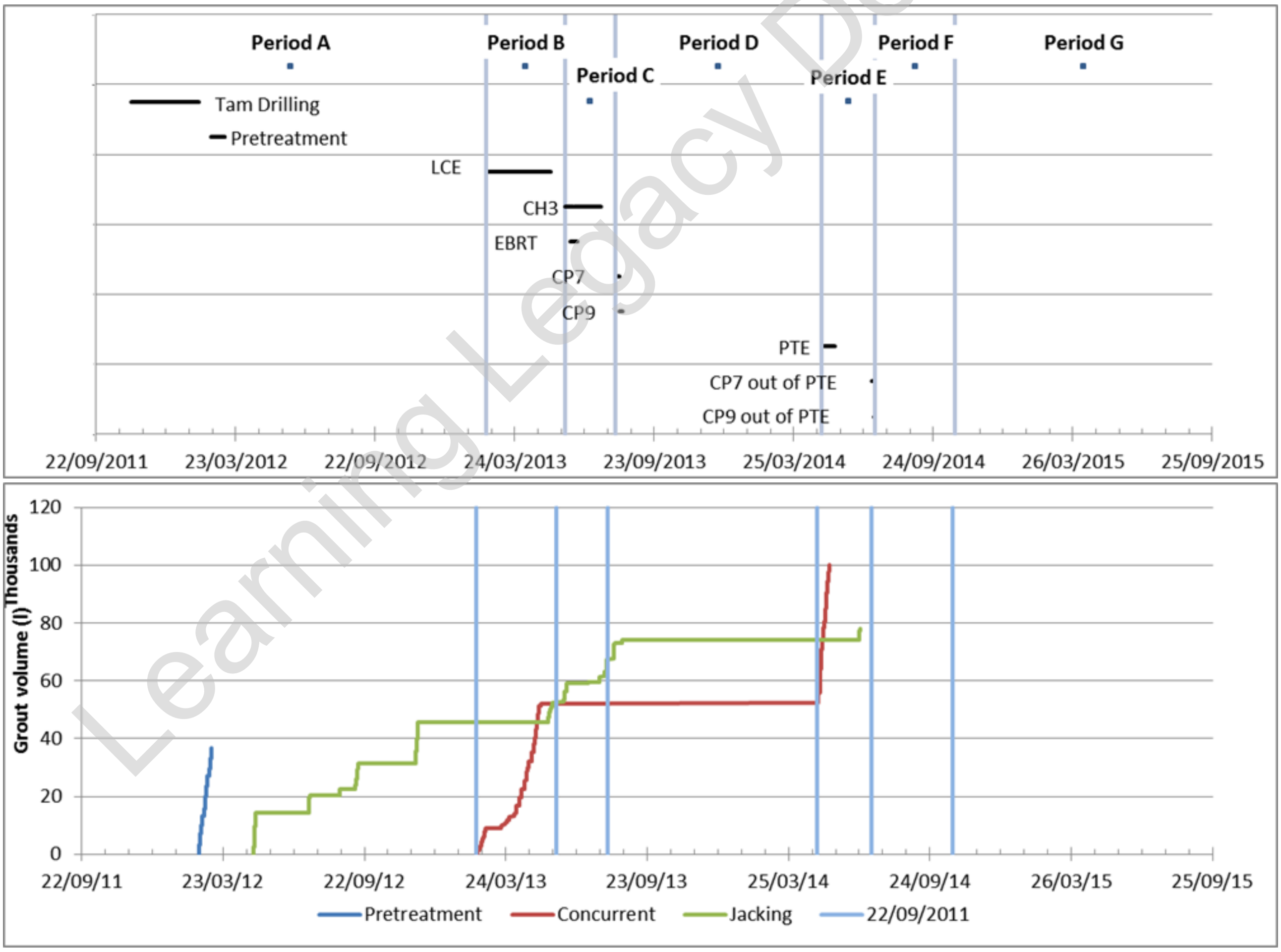


Figure 2.3 Distribution of grout injected from GS3: Pretreatment grouting. Grout Intensity (l/m²).

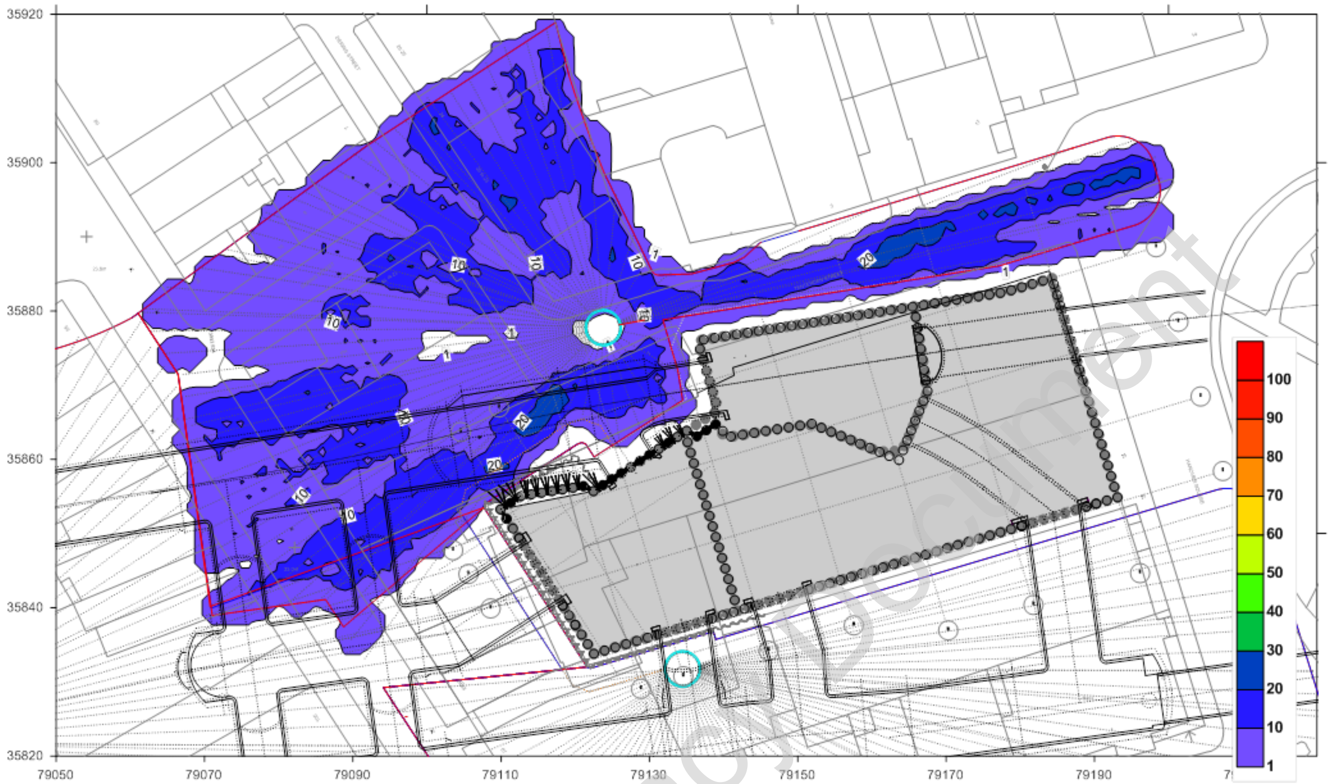


Figure 2.4 Distribution of grout injected from GS3: Concurrent grouting. Grout Intensity (l/m²).

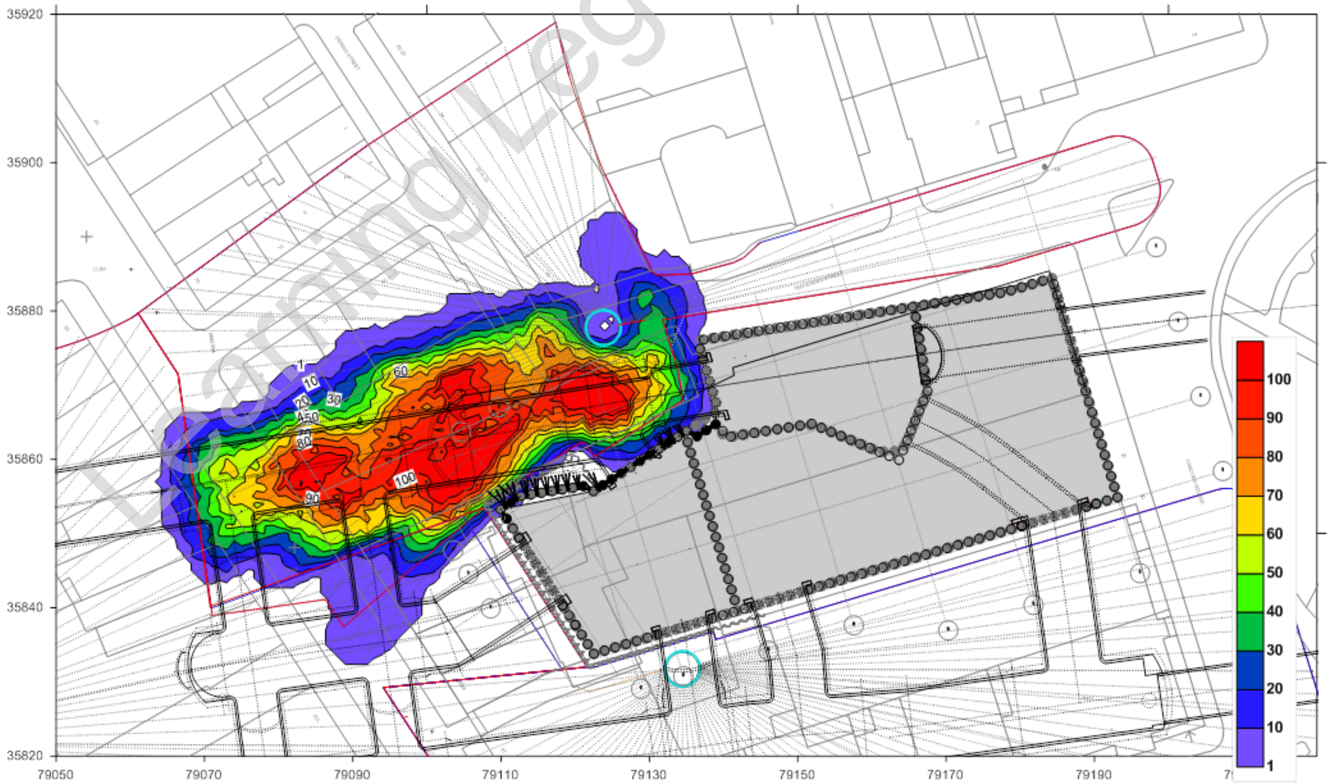


Figure 2.5 Distribution of grout injected from GS3: Jack grouting. Grout Intensity (l/m^2).

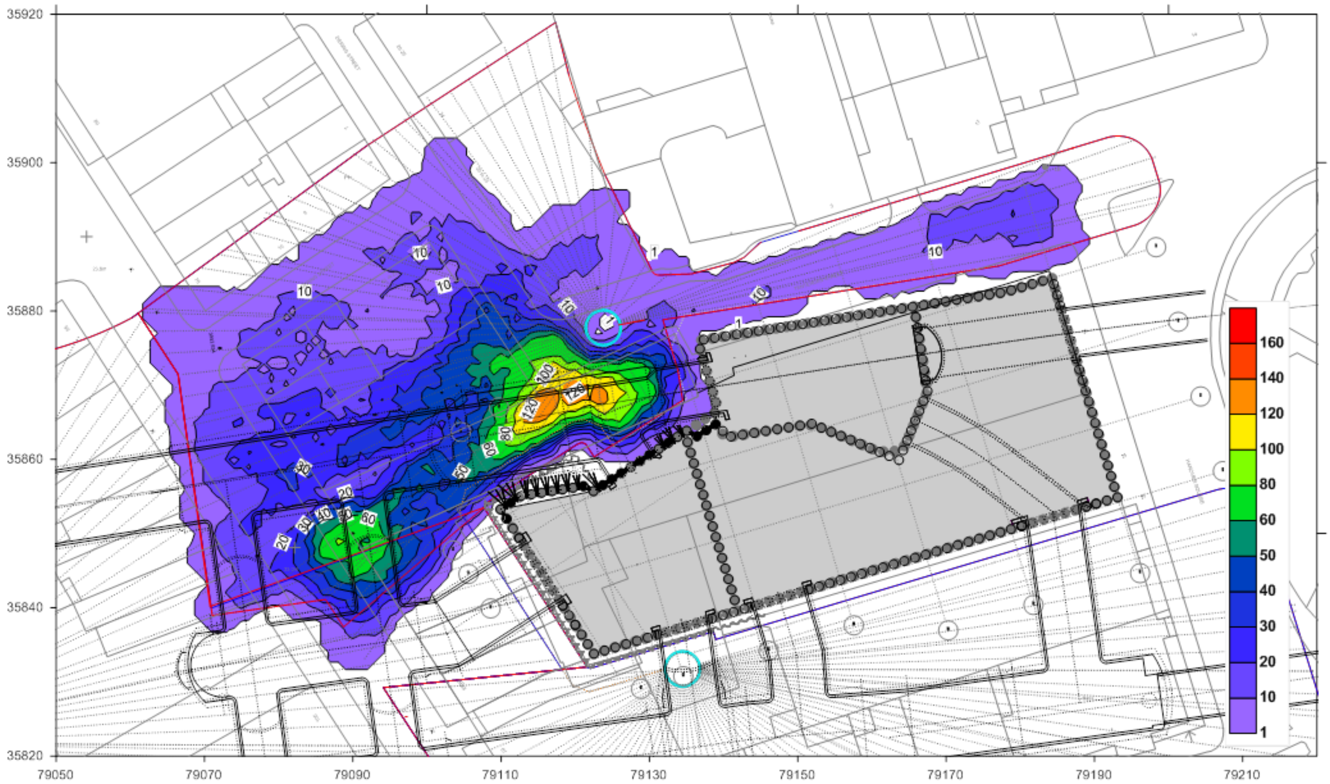
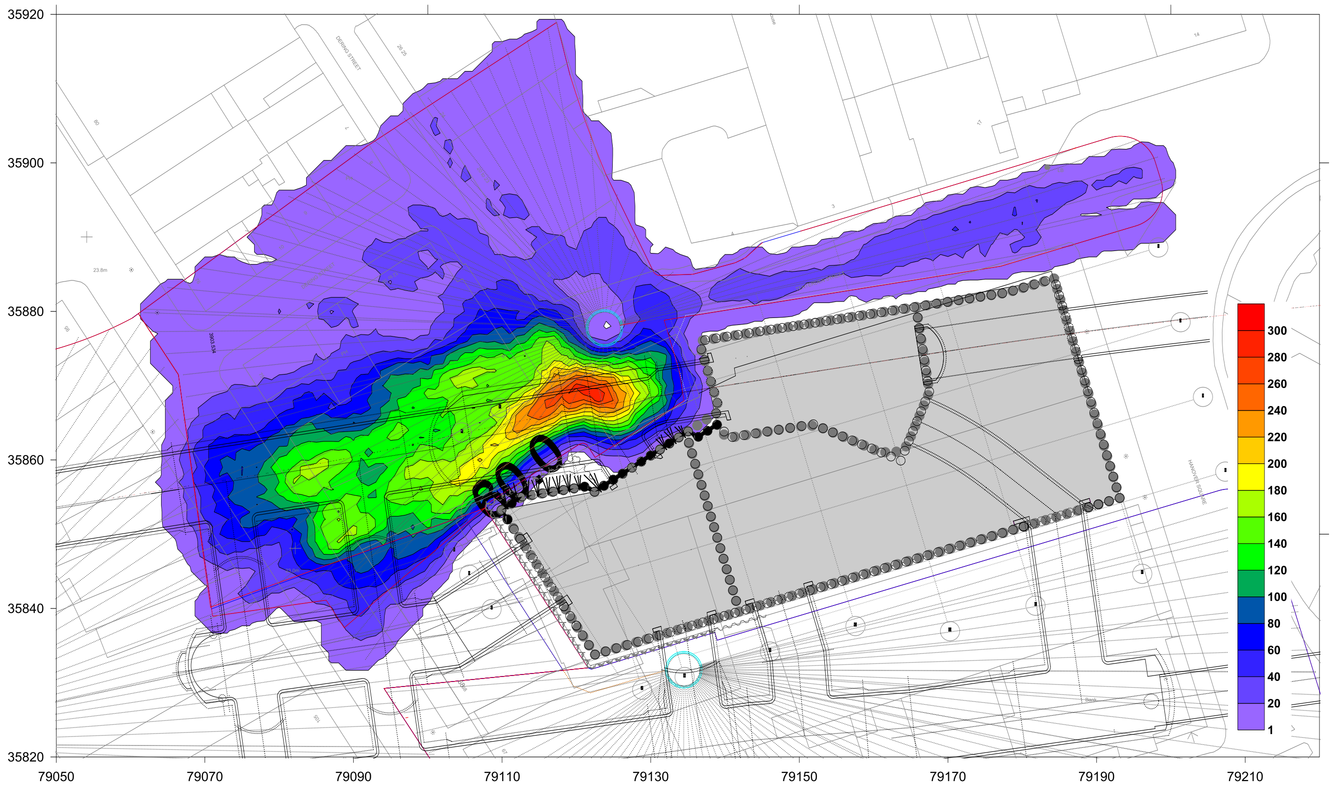


Figure 2.6 Distribution of grout injected from GS3: All grouting. Grout Intensity (l/m^2).



3. COMPARISON OF OBSERVED AND PREDICTED SETTLEMENT

3.1. Settlement Overview

Contours of total predicted short term settlement (supplied on C122 based on simple empirical methods) are shown in Figure 3.1.1. The measured settlement to May 2015, including consolidation settlement during the period of construction and for a period of 10 months after tunnelling was complete in the GS3 area, is shown in Figure 3.1.2.

The following points are noted:

- Settlements are generally less than or similar to the predicted values, notwithstanding that the observed movements include a significant proportion of consolidation settlement over the 3 ½ year construction period.
- The most obvious differences between the predictions and the observations are:
    - the settlements along Tenterden Street are much less than predicted (10mm maximum contour cf. 70mm predicted;
    - Over the west end of the concourse tunnel (CH3) the recorded magnitude of settlement is similar to that predicted (50mm cf 60mm);
    - the extent of the zone of settlement on the northern boundary of GS3 is substantially less than predicted with generally less than 10mm settlement recorded at the 20mm predicted contour.

Figure 3.1.1 Predicted settlement contour (mm) (supplied by C122)

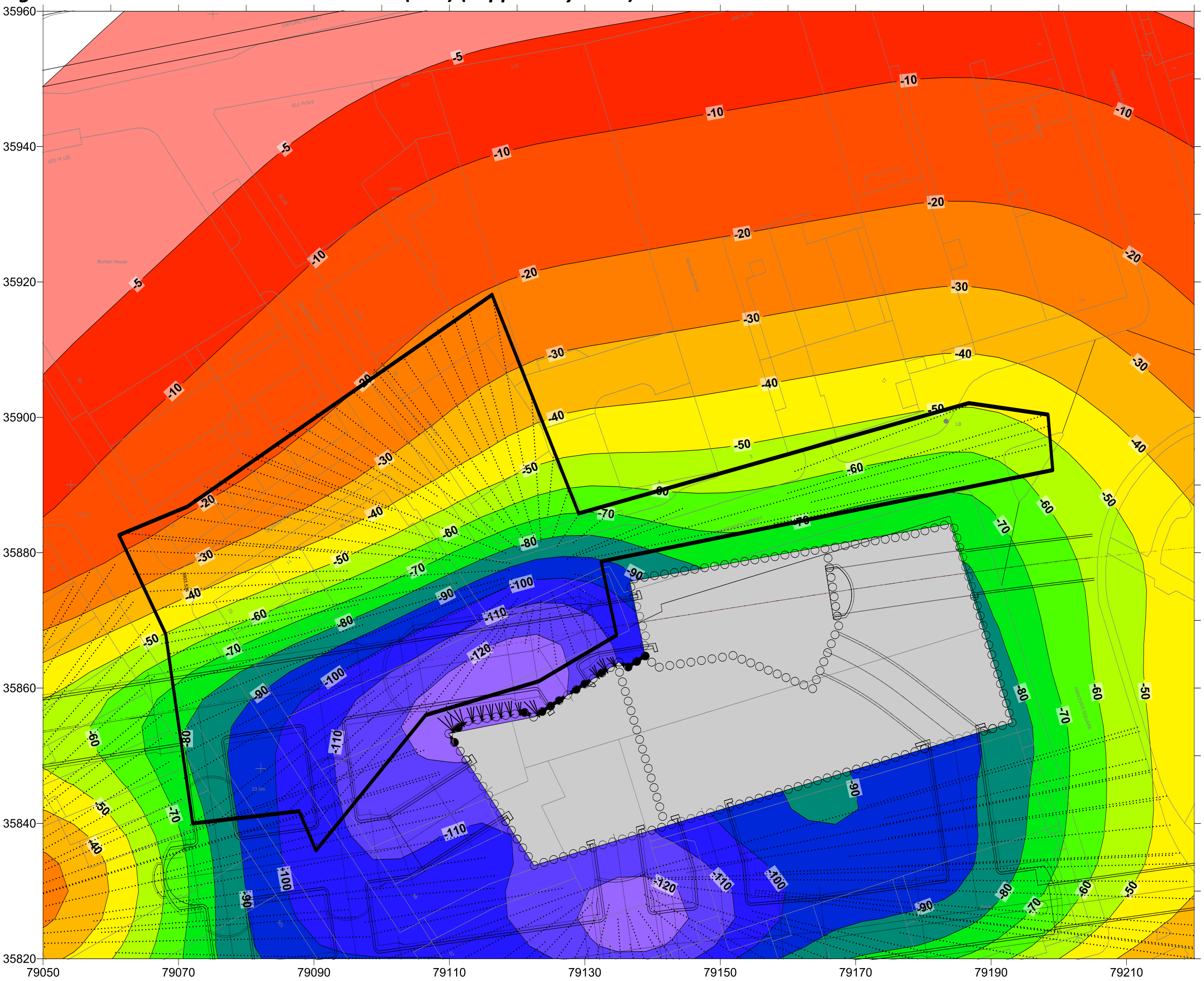
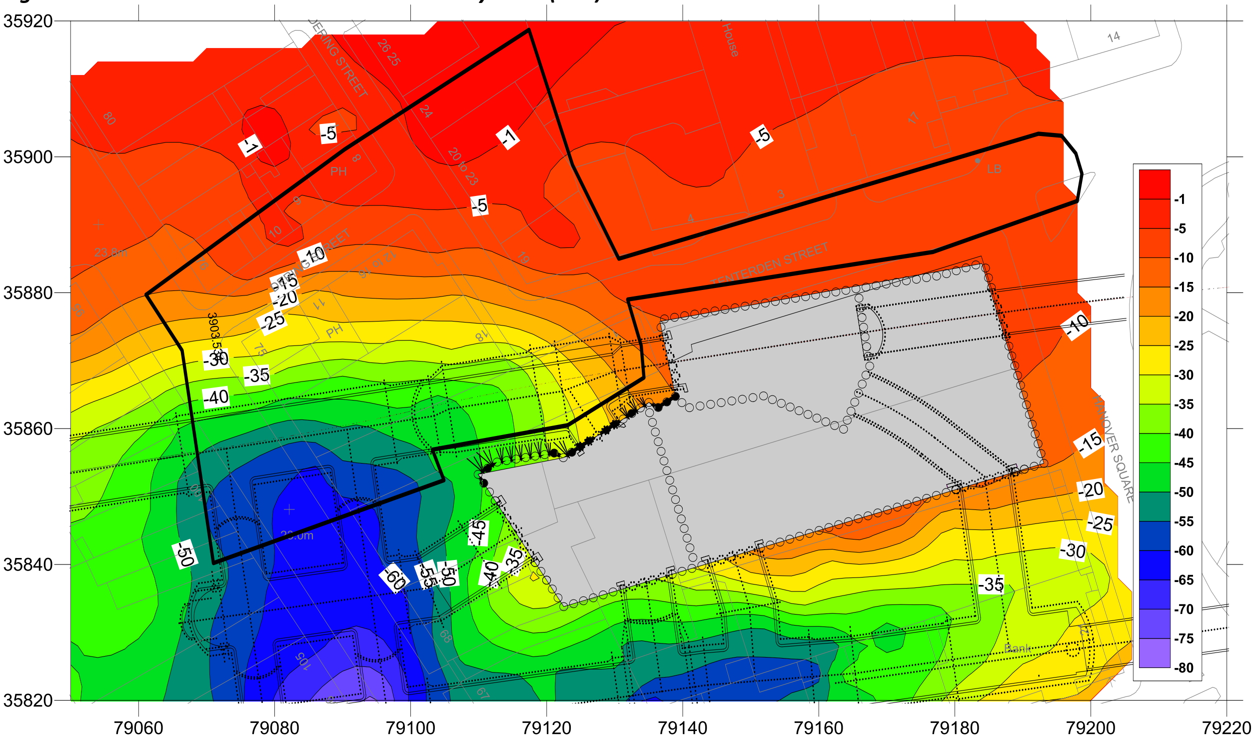


Figure 3.1.2 Observed settlement contour in May 2015 (mm)



In order to compare the predicted and actual movements at various stages of construction, the overall monitoring period from September 2011 to July 2015 has been divided into a number of periods, based largely on tunnel excavation. The dates of each period and the associated construction activities are summarised in Table 2.1.

The following plots are presented, as appropriate, for each period:

1. Volume loss settlement for tunnels constructed in the Period at the specified volume loss values;
2. Observed change in settlement within the Period;
3. Total settlement at the end of the Period;
4. Contour of grout intensity for concurrent grouting within the Period;
5. Contour of grout intensity for grout jacking within the Period

3.2. Period A – Prior to tunnelling in GS3 area: 22/09/11 – 14/02/13

Period A includes all of the preparatory work prior to the commencement of tunnelling, including demolition, piling and excavation of the Masterplan Shaft (MPS) and North-West Shaft (NWS) of the Western Ticket Hall. BFK works comprised the drilling and pre-treatment of TaMs from GS3.

The calculated short term movements associated with piling and excavation of the Masterplan and North-west shafts (as supplied by C122 based on simple empirical methods) are shown in Figure 3.2.1. Greatest settlement is at the MPS and NWS piled wall adjacent to GS3 where ~50mm settlement is indicated.

The observed settlements are shown on Figure 3.2.2. Pre-treatment was entirely completed in Period A and, consequently, the contours of grout intensity shown in Figure 3.2.3 are identical to those in Figure 2.3. A total of 37m^3 of grout was injected. Extensive Grout Jacking (~45m^3) was also undertaken in Period A (Figure 3.2.4) in response to the observed movements and ahead of the TBM drives. Grout jacking targeted at generating approximately 50% of the expected volume loss settlement was commenced in Period A. The intensity contours are shown in Figure 3.2.4.

A maximum settlement of over 15mm was produced by the preparatory works with more generally less 5mm to 10mm over the majority of the footprint of the grouting arrays. The greatest settlement is at the re-entrant corner between the two shafts. The highest intensity of grout injected (>60l/m^2) was below the corner of 18 Dering Street to control the slopes on this structure. The observed settlement was much lower than the predicted value of ~50mm. The contours of grout intensity show that during pretreatment and grout jacking episodes, effort was concentrated in the area of greatest settlement of buildings: over the majority of the area less about 20l/m^2 was required.

Figure 3.2.1. Period A: Total predicted settlement from ETH MasterPlan and North west shafts (mm) (supplied by C122)

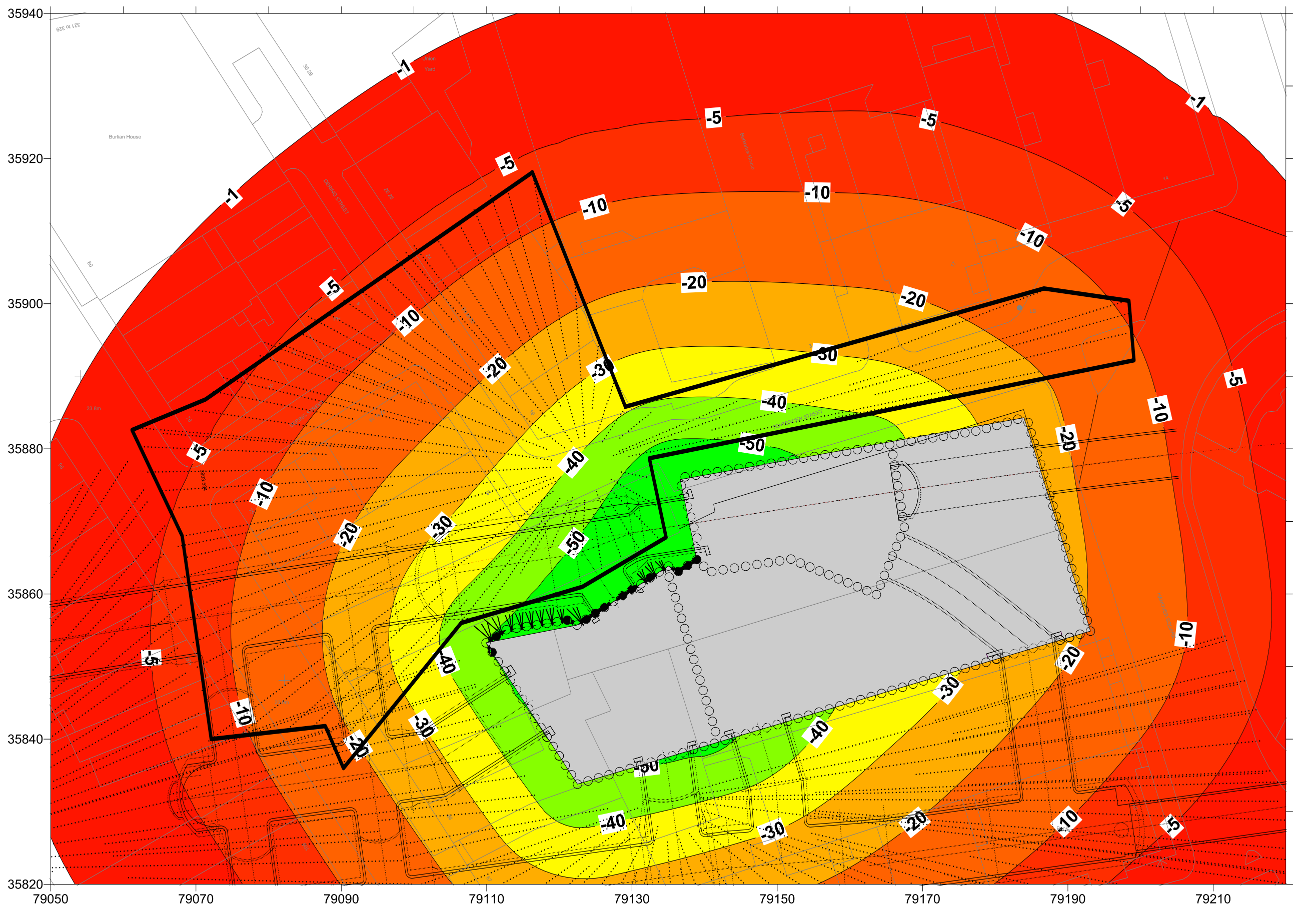


Figure 3.2.2. Period A: Total measured settlement (mm)

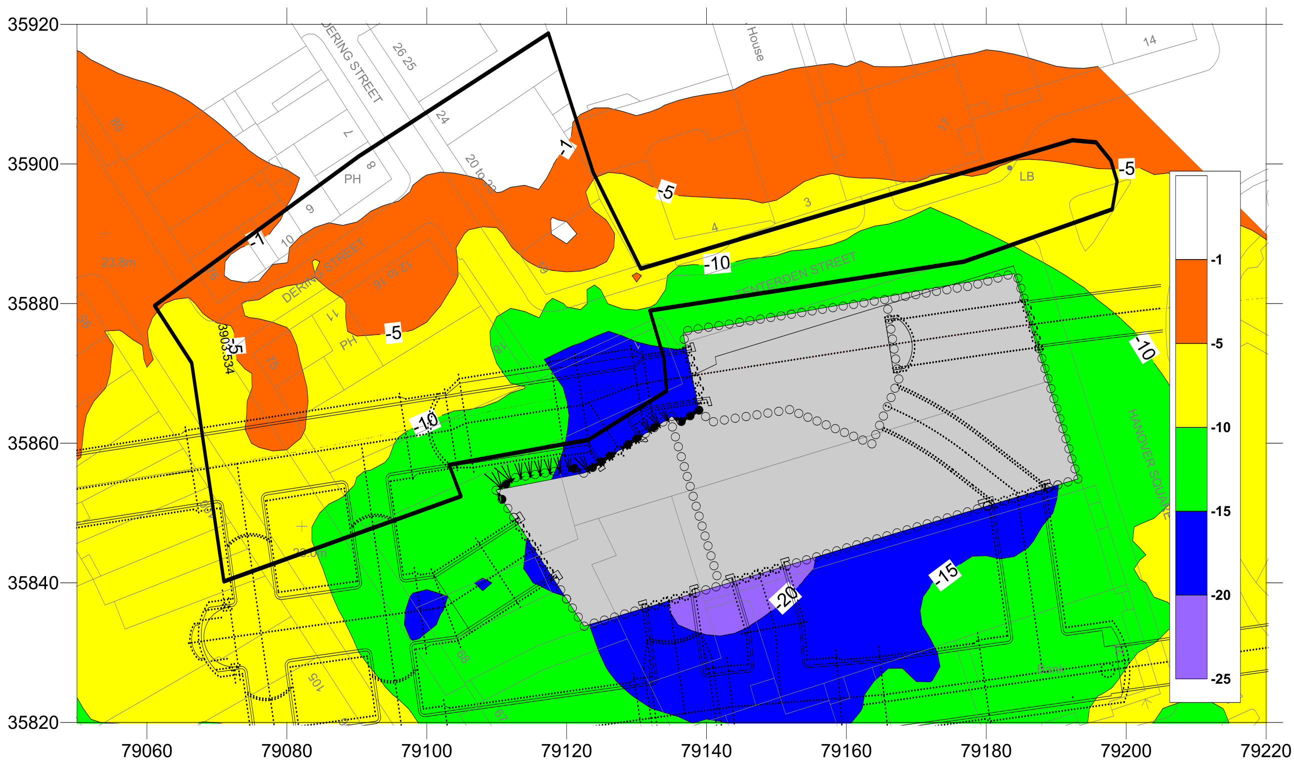


Figure 3.2.3 Distribution of grout injected from GS2: Pretreatment grouting. Grout Intensity (l/m²).

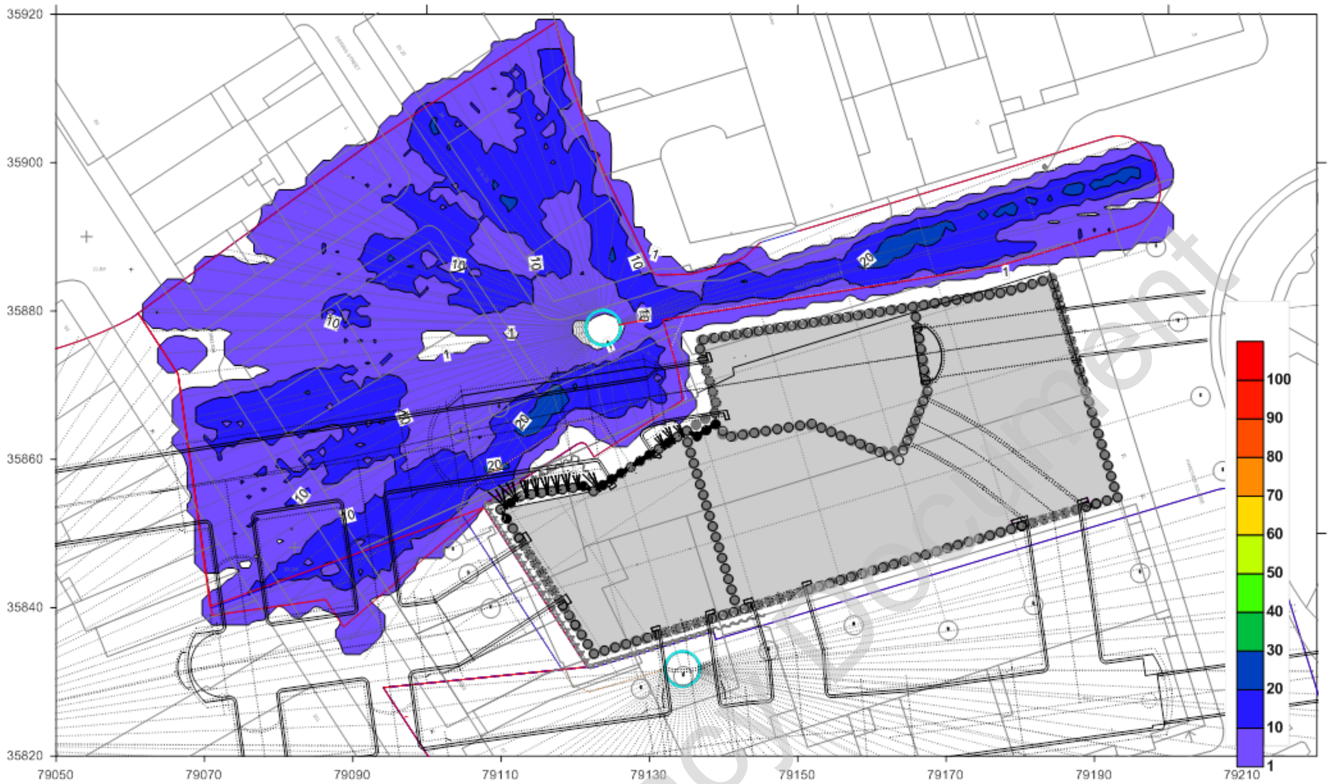
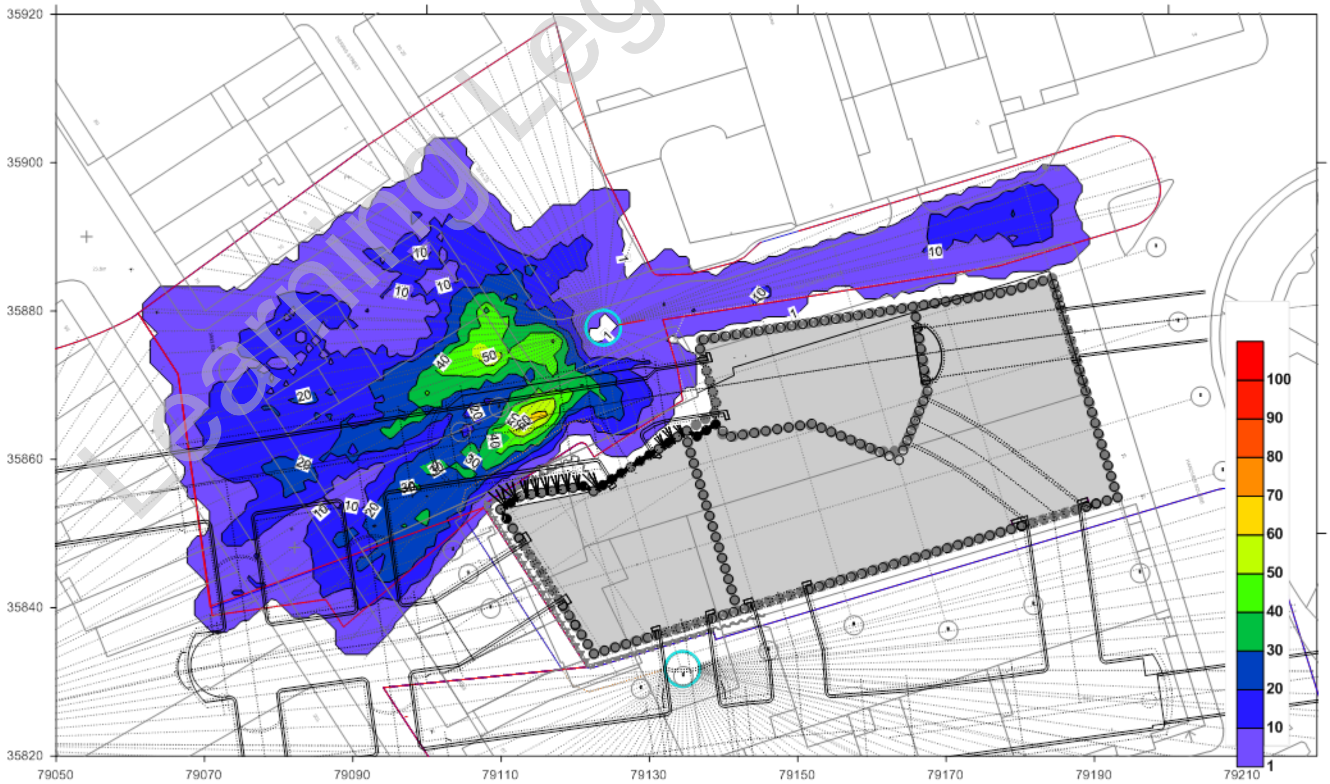


Figure 3.2.4 Distribution of grout injected from GS2: Pre-TBM Grouting Jacking. Grout Intensity (l/m²).



3.3. Period B – LCE1 & LCE2: 25/03/13 – 29/05/13

Figure 3.3.1 Period B: (a) Volume loss settlement (mm). (b) Change in measured settlement (mm).

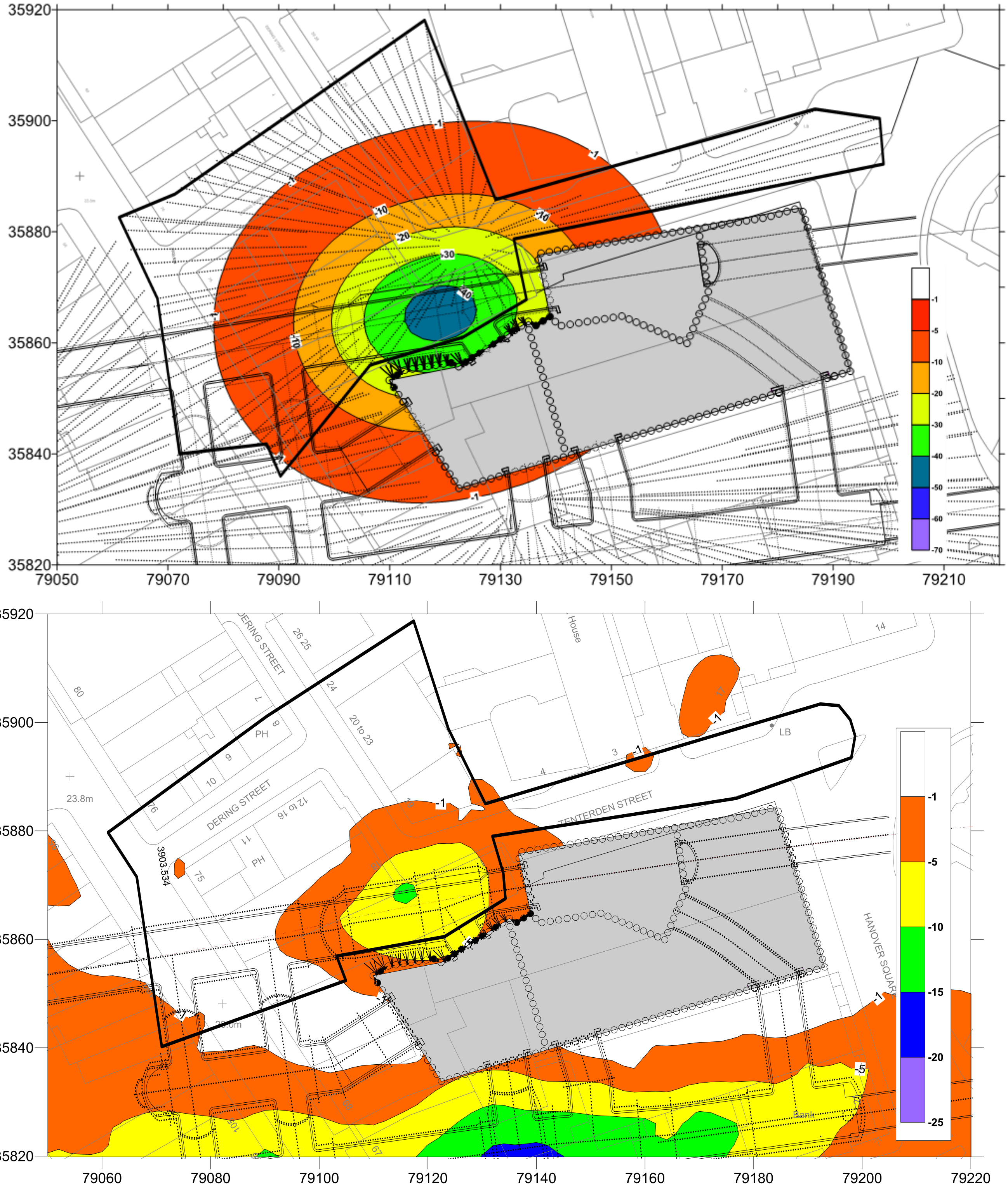


Figure 3.3.2 Period B: Total measured settlement (mm).

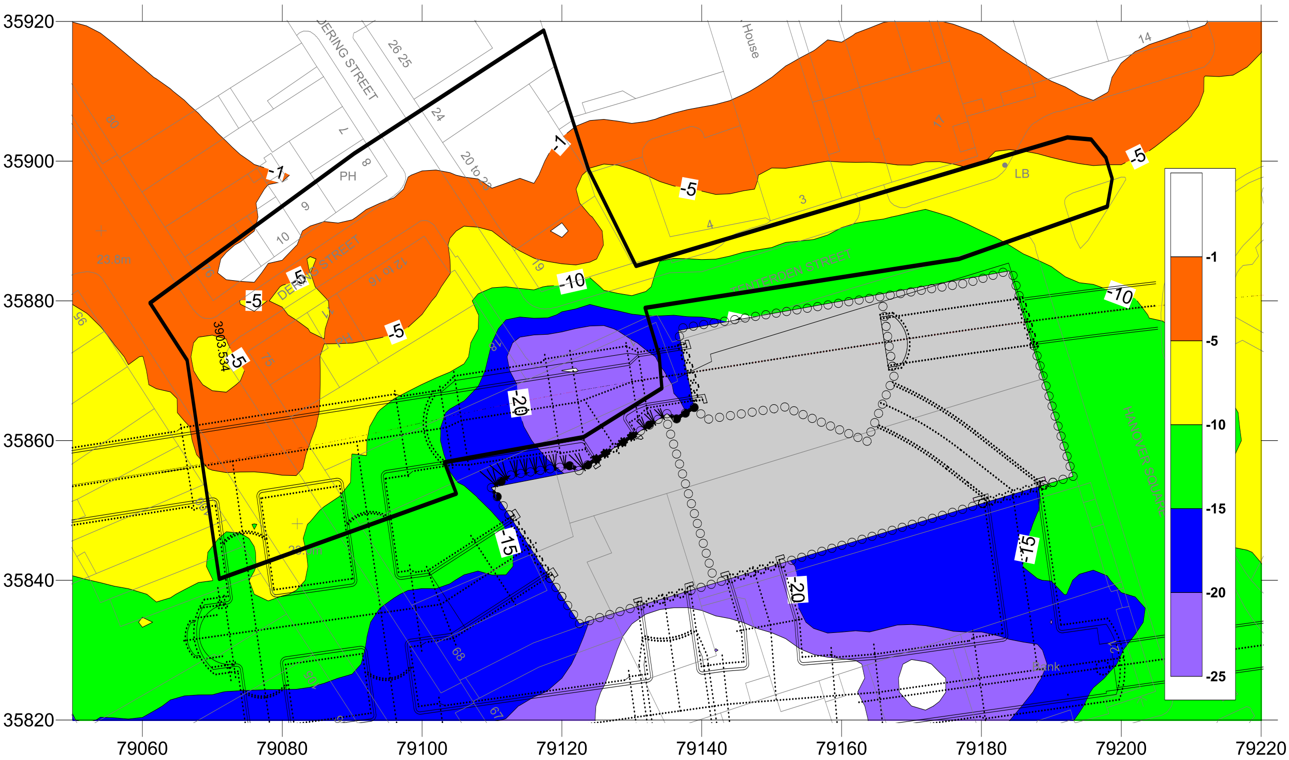


Figure 3.3.3 Period B: Distribution of grout injected from GS3: Concurrent grouting. Grout Intensity (l/m^2).

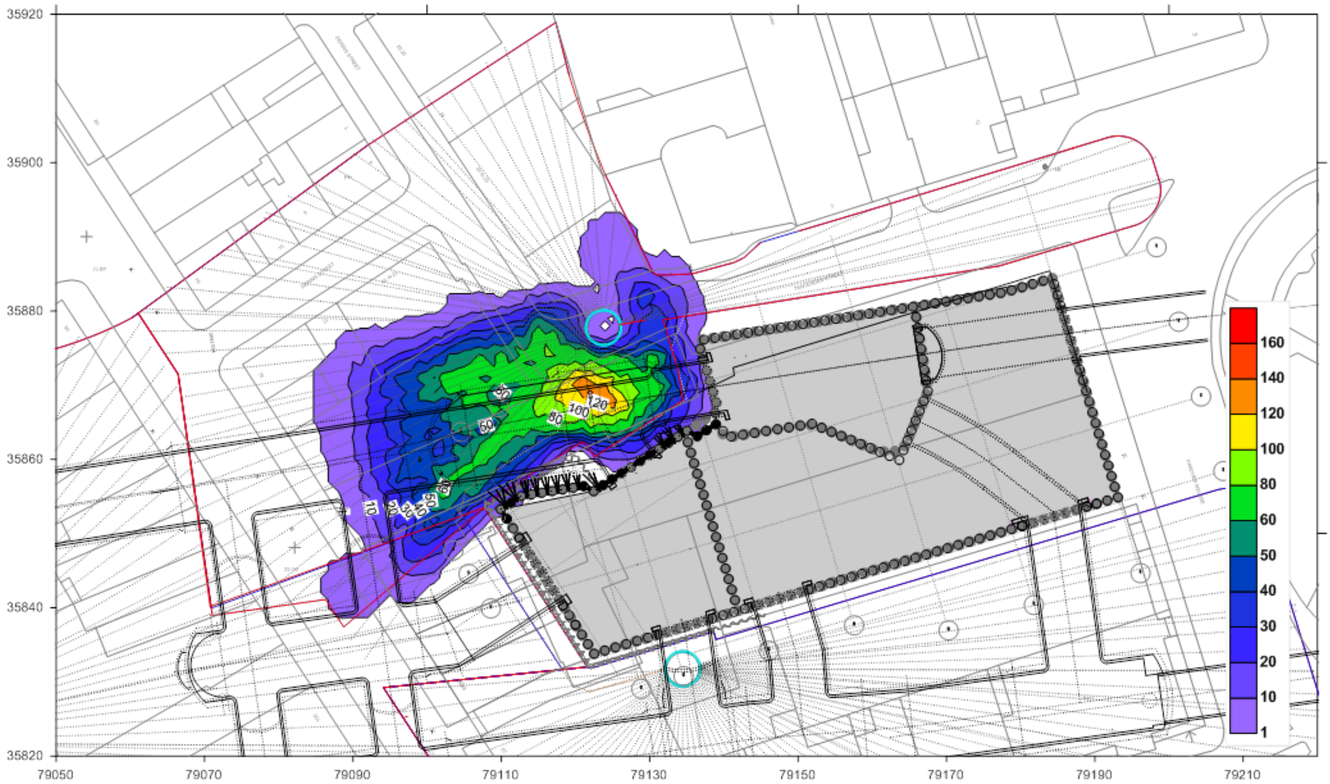


Figure 3.3.3 Period B: Distribution of grout injected from GS3: Jack grouting. Grout Intensity (l/m²).

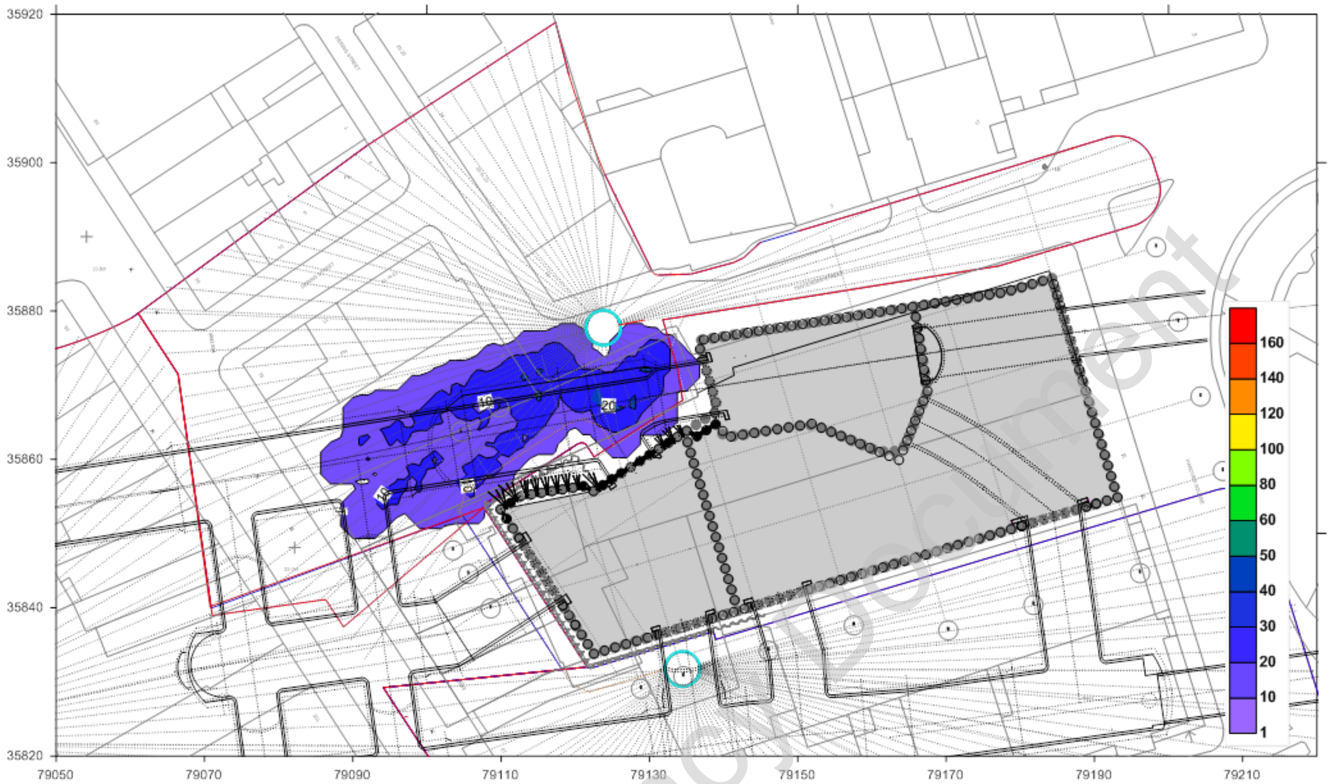


Figure 3.3.1(a) shows that over 40mm volume loss settlement was anticipated from the excavation of LCE1 and LCE2. It is noteworthy that a substantial amount of the settlement is predicted to occur within the footprint of the ETH, since the simple empirical volume loss calculations do not take account of the presence of the ETH structure.

Figure 3.3.1(b) shows that maximum recorded settlement was locally 10mm at the south-eastern corner of 18 Dering Street, with generally 5mm over the tunnel footprint. Over the remainder of the grouting zone the settlement was negligible. In the south section of Figure 3.3.1(b) the effect of the SCL works within the GS5 area are evident but these had a negligible effect within the GS3 area.

At the end of Period B the cumulative movements (Figure 3.3.2) show a maximum of ~20mm adjacent to the MPS shaft, ~10mm along Tenterden Street and less than 1mm at the north boundary of the GS3 area.

Concurrent grouting was undertaken with LCE1 and LCE2 both pilot and enlargement. Grouting was restricted due to the exclusion zone over the tunnel face which allowed only front injections at the break out from the NWS. The injections were also restricted by exclusion zones adjacent to both the MPS and the NWS as well as around the grout shaft itself. The contour of grout intensity shown in Figure 3.3.3, is therefore asymmetric with respect to the tunnel. The limited length of the tunnel (33m) also resulted in front and rear injections only being completed over part of the area.

Grout jacking was also undertaken in Period B following completion of the tunnelling, with up to 20l/m^2 in the area of maximum settlement. The grouting successfully limited settlement to a small proportion (~25%) of that associated with a 1.5% volume loss.

3.4. Period C - EBRT, CH3: 30/05/13 – 15/07/13

Figure 3.4.1 Period C: (a) Volume loss settlement (mm). (b) Change in measured settlement (mm).

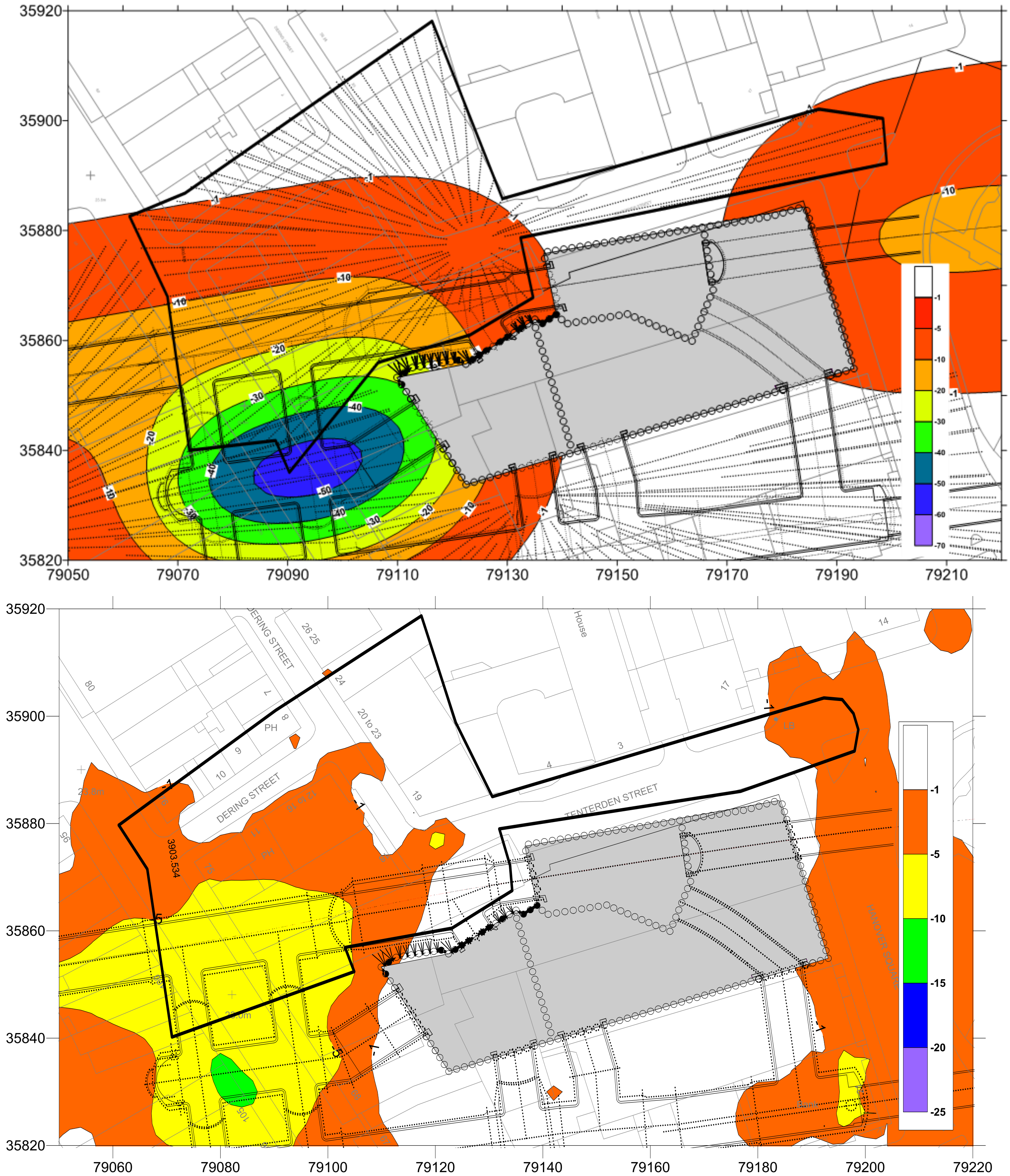


Figure 3.4.2 Period C: Total measured settlement (mm).

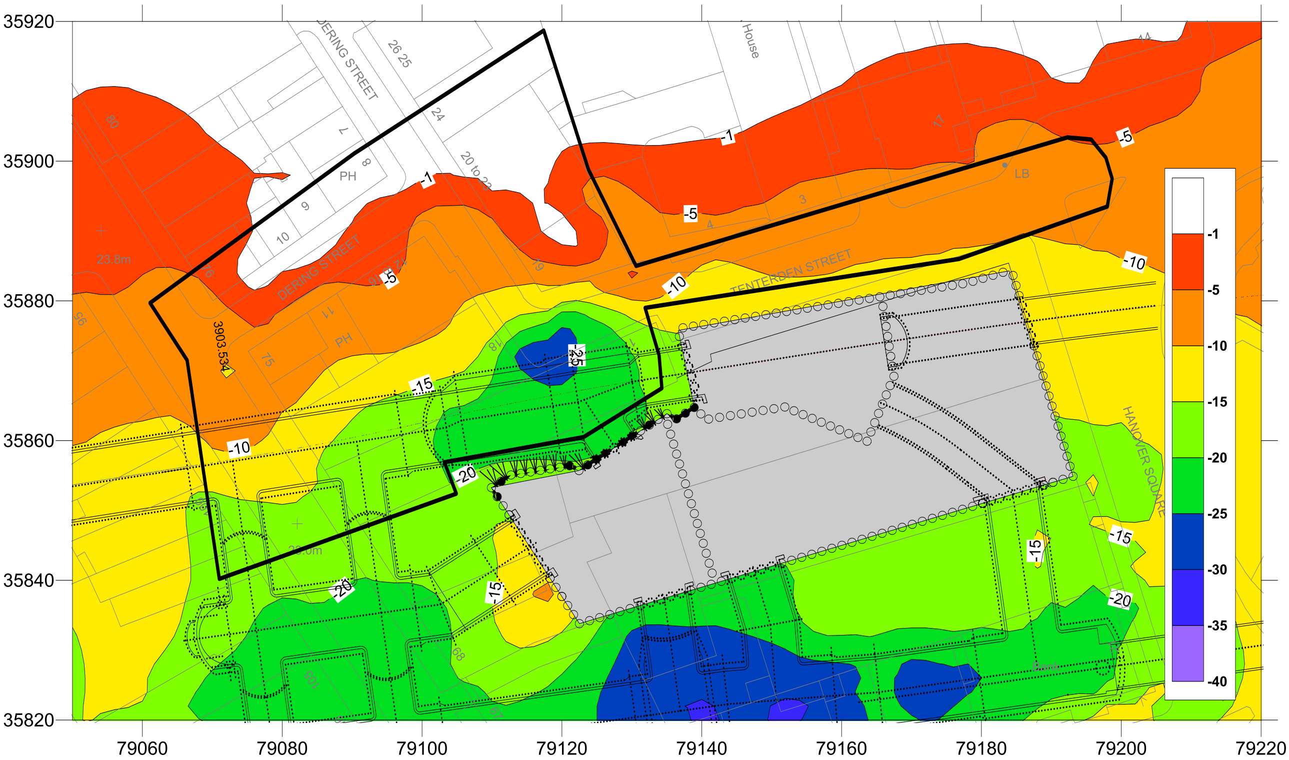


Figure 3.4.3 Not used.

Figure 3.4.4 Period C: Distribution of grout injected from GS3: Grout jacking. Grout Intensity (l/m^2).

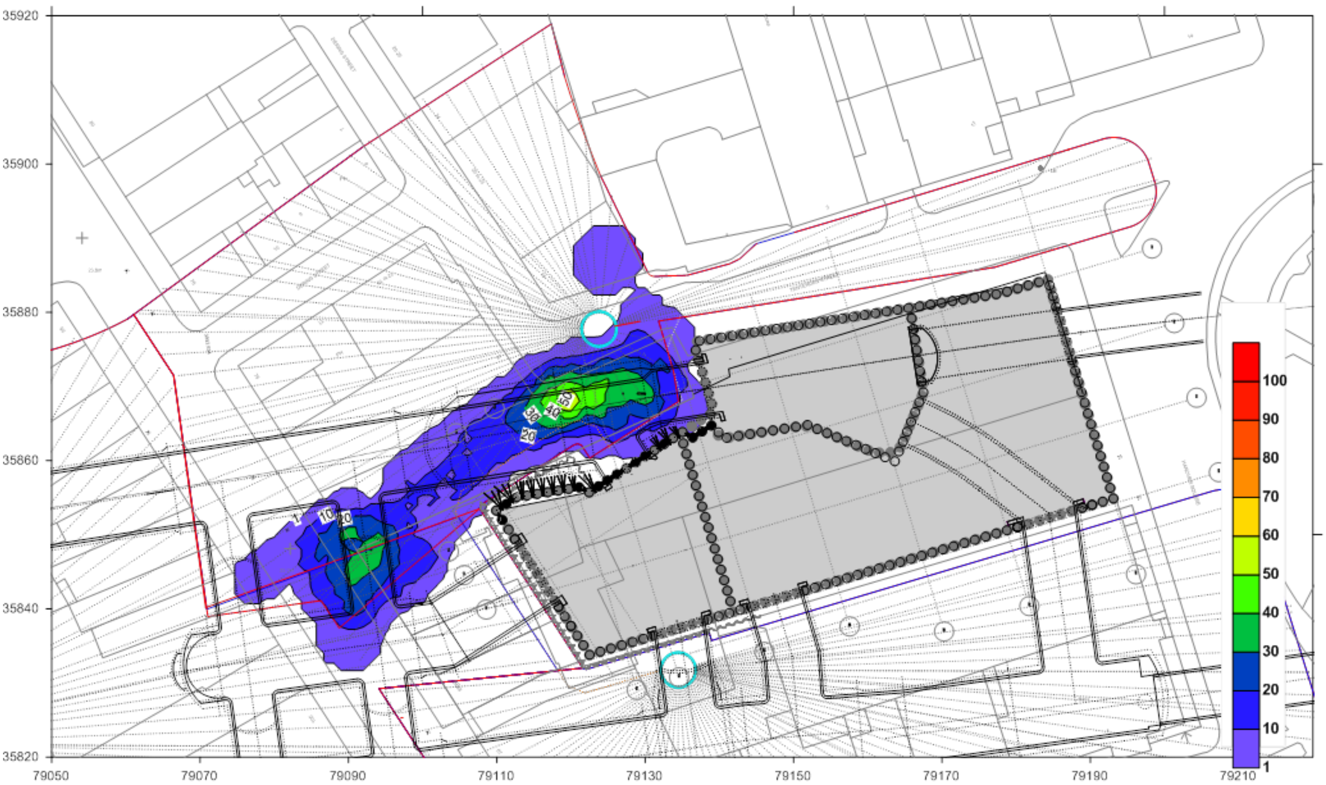


Figure 3.4.1(a) shows that over 50mm volume loss settlement was anticipated for CH3 and about 10mm for the EBRT.

Figure 3.4.1(b) shows the recorded settlement with a maximum of 12mm over CH3. The movements within the GS3 area were less than 10mm in Period C and, at the end of Period C, the cumulative movements (Figure 3.4.2) had increased slightly to 25mm locally.

No concurrent grouting injections for CH3 were undertaken from GS3: the arrays from GS2 and GS5 were used. A limited amount of jack grouting was undertaken from GS3, with an episode after completion of the CH3 pilot and a second episode after completion of the enlargement. Figure 3.4.4 shows that the injections were targeted at both residual movements from CH3 and the area of maximum settlement within the GS3 arrays. The grout intensity reached 30 l/m^2 and 50 l/m^2 in the two areas respectively.

3.5. Period D - CP8, CP10, CP7 & CP9, ETH: 04/08/13 – 01/05/13

Figure 3.5.1 Period D: (a) Volume loss settlement (mm). (b) Change in measured settlement (mm).

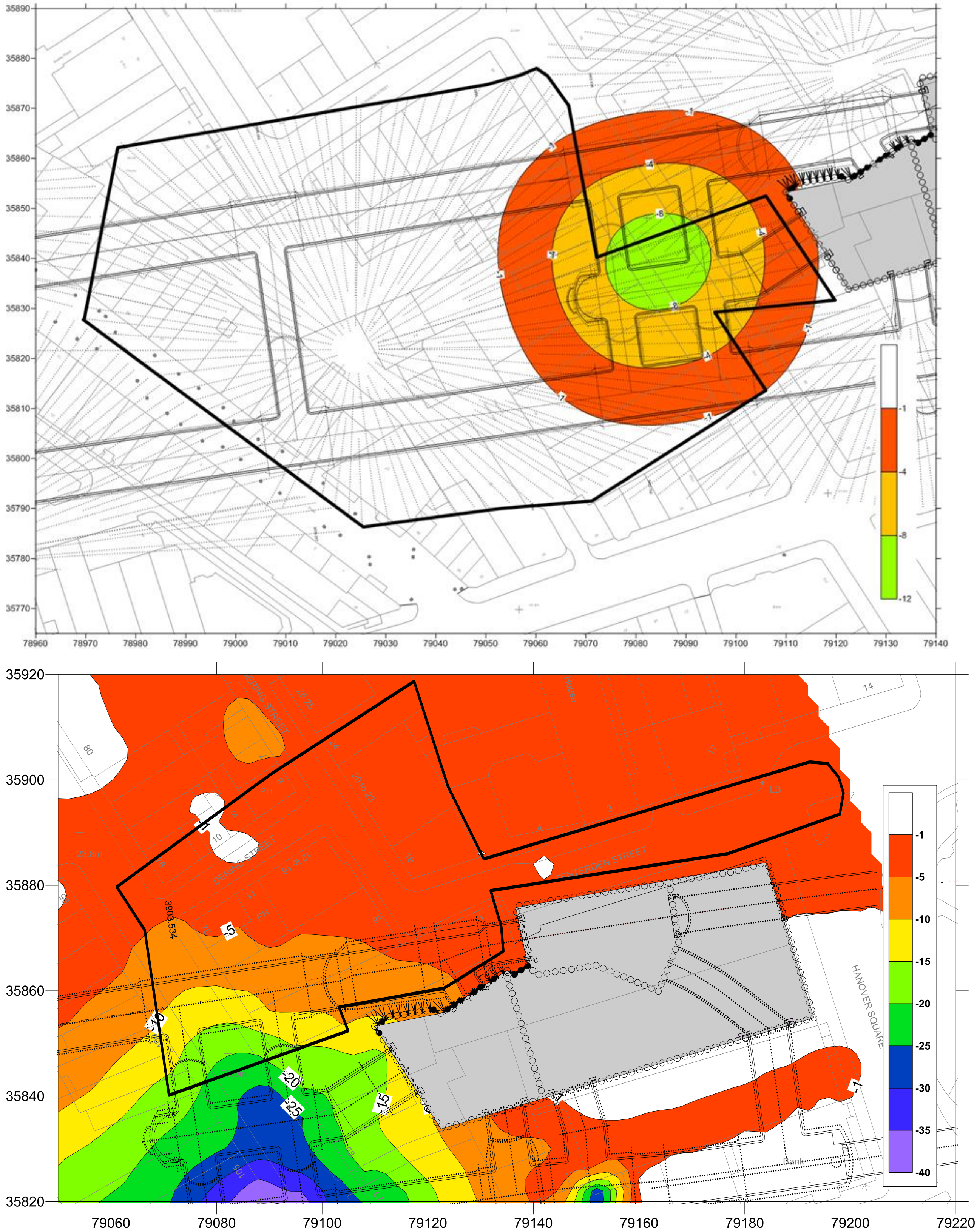


Figure 3.5.2 Period D: Total measured settlement (mm).

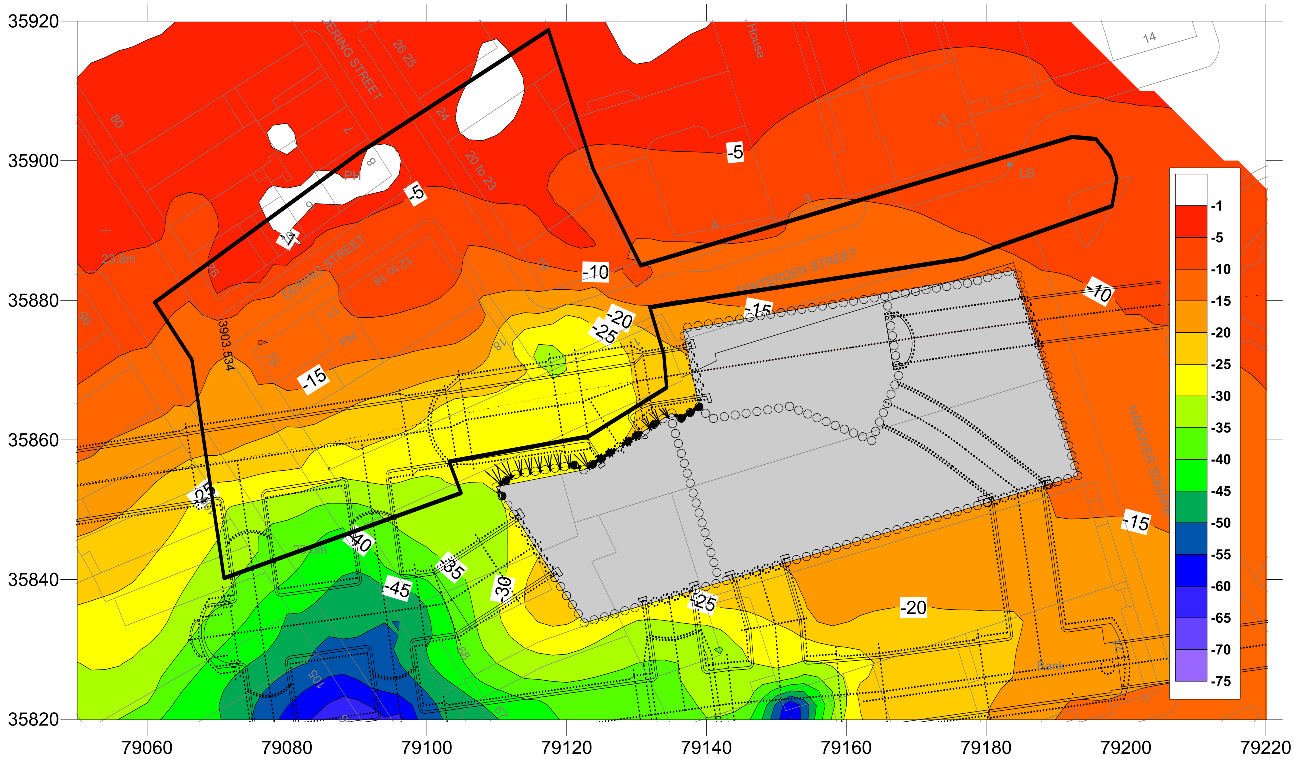
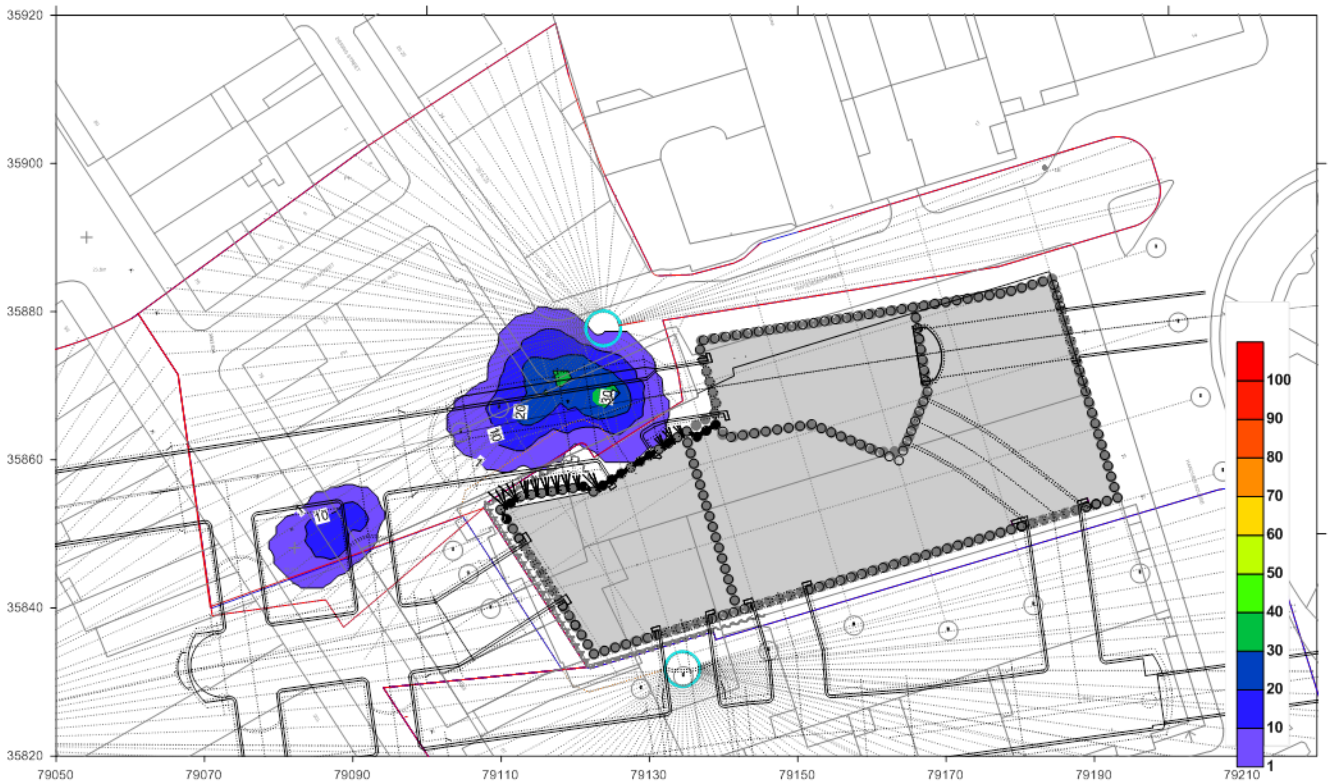


Figure 3.5.3 Period D: Distribution of grout injected from GS2: Grout jacking. Grout Intensity (l/m^2).



There was only minor excavation at the start of Period D with cross passages CP7 and CP9 constructed out of CH3 in up to a couple of metres from the respective future platform tunnel junctions completed in the first 2 weeks. The maximum volume loss settlement for all four CPs is ~10mm, as shown in Figure 3.5.1(a). During the remainder of the 9 months of Period D, there were no further C300 / C410 excavation works. Excavation of the ETH by others commenced during Period D but no allowance for this is included in the contours.

The maximum observed settlement from volume loss associated with the cross passages was locally ~8mm and about 4mm over the whole of the volume loss zone of influence (see GS2 report C300-BFK-C4-RGN-CRT00_ST005-51179). No concurrent grouting was undertaken with these tunnels due to their short length and the extent of the exclusion zone specified in the SCoGM. Grout jacking was targeted based on the pre-existing settlements as well as the anticipated volume loss movements to control slopes and distortions.

Figure 3.5.1(b) shows that there was a significant post-construction increase in settlement over CH3 and the CPs giving an increase of up to 20mm at the boundary of the GS3 arrays. Over most of the GS3 area (Dering Street and Tenterden Street) the increase in settlement was less than 5mm.

Figure 3.5.2 shows that the location of the maximum settlement (40mm) is located on New Bond Street.

The contour of grout intensity in Figure 3.5.3 shows that a limited amount of grout jacking was undertaken: this was undertaken at the start of Period D and is a continuation of the post-CH3 and 18 Dering Street episodes described in Section 3.4. A maximum intensity of 40 l/m2 was injected.

3.6. Period E - PTE, CP8 & CP10 (out of PTE), ETH: 02/05/14 – 10/07/14

Figure 3.6.1 Period E: (a) Volume loss settlement (mm). (b) Change in measured settlement (mm).

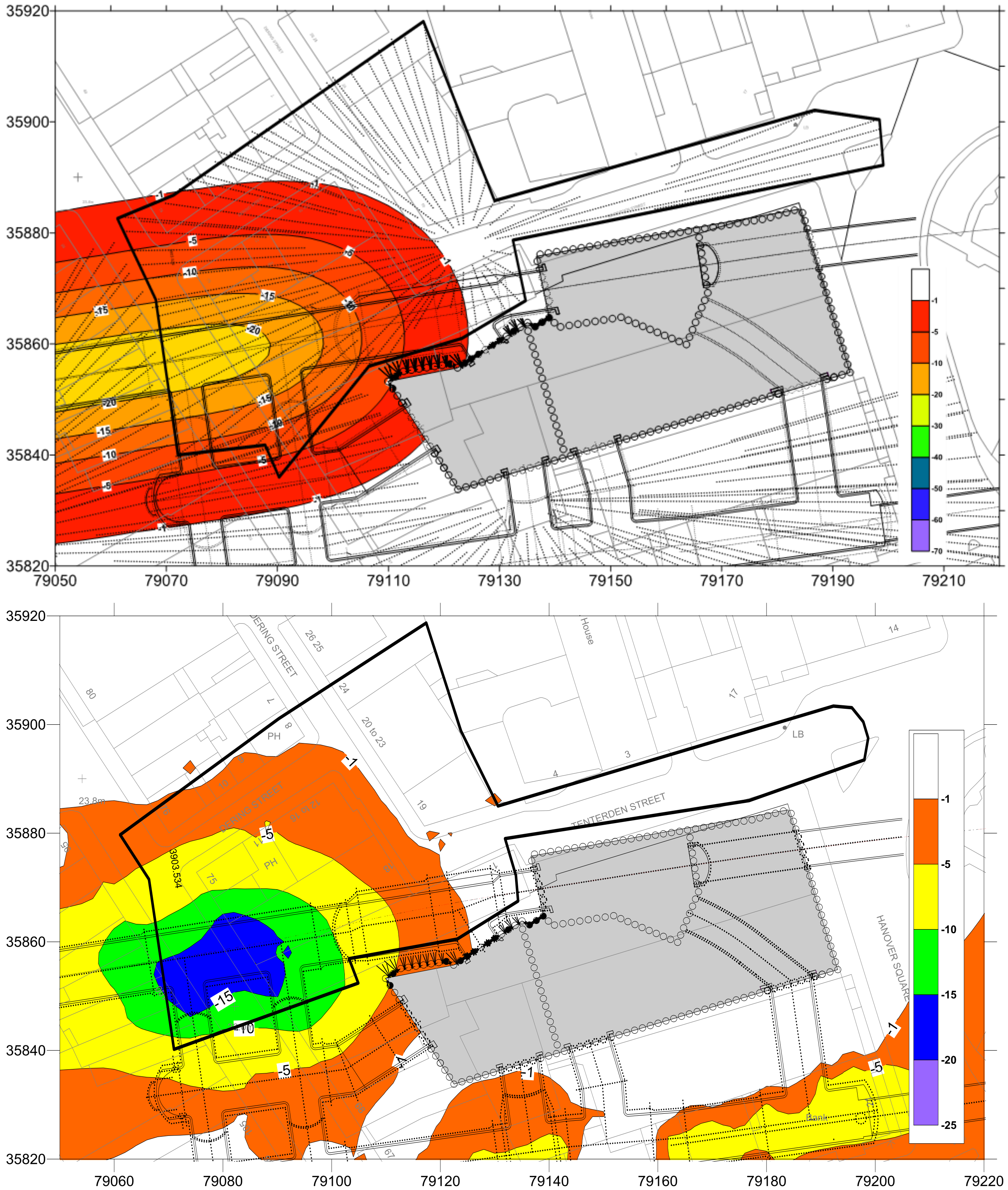


Figure 3.6.2 Period E: Total Measured Settlement (mm)

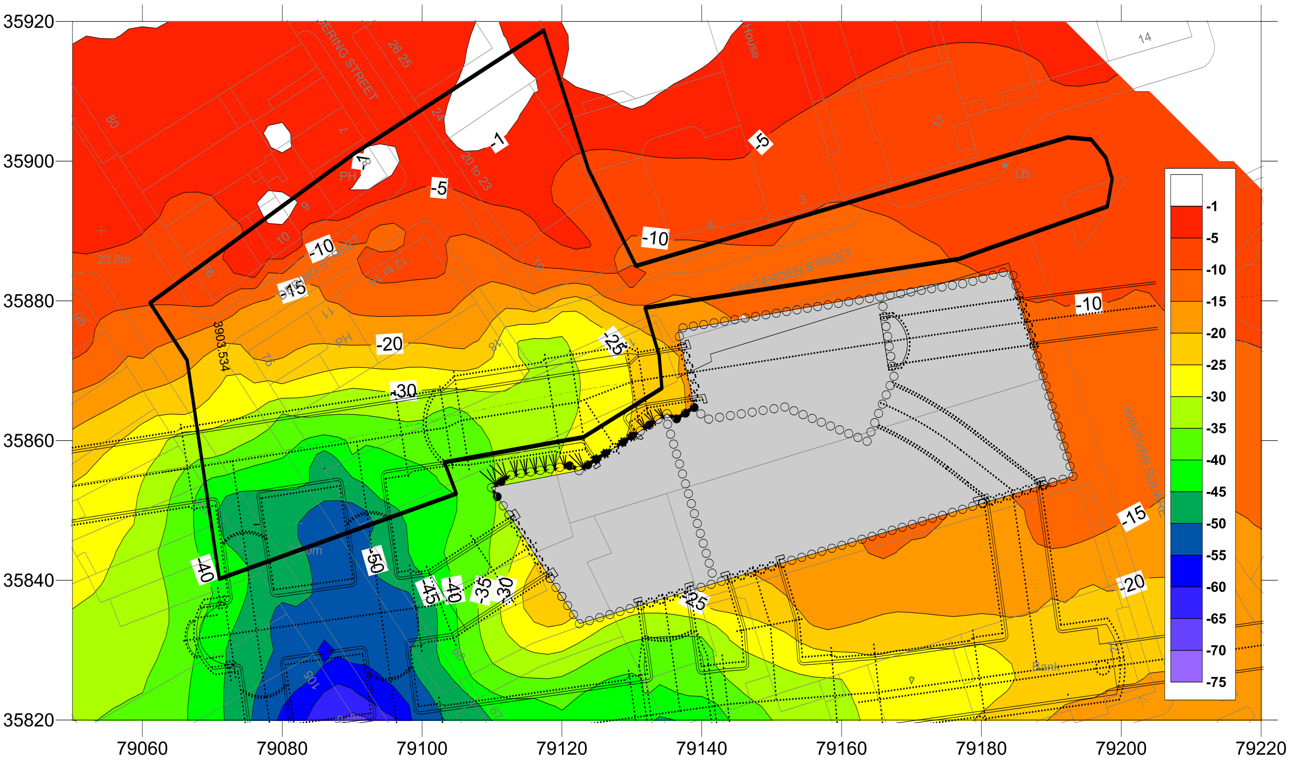


Figure 3.6.3 Period E: Distribution of grout injected from GS3: Concurrent grouting. Grout Intensity (l/m²).

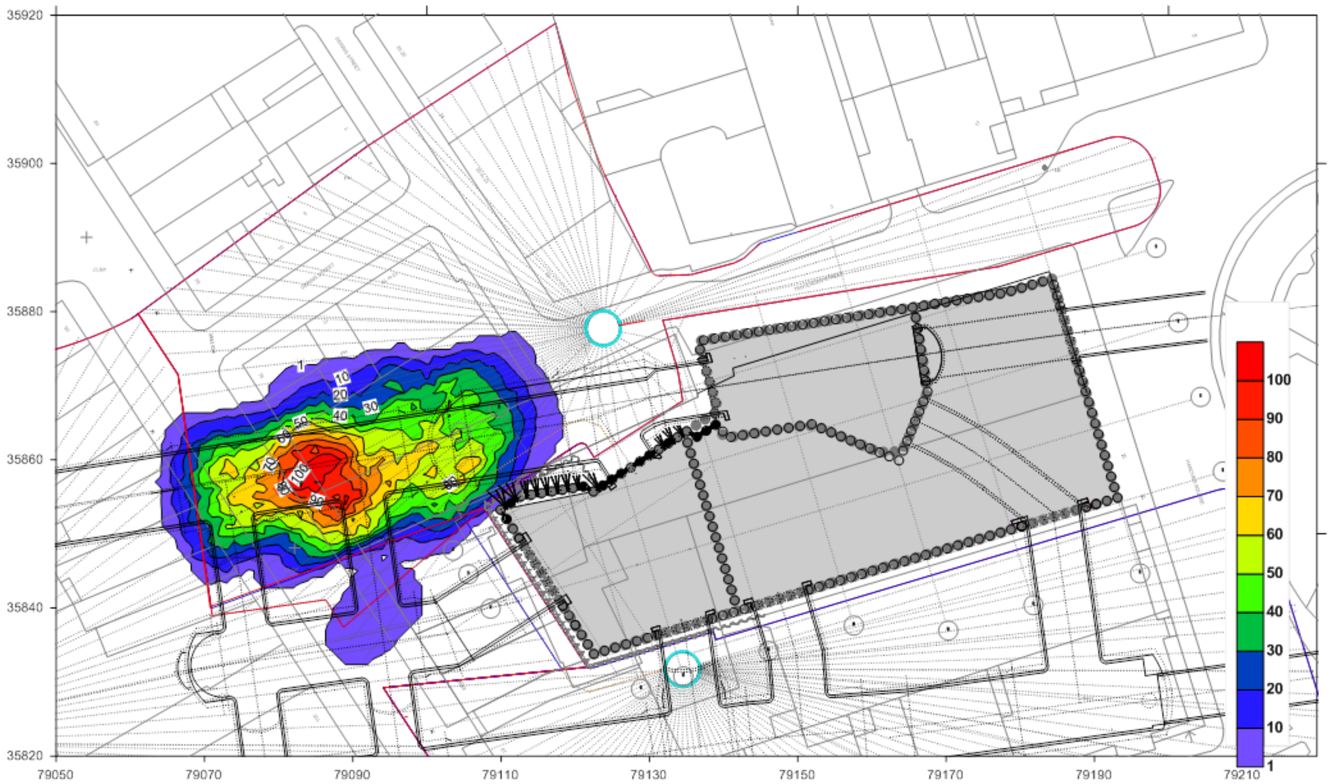


Figure 3.6.4 Period E: Distribution of grout injected from GS3: Grout jacking (l/m²).

The main activity in Period E is the PTE. The stub tunnels completing CP7 and CP19 are included in the volume loss contour (Figure 3.6.1(a)) but contribute a maximum of less than 5mm. The volume loss for the PTE is based on 1.25% as specified for enlargements from running tunnels. The maximum calculated volume loss settlement is just over 20mm. Excavation of the ETH by others continued during Period E but no allowance for this is included in the contours.

The actual settlements recorded in Period E are shown in Figure 3.6.1(b) and give a maximum just over 15mm across New Bond Street. The settlements decrease significantly to the west with less than 10mm within the extent of the GS2 arrays. Negligible movements were recorded to the east of the shaft along Tenterden Street, adjacent to the ETH.

The total settlement at the boundary of GS3 on New Bond Street is over 50mm, but settlement increases further to the south in the GS2 area.

The contours of concurrent grouting intensity in Figure 3.6.4 are centred on the PTE with a peak intensity of 100 l/m^2. The variation in intensity over the centreline of the tunnel is a result of the management of the grout volumes to allow more settlement where this would be beneficial in controlling slopes or to limit heave from the front injection to the specified limit of 5mm. The lower intensity to the east of the grouting zone is a result of the commencement of the PTE from LCE2: this area only receives the rear injections. At the west end, the impact of injections from GS2 is not included in the contours.

3.7. Periods F & G- No tunnelling (ETH below level -2): 11/07/14 – 13/10/15

BFK excavation works were completed in Period E. As noted in Section 3.5, the ETH excavation was commenced in Period D and continued throughout Period E to -2 level (completed 18/07/14). Excavation has continued since the completion of tunnelling and has reached -3 level at 10/05/15. The final excavation level (-5) was completed in October 2015 and the base slab was completed in January 2016. The contour plot shown in Figure 3.7.1 has been supplied by CRL (C122) as the estimated settlement for the full depth of the ETH excluding the Masterplan and NW shafts.

An abridged version of this report was submitted in October 2014 (C300-CCM-09101) to justify de-commissioning of the Grout Shaft. As part of this report, the potential further settlements due to the remainder of the ETH excavation were estimated. Figure 3.7.2 uses a simple empirical method to estimate the magnitude of movement for the excavation completed in Period E and that remaining in Period F and subsequently. The "final excavation" curve is taken from the contour in Figure 3.7.1. The "excavation -2 level" curve utilises the assumptions that the movements and the extent of movement are both proportional to the excavation depth. A maximum of about 15mm is shown at the wall for both stages, but the deeper part of the excavation produces a much wider flatter settlement trough.

The report was accepted and the grout shaft was de-commissioned from October 2014. There was no compensation grouting undertaken in either Period F or Period G.

Figure 3.7.1 Period G: Contour of settlement for ETH excavation excluding MasterPlan & North (mm). (supplied by C122)-

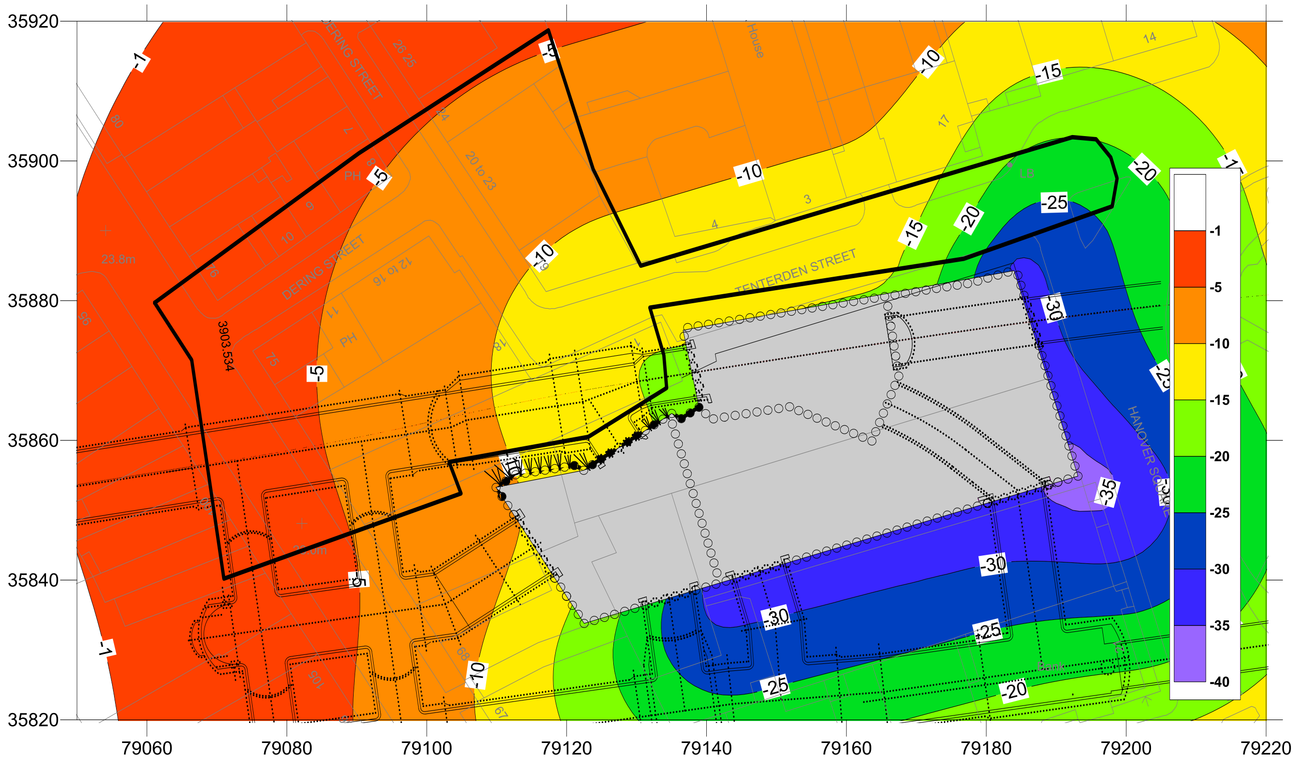


Figure 3.7.2 Period G: Estimate of settlement for ETH excavation post tunnelling

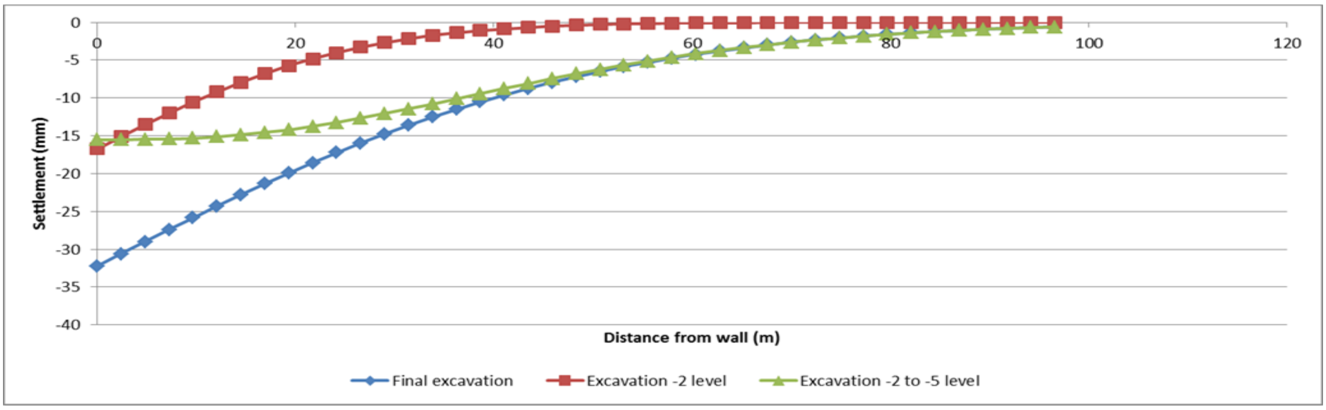


Figure 3.7.4(a) shows a maximum increase in settlement of ~5mm during the 3 months following the the completion of tunnelling (Period F). The 2.5mm contour covers a wide area to the west of the ETH indicating little change in slope within this area. The contours are also widely spaced in comparison to those in Figure 3.7.4(b).

The total settlement at the end of Period F is shown on Figure 3.7.4(b) with a maximum settlement of just over 55mm at the southern boundary of the GS3 arrays.

The grout shaft was de-commissioned during Period G and as a result the internal building monitoring (HLC) was discontinued. The contours presented in Figure 3.7.5 are based on BRE and PLP data only. Figure 3.7.5(a) shows a maximum increase in settlement of under 10mm over the ~1 year duration of Period G. The settlement is centred over the SCL tunnels with less than 5mm settlement adjacent to the ETH in the GS3 area.

The total settlement at the end of Period G is shown on Figure 3.7.5(b) with a maximum settlement of just over 65mm at the southern boundary of the GS3 arrays.

Figure 3.7.4 Period F: (a) Observed settlement in Period F (mm); (b) Total settlement (mm)

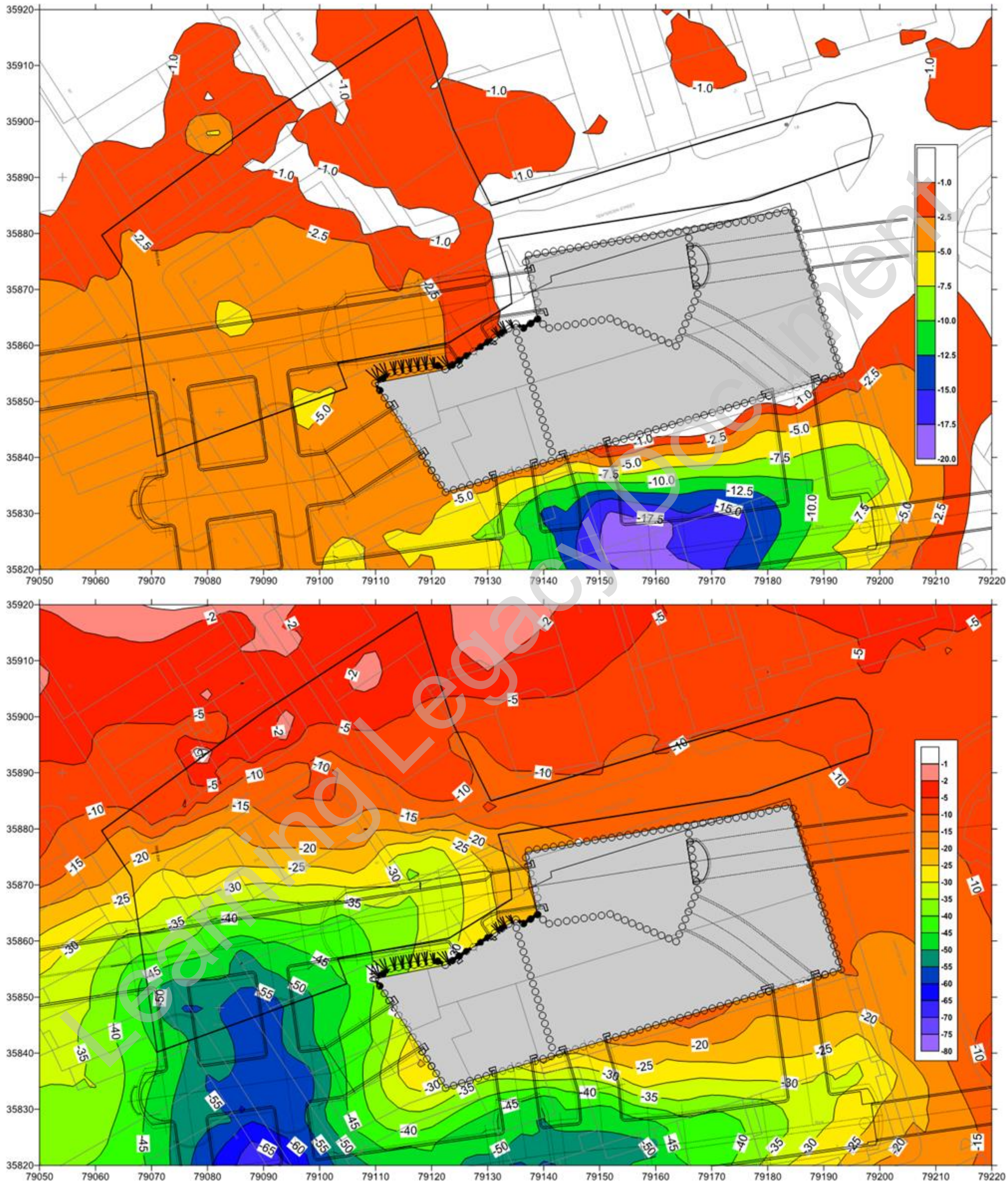
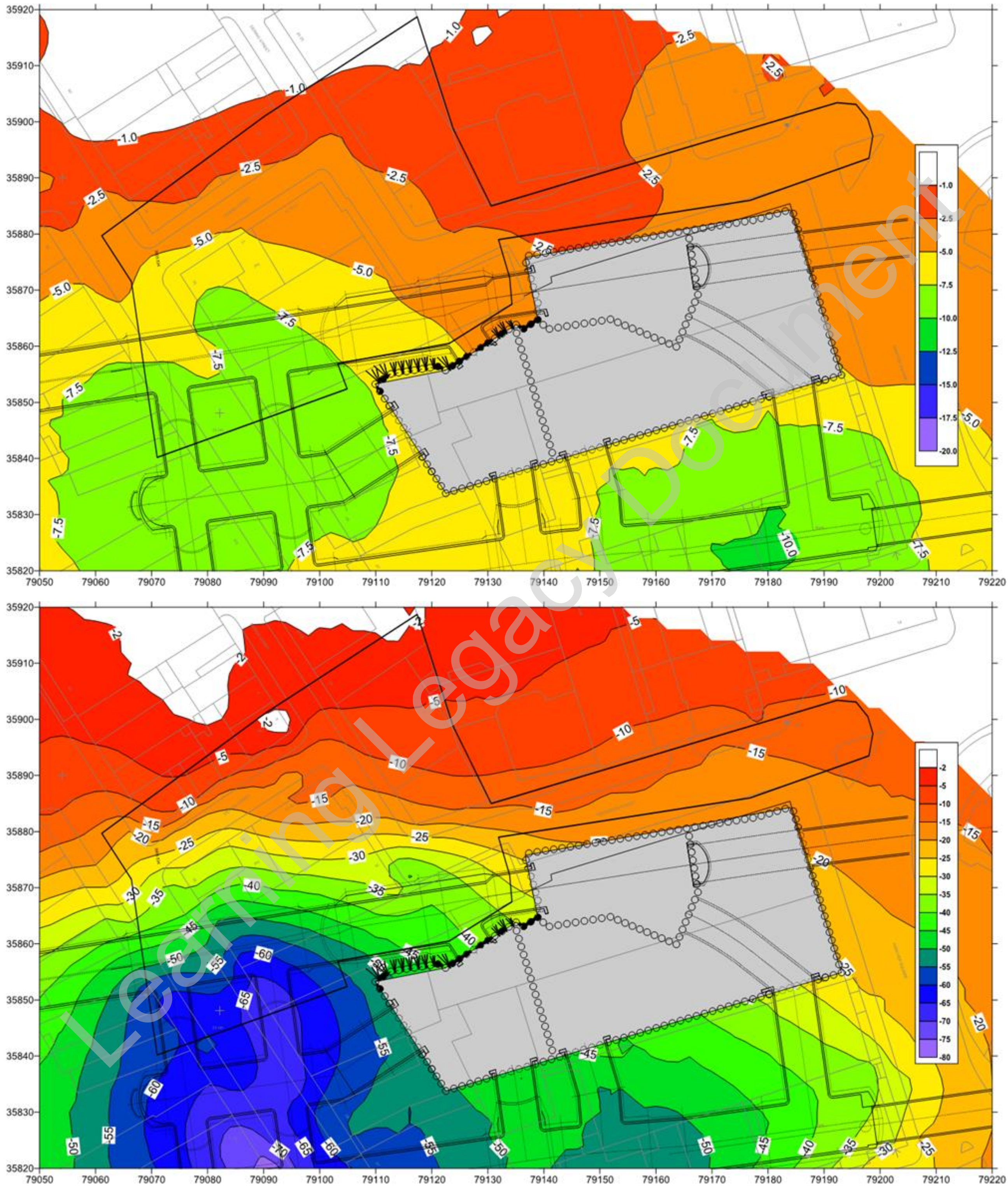


Figure 3.7.5 Period G: (a) Observed settlement in Period G (mm); (b) Total settlement (mm)



4. BUILDING SETTLEMENT AND SLOPES

4.1. Slope triggers

The locations where slope triggers have been exceeded are shown for BRE monitoring of building facades and PLP monitoring of kerb lines on Figure 4.1. A larger version of Figure 4.1 is included in Appendix B. Details are given in Table 4.1.

Slope triggers are as follows:

- GREEN 1:1250 0.8mm/m
- AMBER 1:1000 1.0mm/m
- RED 1:500 2.0mm/m

Figure 4.1. Locations where building slope triggers have been exceeded.

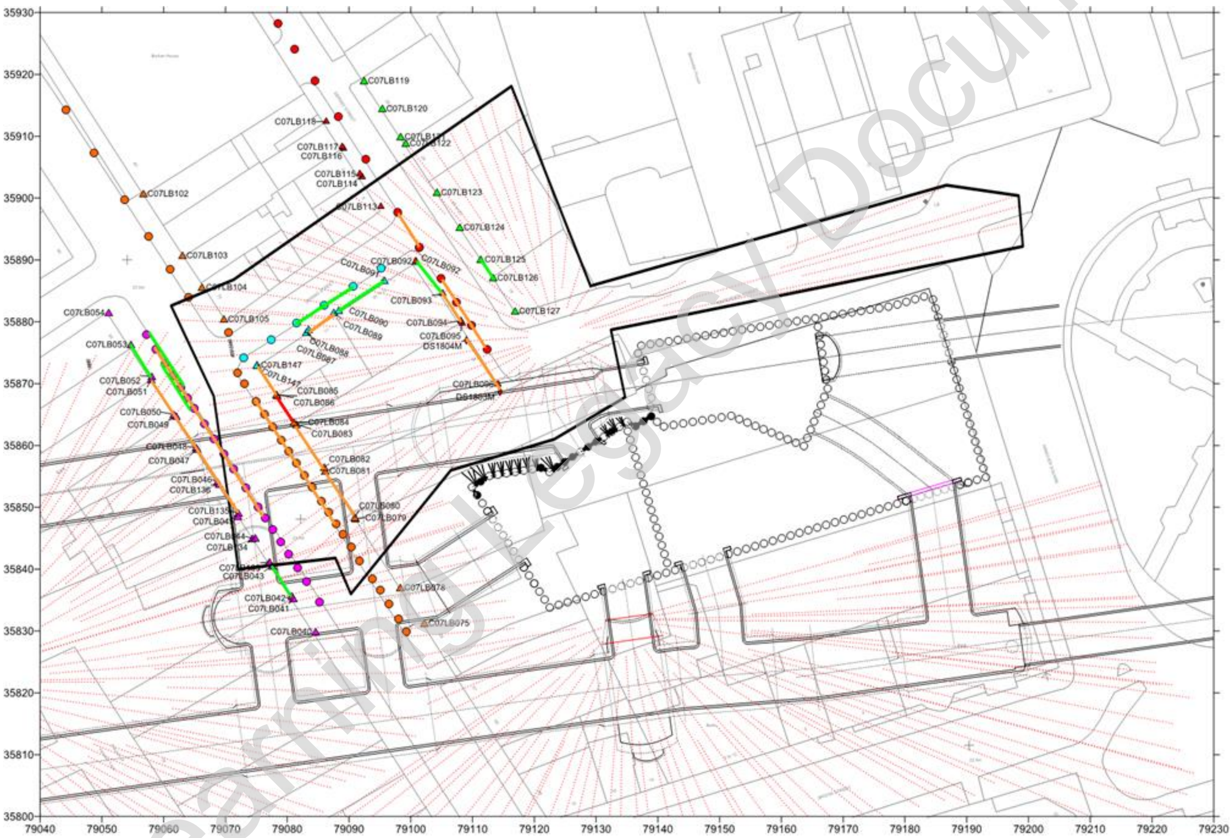


Table 4.1 Details of Amber and Red trigger breaches on BRE & HLC

Instruments	Building	Trigger Breach Dates				Slope	
		Amber		Red		Maximum	Final
		Start	Finish	Start	Finish	(mm/m)	(mm/m)
Dering Street - West							
C07LB093-C07LB094	12-16 Dering Street	14/06/2013	28/07/2015	-	-	1.43	1.36
DS1803M-DS1804M	18 Dering Street	24/04/2013	15/07/2015	-	-	1.77	1.77
Dering Street - South							
C07LB088-C07LB089	11 Dering Street	29/08/2014	28/07/2015			1.16	1.16
New Bond Street - East							
C07LB086-C07LB147	75 New Bond Street	23/01/2013	21/07/2015			1.39	1.23
C07LB084-C07LB085	74 New Bond Street	08/05/2014	13/07/2014	11/05/2014	21/07/2015	2.43	2.39
C07LB083-C07LB082	73 New Bond Street	15/08/2013	21/07/2015			1.88	1.59
C07LB081-C07LB080	72 New Bond Street	06/02/2014	09/05/2014			1.19	0.42

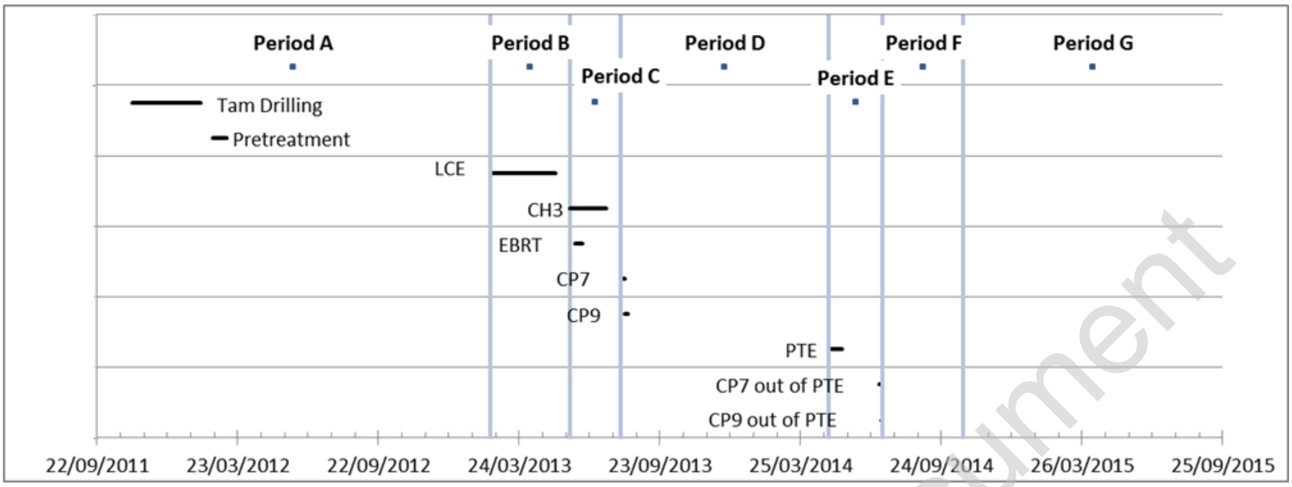
BRE monitoring data from the facades within the footprint of GS3 are presented in the following sections, namely New Bond Street east, Dering Street south, Dering Street north, Dering Street west, Dering Street east and Tenterden Street north. HLC data is used where no BRE data is available; namely, the southern end of the Dering Street west facade. The locations of the HLC on are shown on Figure 4.1. All HLC data presented is based on daily means.

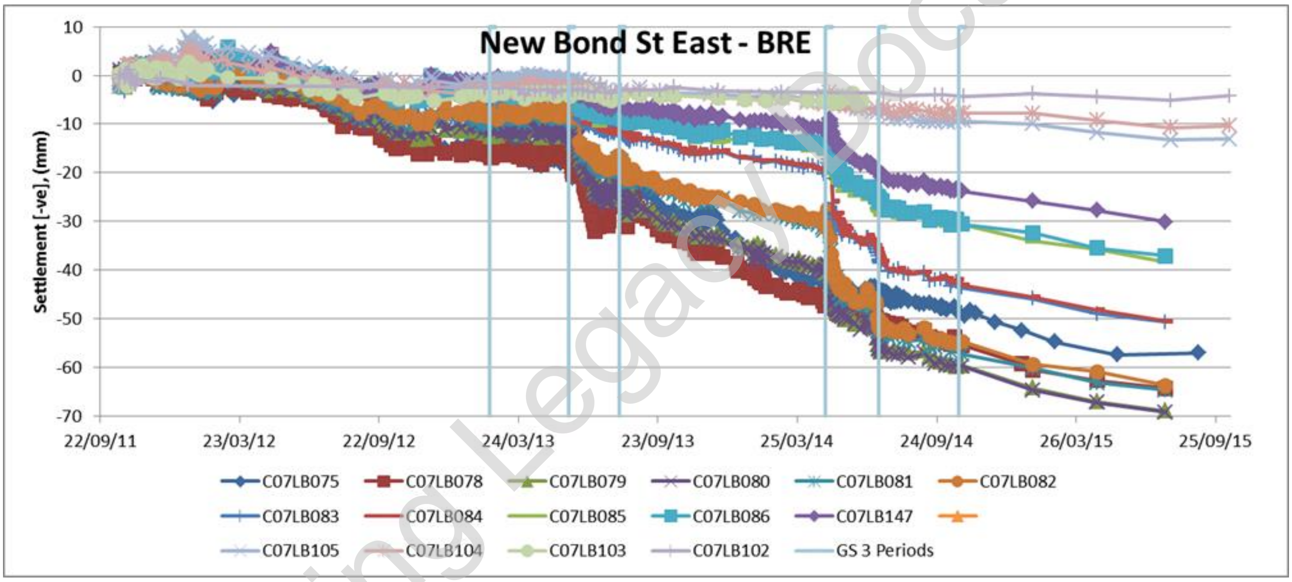
The GS3 arrays extend below the west façade of New Bond Street but the buildings to the west of New Bond Street are primarily within the GS2 area and the data is included in that report.

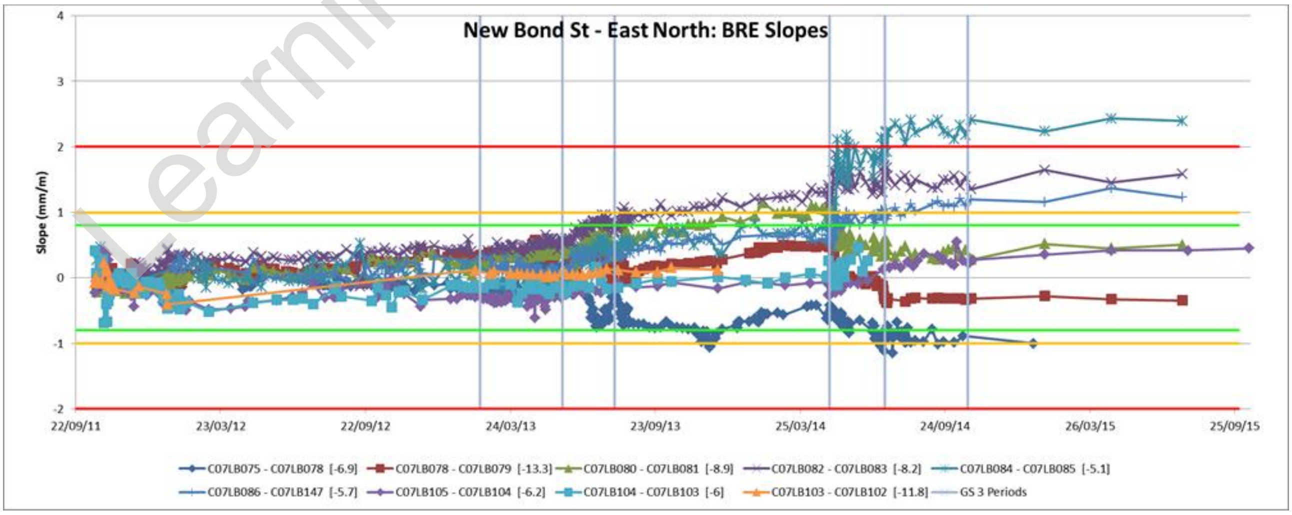
The plots presented for each façade comprise:

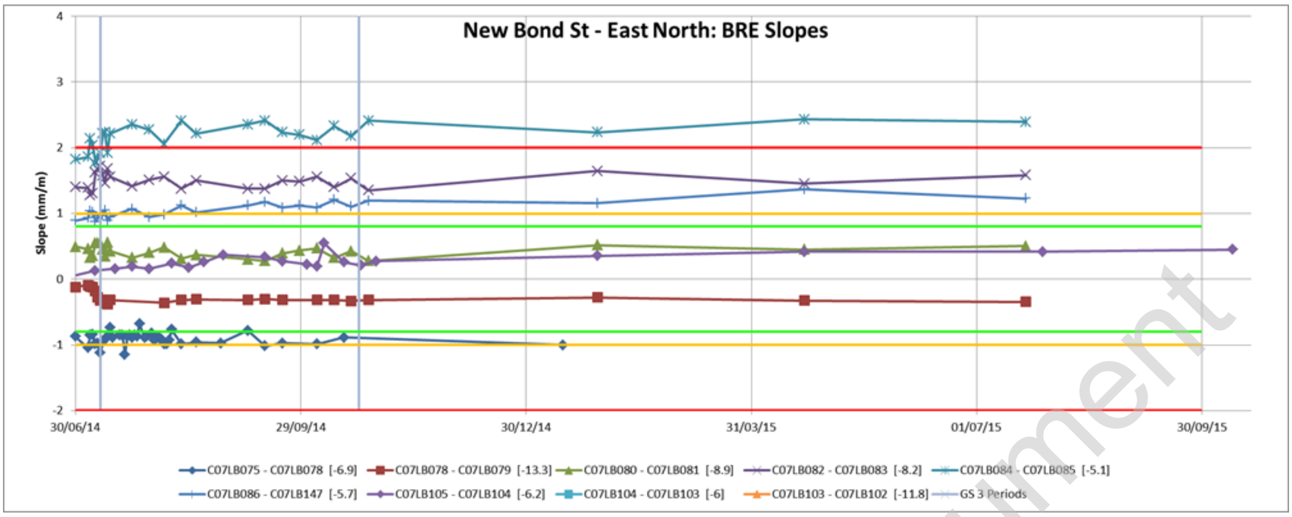
1. Summary of tunnel construction and associated construction periods.
2. Time settlement history (1 or 2 plots).
3. Settlement profile plots with a series as close as possible to the date of the end of each construction period.
4. Time slope history over the full construction period with the distances between the points in metres shown in the legend in square brackets.
5. Time slope history since the completion of tunnelling i.e. construction Period G.
6. Deflection ratio plots are provided as necessary.

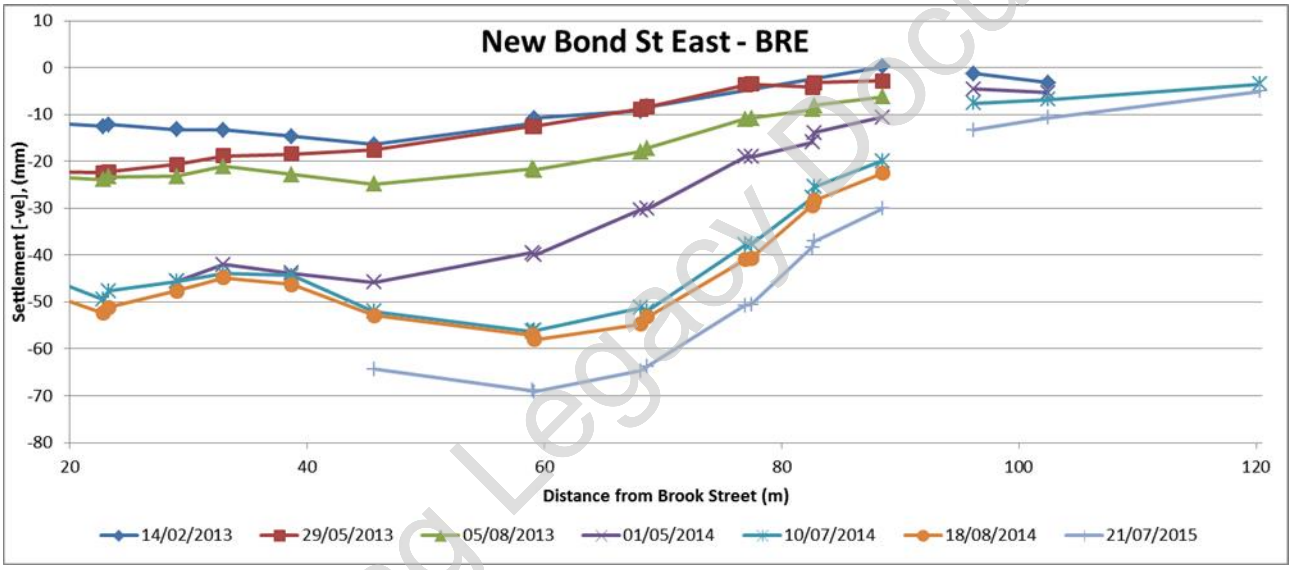
4.2. New Bond Street – East







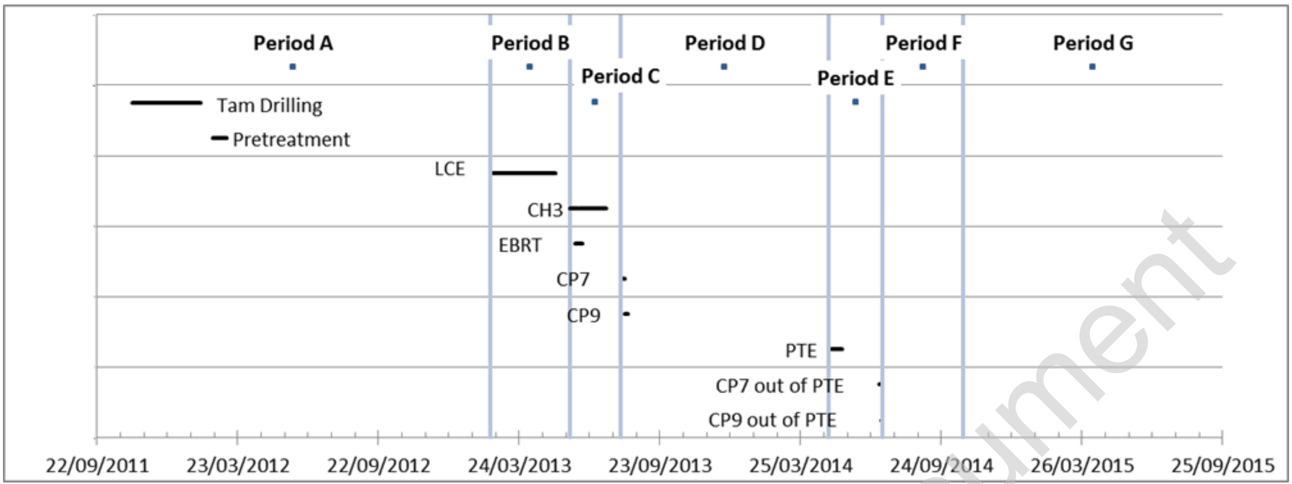


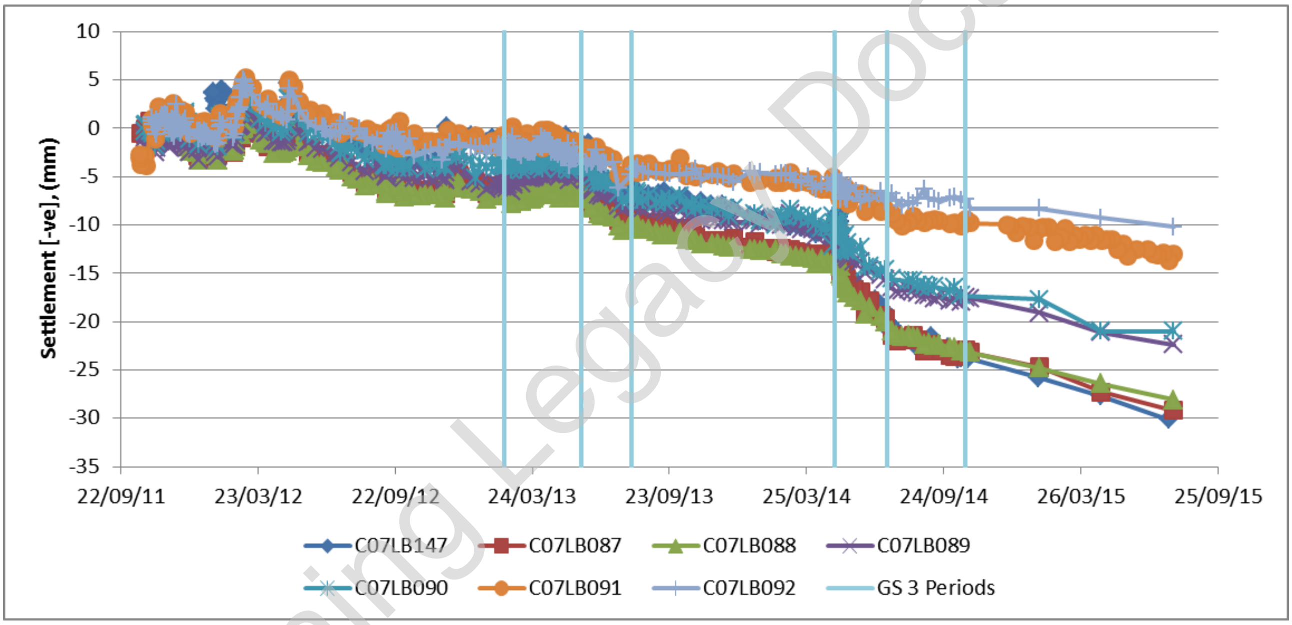


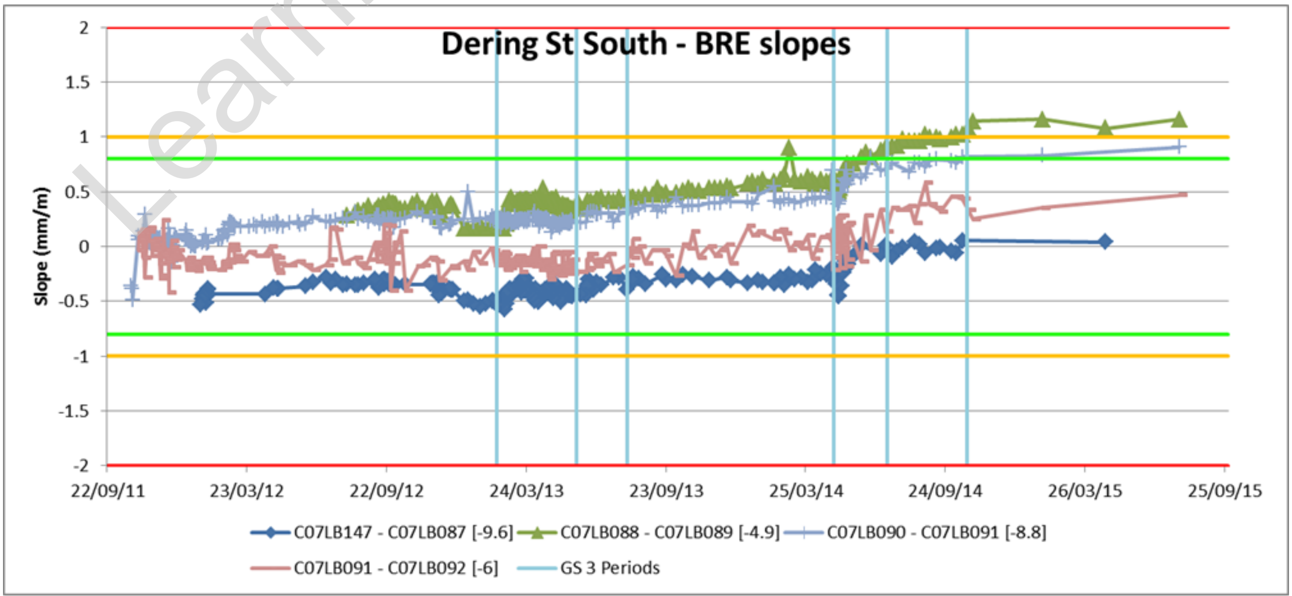
The following points are noted:

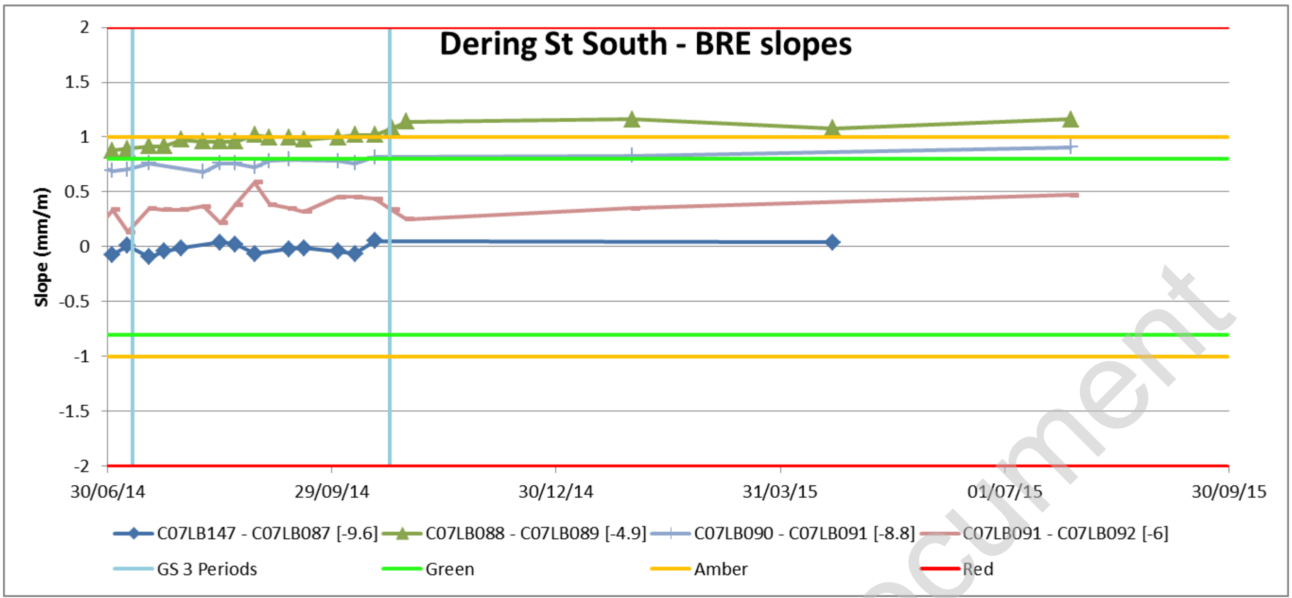
- The New Bond Street east façade is partly covered by GS3 but also partly by GS2 and GS5 arrays.
- The key events are the EBRT and CH3 in Period C and PTE in Period E. Settlement had increased to a maximum of 17mm prior to tunnelling and only increased by a few millimetres due to the LCE excavation. Settlement was less than 20mm prior to the EBRT and CH3 in Period C. During Period C the maximum settlement exceeded 30mm, but grout jacking reduced this to about 25mm at the end of the period. At the beginning of Period D, the construction of CP7 and CP9, together with grout jacking, produced negligible change in settlement. Over the remaining 7 months of Period D consolidation settlement of around 20mm increased the maximum settlement to 45mm. In Period E, the construction of PTE and the connections to CP7 and CP9 produced about 15mm increase, however, the location of the maximum settlement changed resulting in a maximum settlement of 56mm.
- Post construction settlement continued to increase and reached 60mm within about 3 months to October 2014 (Period F) and 69mm by July 2015 when monitoring was terminated.
- The rate of post construction settlement was approximately constant to the end of Period F. In Period G, from about October 2014, there has been an apparent small increase in rate albeit confirmed by few sets of readings. ETH excavation has continued in Period G. The maximum average rate of settlement over a 9 month period is 7mm/year.
- The profile plot confirms that the consolidation settlement is relatively uniform over a wide area resulting in little change in slopes.
- Three slope triggers have occurred as listed in Table 4.1. Post construction the slopes are constant or increasing very gradually. By inspection, there are no deflection ratio triggers.

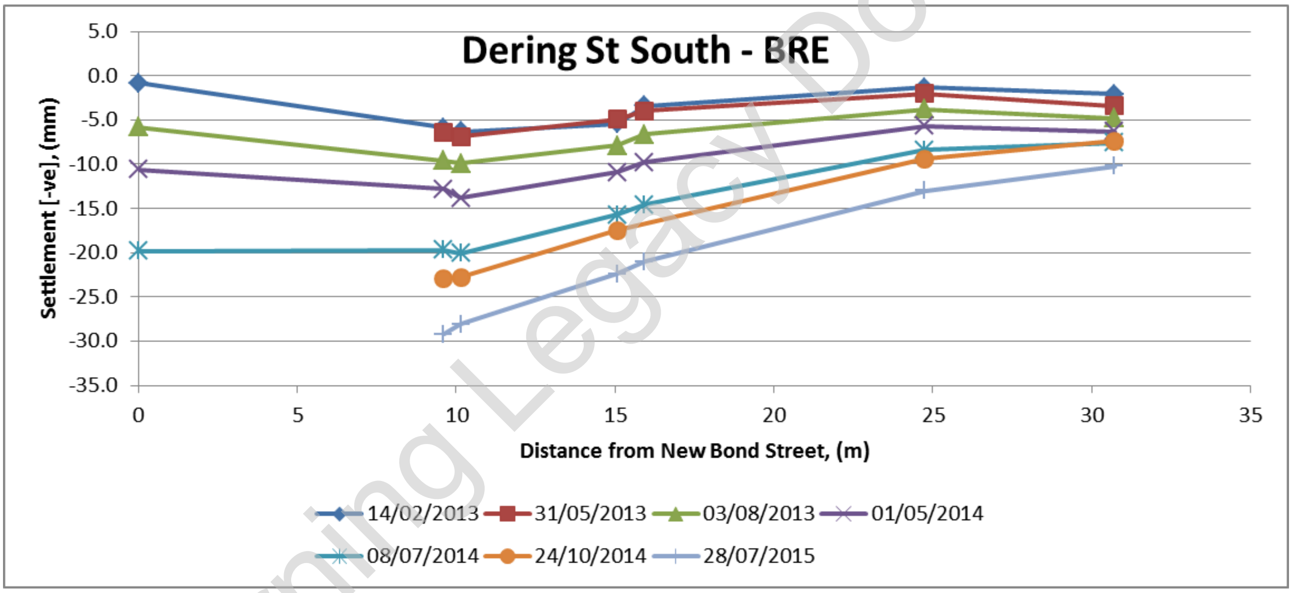
4.3. Dering Street - South







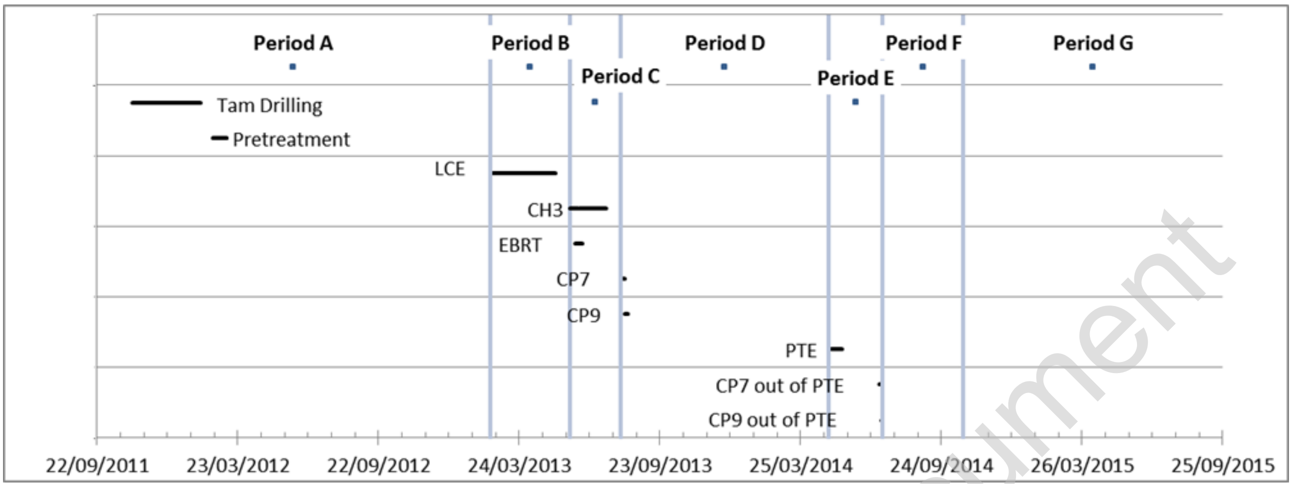


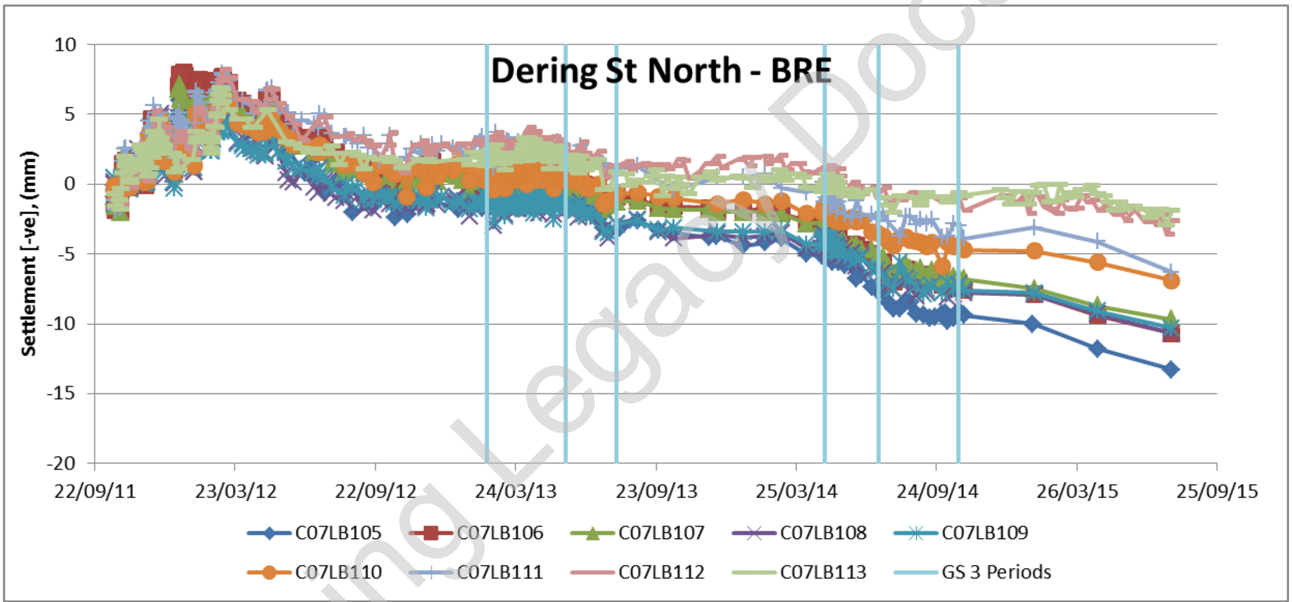


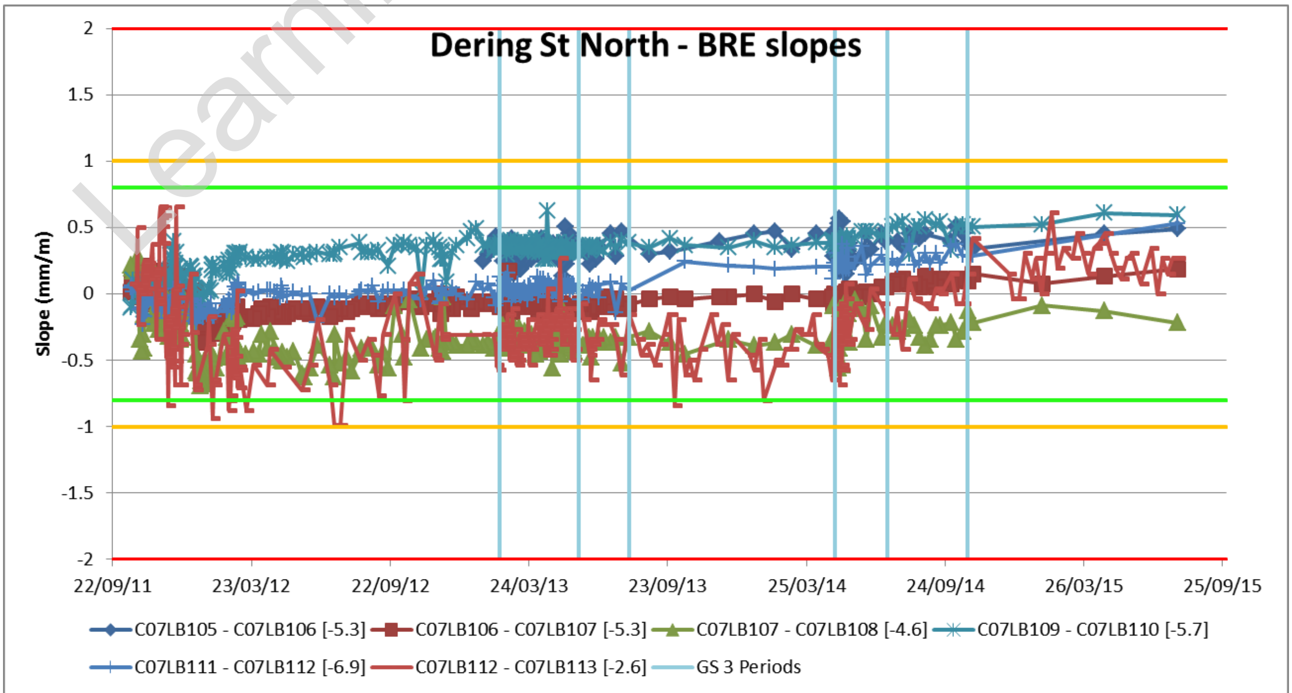
The following points are noted:

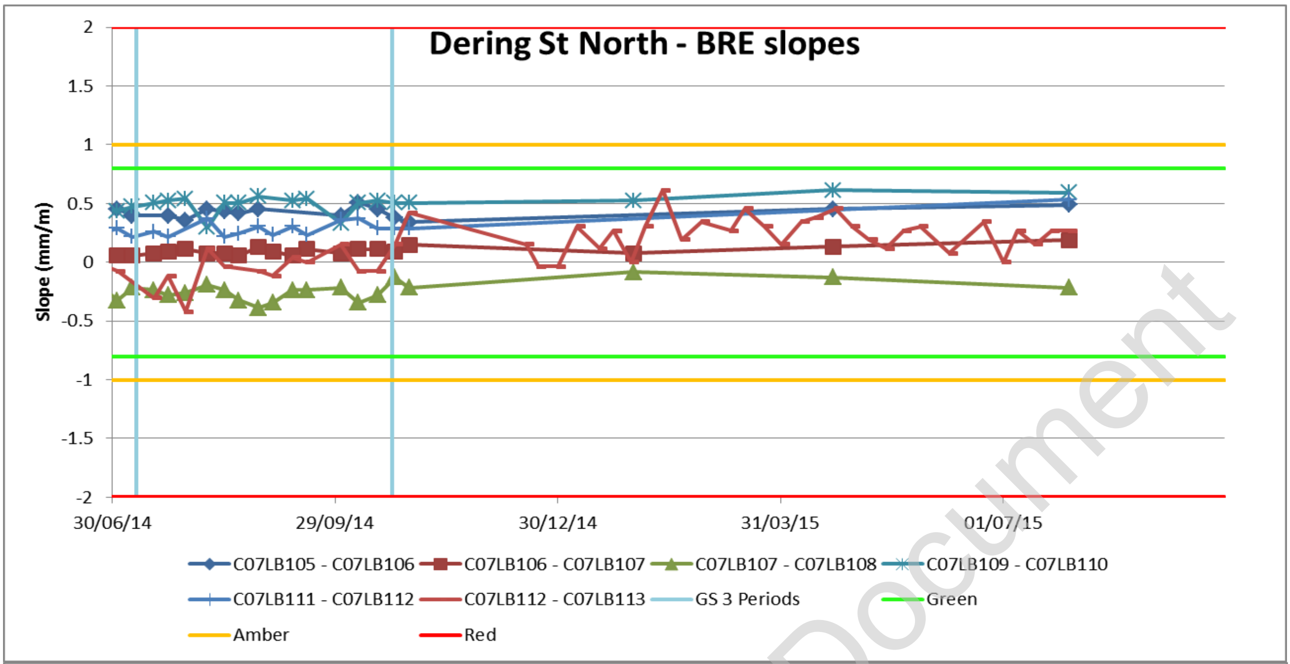
- The Dering Street south façade is fully within the plan extent of the GS3 array.
- The key events are the EBRT in Period C and PTE in Period E. In Period A heave is evident associated with TaM drilling and pre-treatment. During the remainder of Period A, settlement increased to 7mm prior to tunnelling. The construction of LCE in Period B with concurrent grouting produced negligible change in movement. The EBRT and subsequent consolidation settlement increased the maximum settlement to about 14mm at the end of Period D. As a result of PTE excavation in Period E settlement had increased to 20mm.
- Post construction consolidation increased settlement by ~3mm in 3 months (Period F) and a further 6mm in the following 9 months (Period G), equivalent to 8mm/year. The settlement during Period F was sufficient to generate 1 amber trigger between points C07LB088 - C07LB089 (distances 10 to 15m), as listed in Table 4.1.
- The rate of post construction settlement has been approximately constant. It is noted that ETH excavation has continued within Period G.
- The profile plot confirms that the post tunnelling settlement is relatively uniform over a wide area resulting in little change in slopes.
- The amber slope trigger occurred due to post construction movements. The slopes are essentially constant within the repeatability of the data. By inspection, there are no deflection ratio triggers.

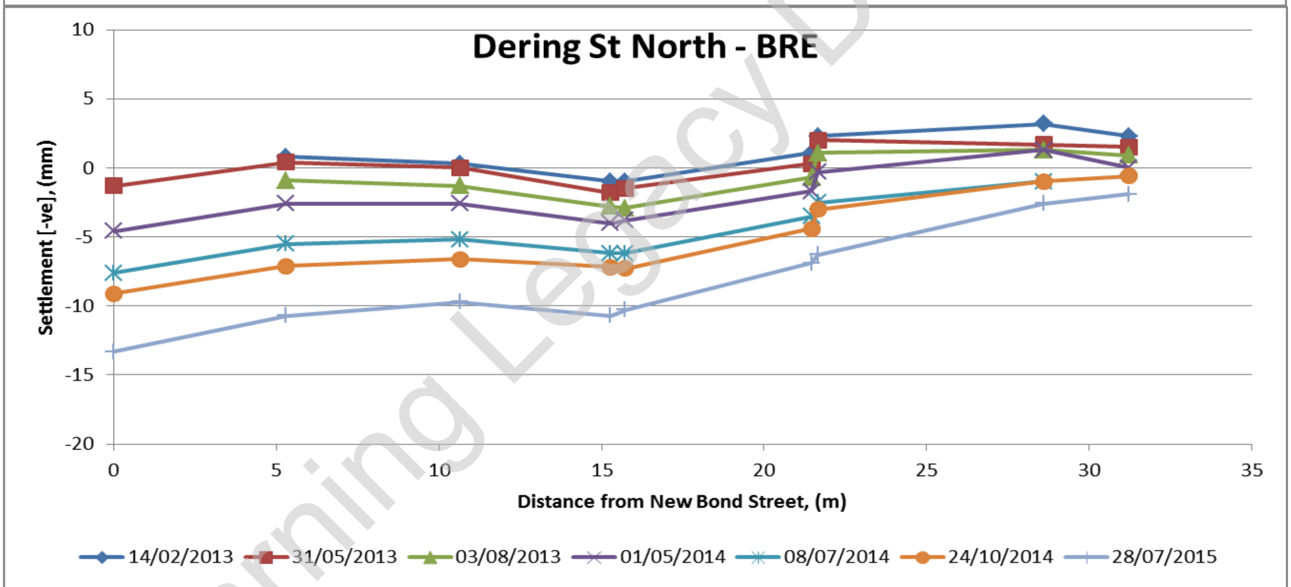
4.4. Dering Street - North







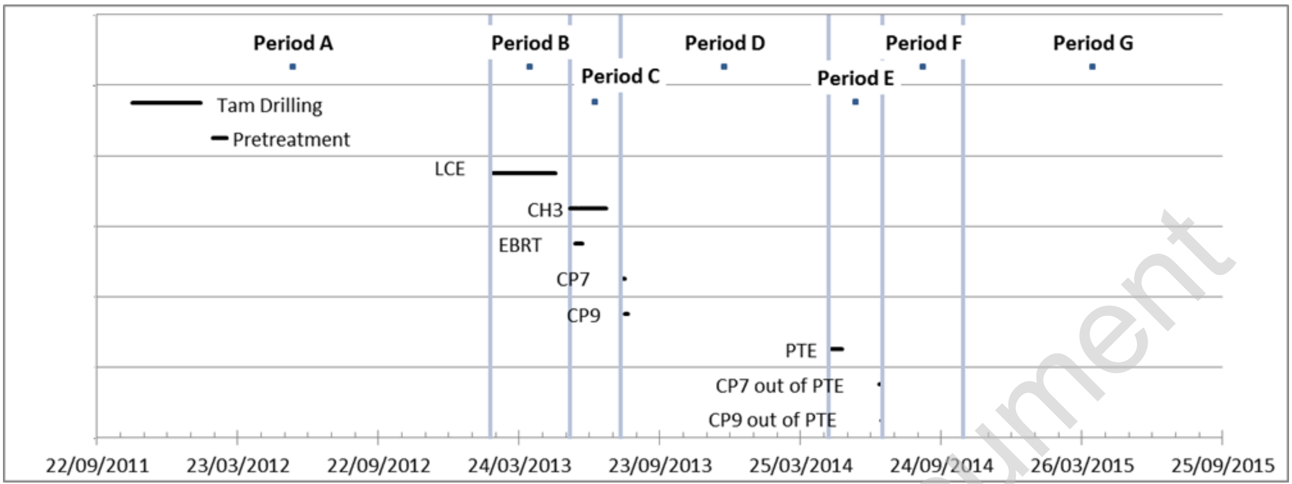


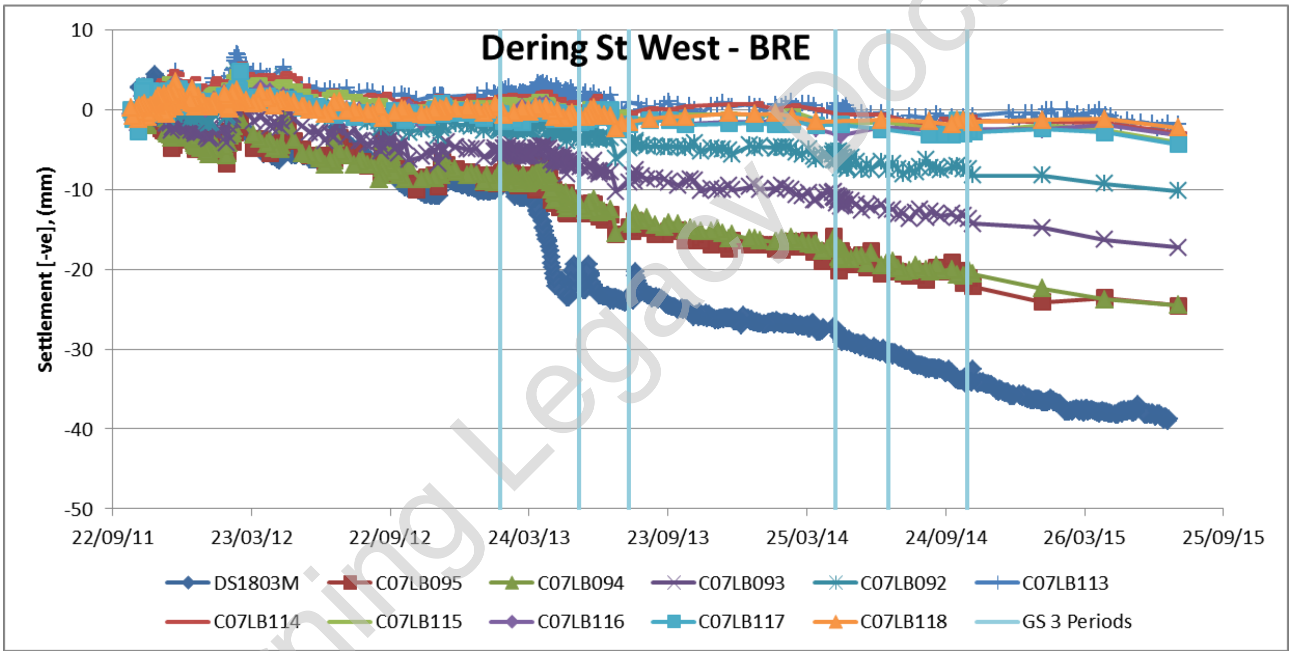


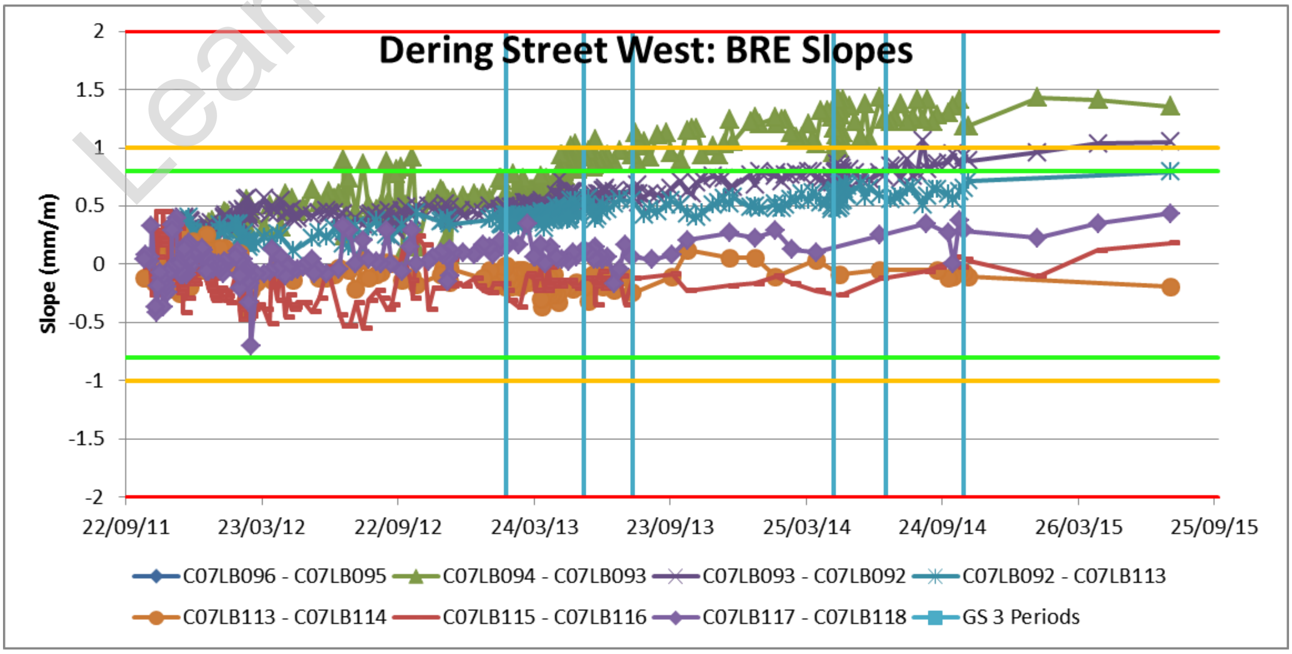
The following points are noted:

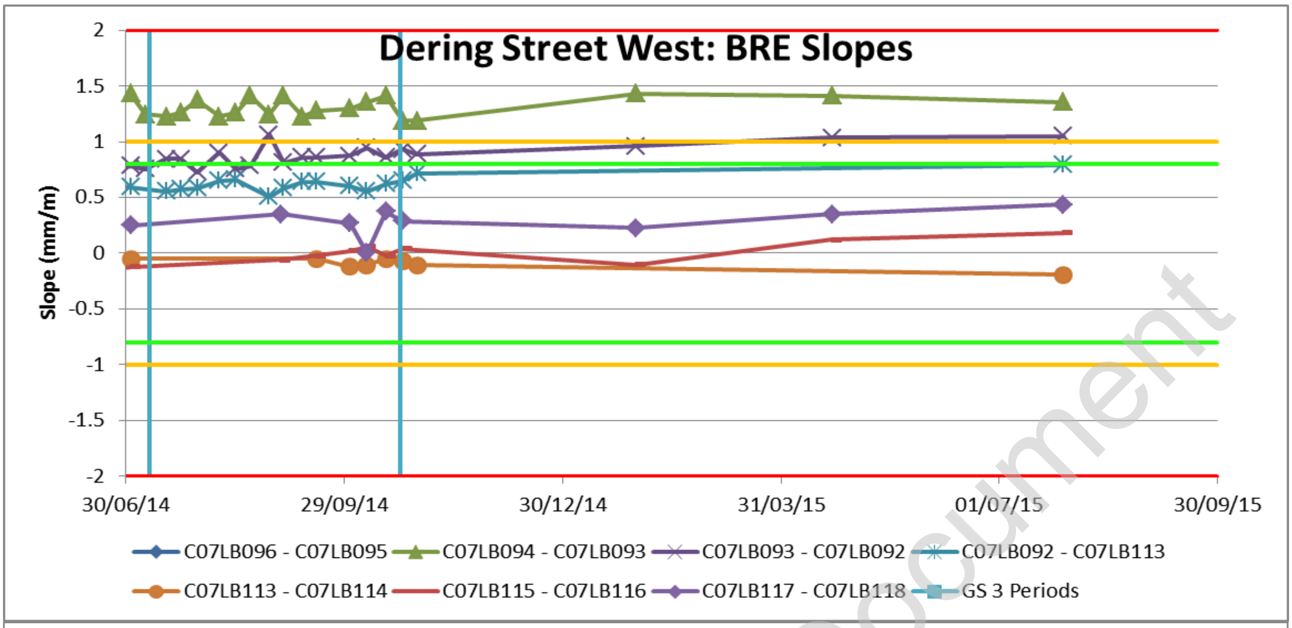
- The Dering Street north façade is within the plan extent of the GS3 array which extends approximately 5m beneath the building line.
- The key events are the EBRT in Period C and PTE in Period E. In Period A heave is evident associated with TaM drilling and pre-treatment. During the remainder of Period A, the heave reduced to give a net maximum settlement of 2mm prior to tunnelling. The construction of LCE in Period B with concurrent grouting produced negligible change in movement. The EBRT (Period C) and subsequent consolidation settlement (Period D) increased the maximum settlement to about 5mm at the end of Period D. As a result of PTE excavation in Period E settlement had increased to 8mm.
- Post construction consolidation increased settlement by ~2mm in 3 months (Period F) and a further 3mm in the following 9 months (Period G), equivalent to 4mm/year. The rate of post construction settlement has been approximately constant. It is noted that ETH excavation has continued within Period G.
- The profile plot confirms that the post tunnelling settlement is relatively uniform over a wide area resulting in little change in slopes.
- No slope triggers have occurred. The slopes are essentially constant within the repeatability of the data. By inspection, there are no deflection ratio triggers.

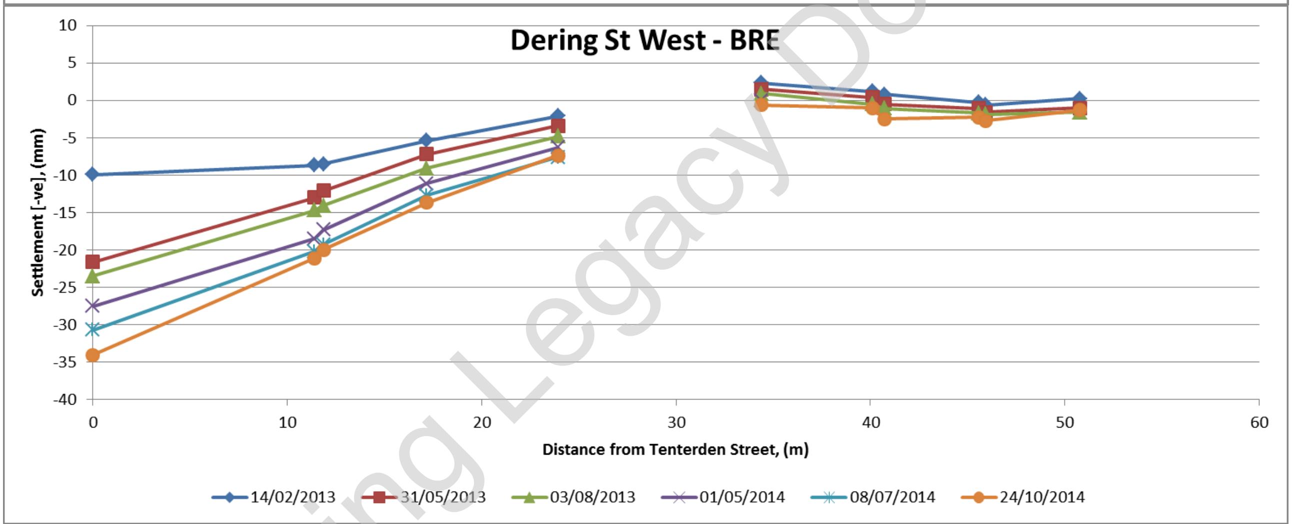
4.5. Dering Street - West







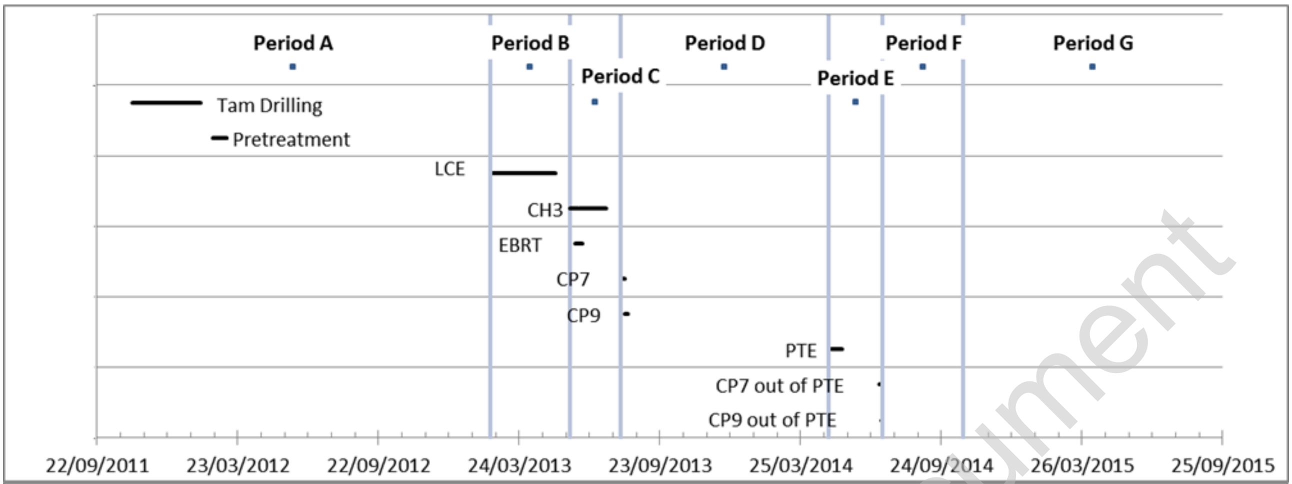


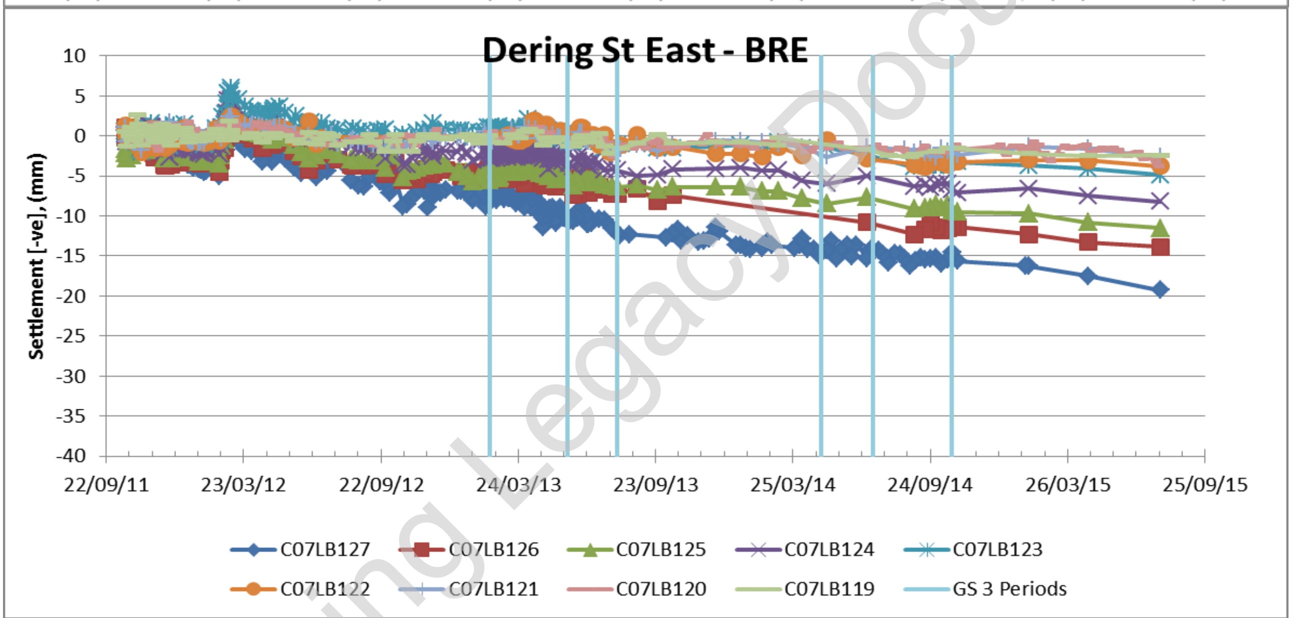


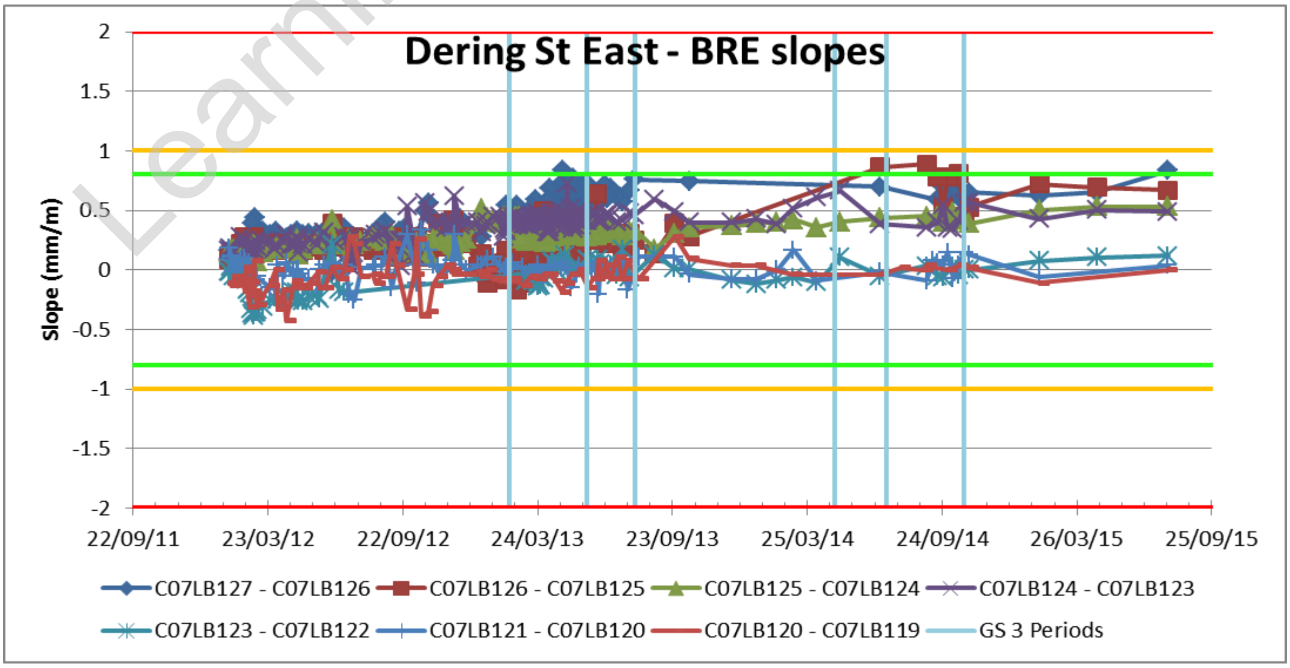
The following points are noted:

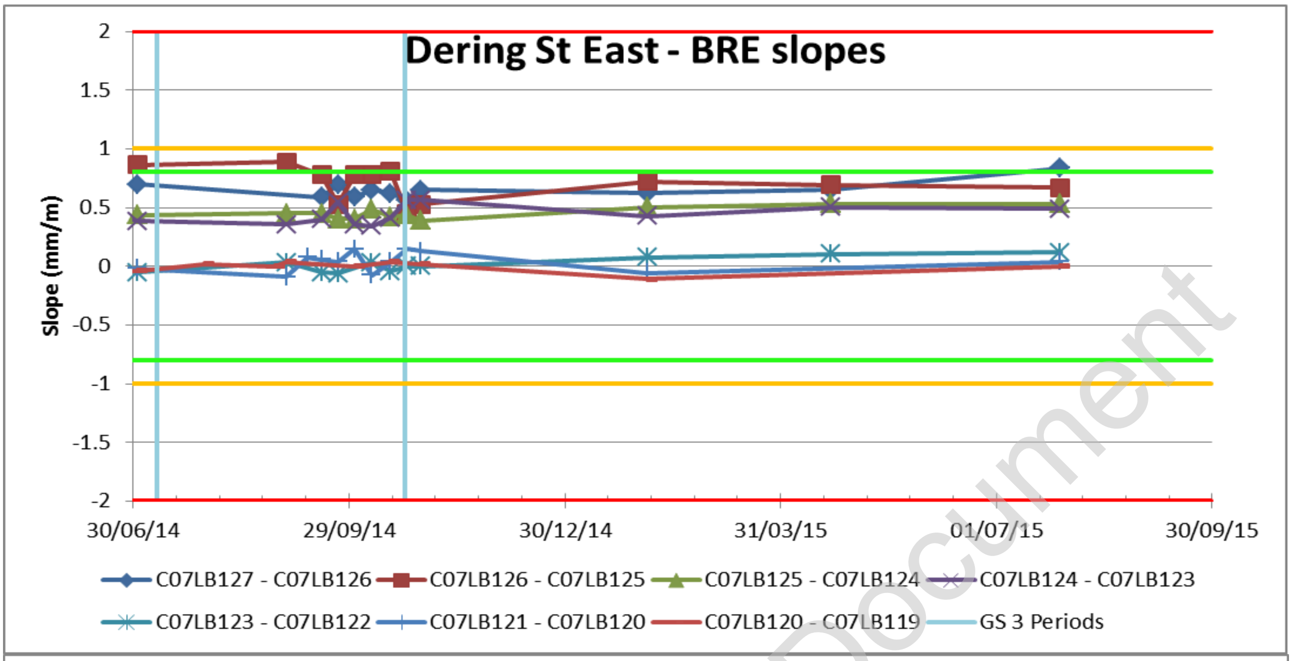
- The Dering Street west façade is mostly within the plan extent of the GS3 array which extends just to the north of the east-west arm of Dering Street (approximately 5m beneath the building line of the north façade).
- The key events are the LCE in Period B and PTE in Period E. In Period A settlement associated with TaM drilling and heave associated with pre-treatment are evident. During the remainder of Period A, the settlement increased despite a number of episodes of grout jacking, reaching 10mm prior to tunnelling.
- The construction of LCE in Period B with concurrent grouting produced a significant increase in movement to 23mm due to the exclusion zone preventing full injections in this area. Subsequent grout jacking reduced the settlement to around 20mm at the end of Period B. The EBRT (Period C) was driven through the back-filled (foam concrete) LCE and had no significant effect. Consolidation settlement (Periods C and D) was controlled by grout jacking and increased settlement by ~8mm to a maximum settlement to about 28mm at the end of Period D. As a result of PTE excavation in Period E settlement had increased to 31mm.
- Post construction consolidation increased settlement by ~2mm in 3 months (Period F) and a further 3mm in the following 9 months (Period G), equivalent to 4mm/year. The rate of post construction settlement has been approximately constant. It is noted that ETH excavation has continued within Period G.
- The profile plot confirms that the post tunnelling settlement is relatively uniform over a wide area resulting in little change in slopes.
- Two slope triggers have occurred as detailed in Table 4.1. Post construction, the slopes are essentially constant within the repeatability of the data. By inspection, there are no deflection ratio triggers.

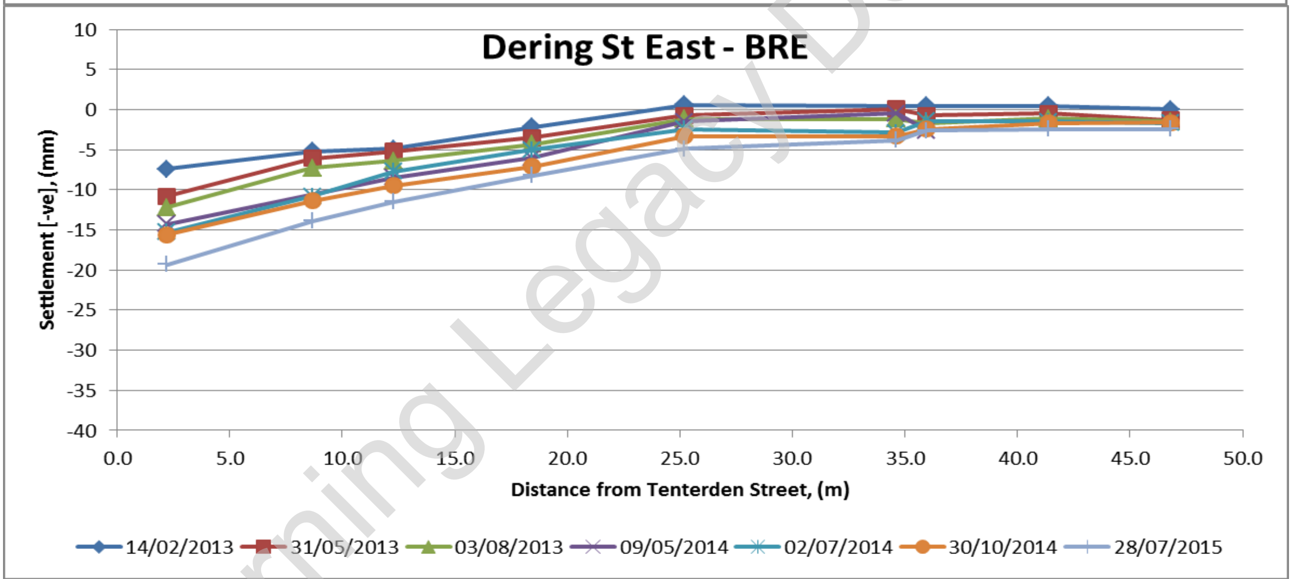
4.6. Dering Street - East







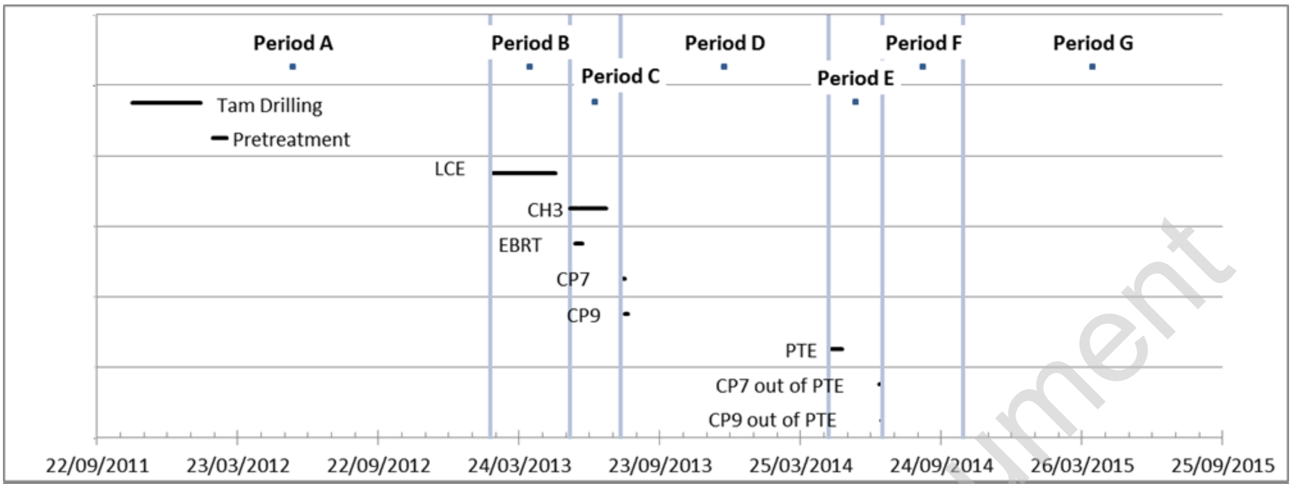


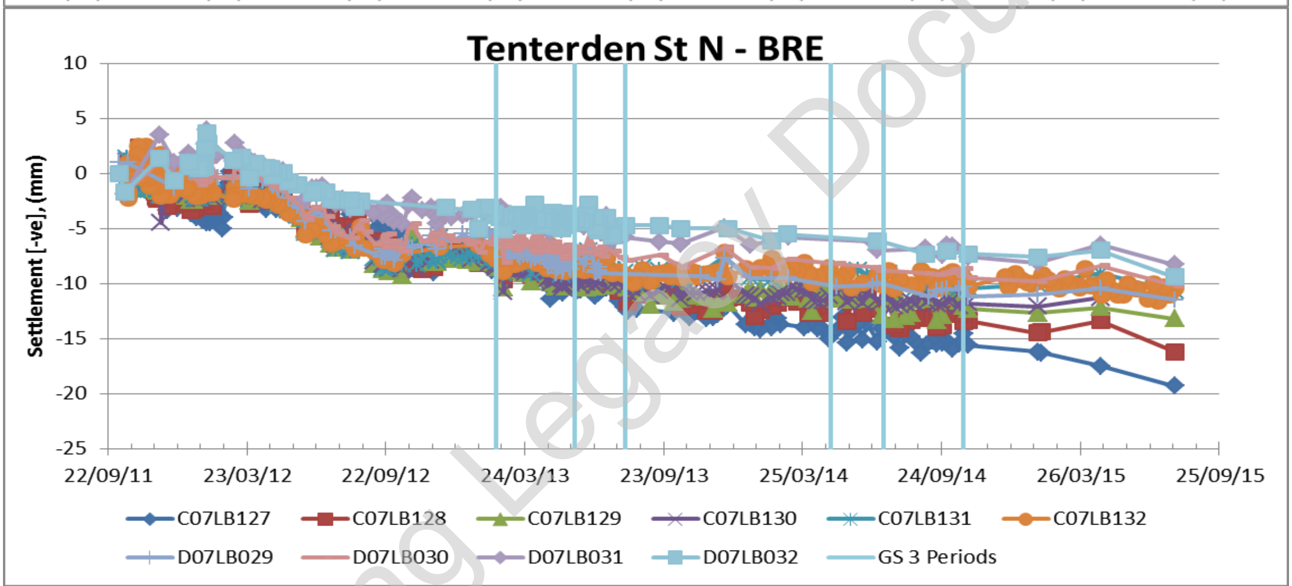


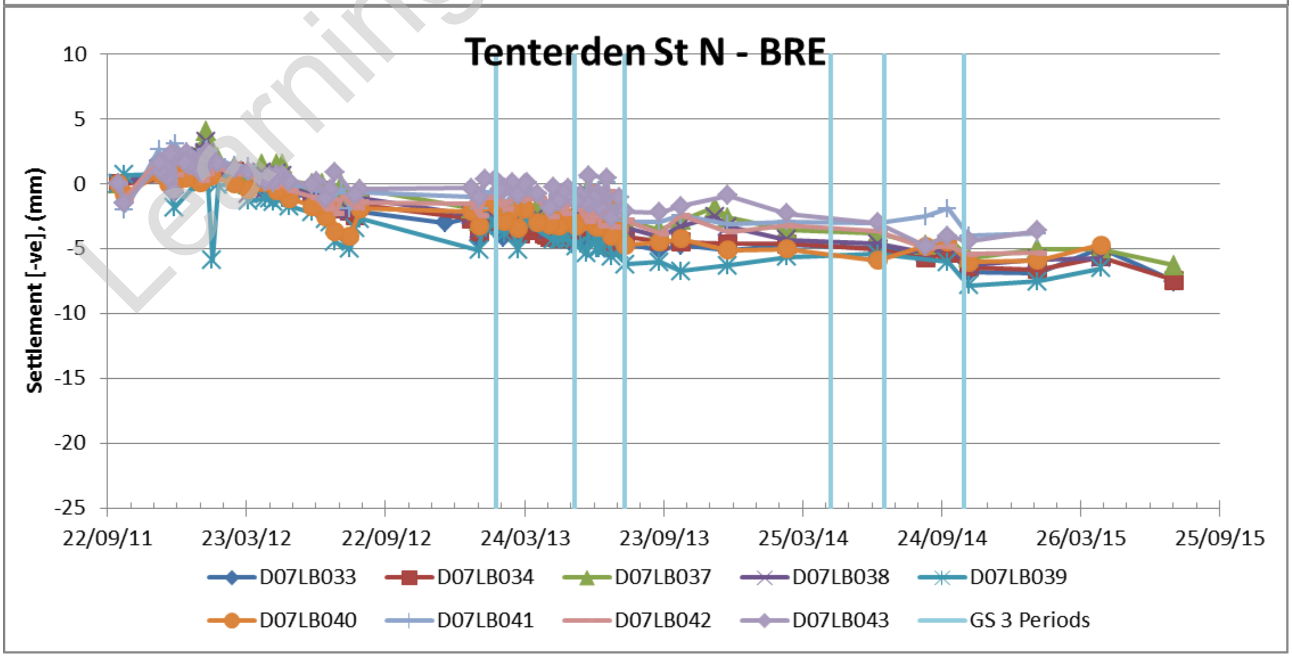
The following points are noted:

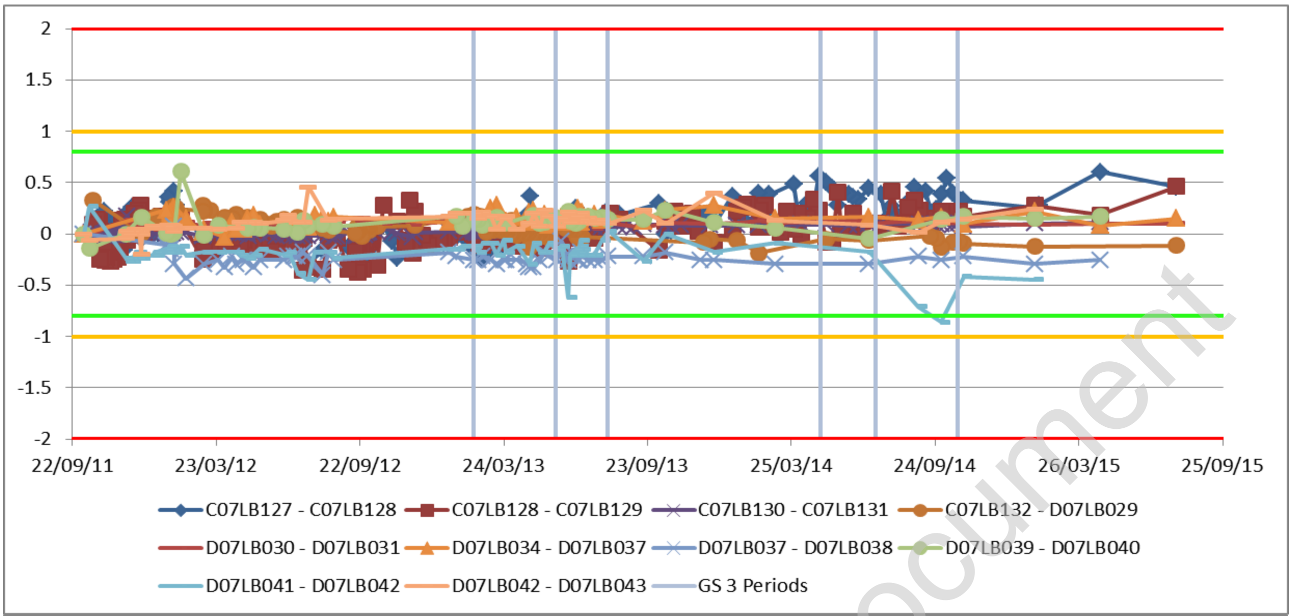
- The Dering Street east façade is within the plan extent of the GS3 array which extends just to the north of the east-west arm of Dering Street (approximately 5m beneath the building line of the north façade).
- Movements are generally small, reaching only 15mm at the end of construction. Approximately 50% (~8mm) settlement was recorded prior to the commencement of tunnelling. In Period A settlement associated with TaM drilling and heave associated with pre-treatment are evident. During the remainder of Period A, the settlement increased probably associated with works by others.
- The construction of LCE in Period B produced a maximum of 3mm settlement. The EBRT (Period C) was driven through the back-filled (foam concrete) LCE and North-west shaft of the ETH and had no significant effect. Consolidation settlement increased settlement to a maximum settlement to about 15mm at the end of Period E.
- Post construction consolidation increased settlement by ~1mm in 3 months (Period F) and a further 3mm in the following 9 months (Period G), equivalent to 4mm/year. The rate of post construction settlement has been approximately constant. It is noted that ETH excavation has continued within Period G.
- The profile plot confirms that the post tunnelling settlement is relatively uniform over a wide area resulting in little change in slopes.
- No slope triggers have occurred. Post construction, the slopes are essentially constant within the repeatability of the data. By inspection, there are no deflection ratio triggers.

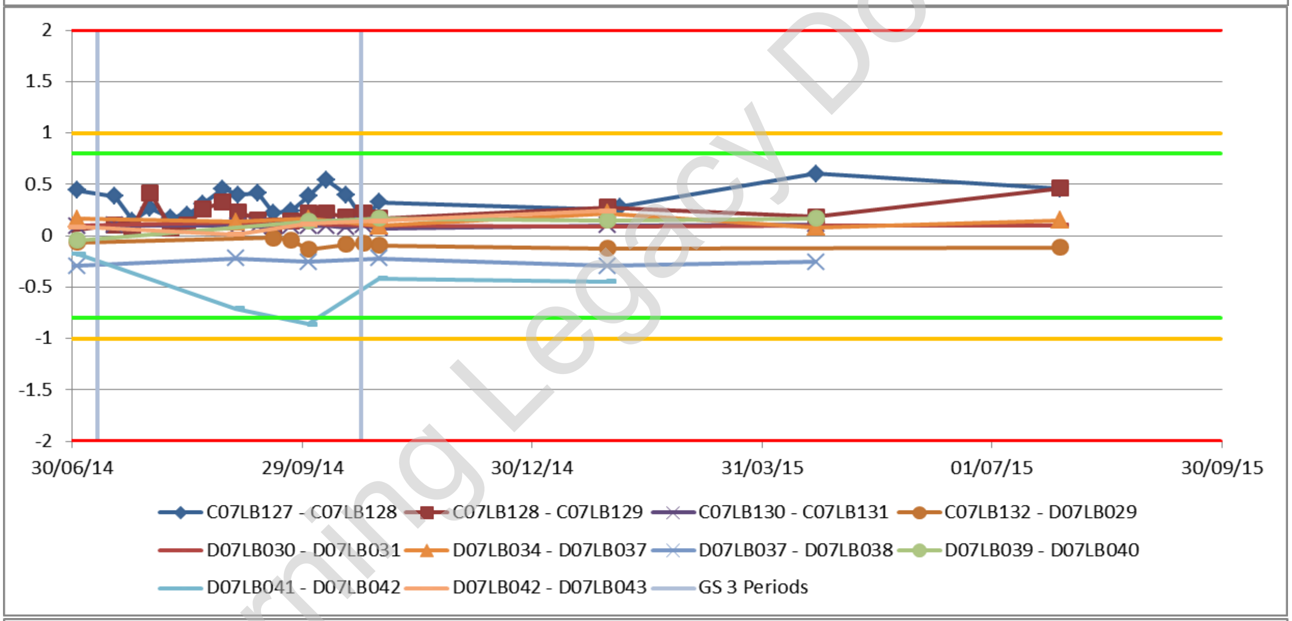
4.7. Tenterden Street – North

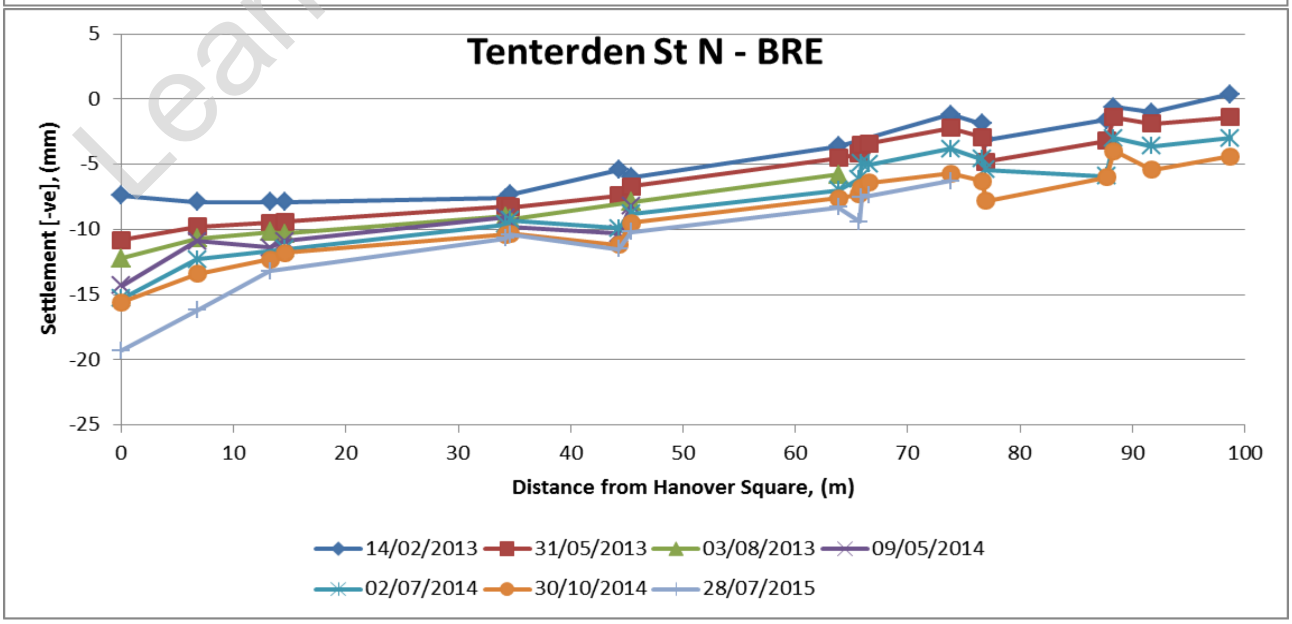












The following points are noted:

- The majority of the Tenterden Street north façade is just outside the plan extent of the GS3 array since most of the buildings have piled foundations. The exception if 19 Dering Street at the western end.
- Movements are generally small, reaching only 15mm at the end of construction. Approximately 50% (~8mm) settlement was recorded prior to the commencement of tunnelling. In Period A settlement associated with TaM drilling and heave associated with pre-treatment are evident. During the remainder of Period A, the settlement increased probably associated with works by others.
- The construction of LCE in Period B produced a maximum of 3mm settlement. The EBRT (Period C) was driven through the back-filled (foam concrete) LCE and North-west shaft of the ETH and had no significant effect. Consolidation settlement increased settlement to a maximum settlement to about 15mm at the end of Period E.
- Post construction consolidation increased settlement by ~1mm in 3 months (Period F) and a further 3mm in the following 9 months (Period G), equivalent to 4mm/year. The rate of post construction settlement has been approximately constant. It is noted that ETH excavation has continued within Period G.
- The profile plot confirms that the post tunnelling settlement is relatively uniform over a wide area resulting in little change in slopes.
- No slope triggers have occurred. Post construction, the slopes are essentially constant within the repeatability of the data. By inspection, there are no deflection ratio triggers.

5. GROUND SETTLEMENT AND SLOPES

5.1. Slope Triggers

The locations where slope triggers have been exceeded are shown for PLP monitoring of ground level on Figure 5.1. A larger version of Figure 5.1 is included in Appendix B. Details are given in Table 5.1.

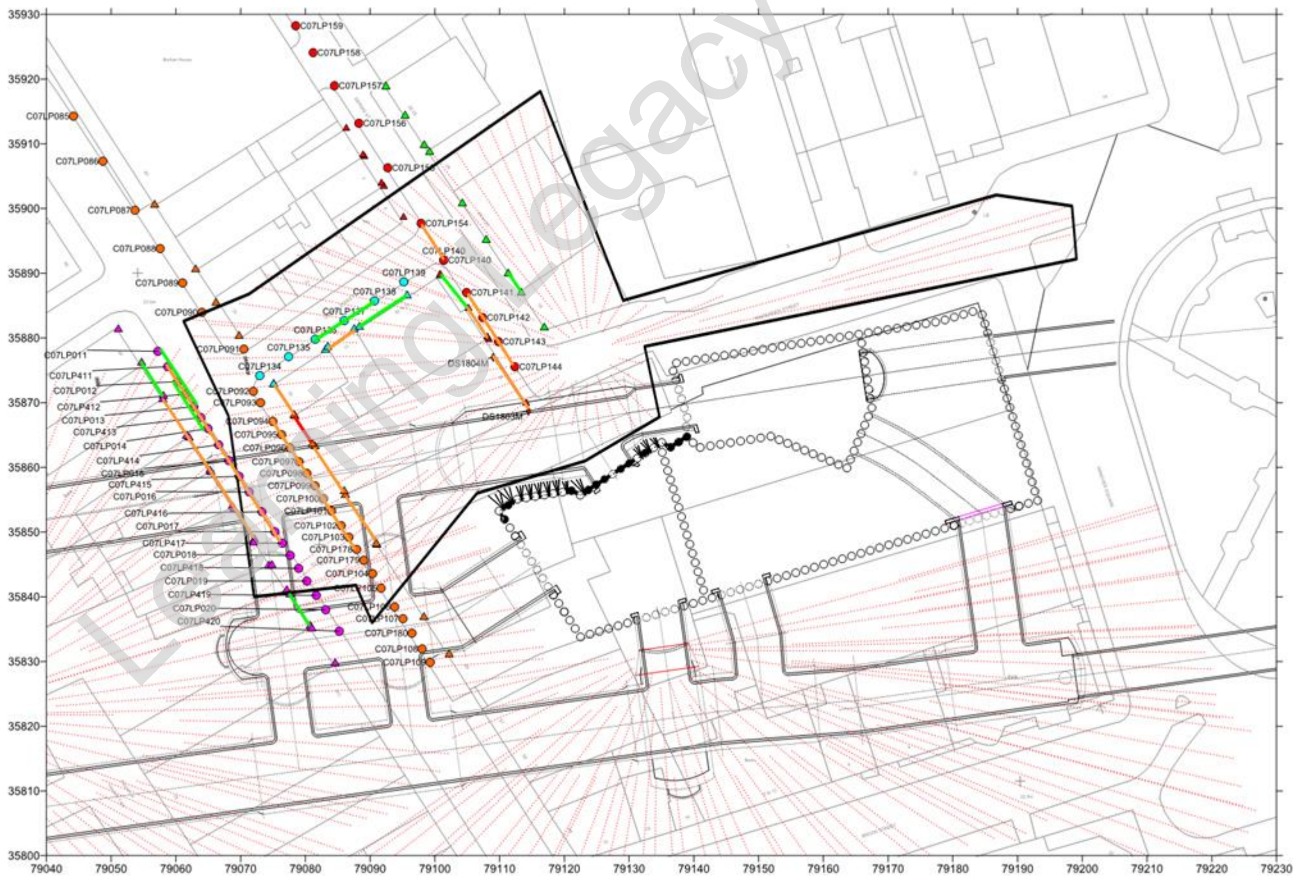
Slope triggers are as follows:

- GREEN 1:1250 0.8mm/m
- AMBER 1:1000 1.0mm/m
- RED 1:500 2.0mm/m

Comparison of Figures 4.1 and 5.1 shows that slope triggers on buildings and on the ground have occurred in similar locations. This is as expected since no significant differential between building settlement and the adjacent pavements has been identified at reviews during construction. Consequently the commentary on the PLP monitoring data is essentially similar to that for the BRE data presented in Section 4.

The GS2 arrays were extended below the east side of New Bond Street as a result of the adoption of the Masterplan shaft creating a “shadow” triangle where TaMs could not be installed from Gs3 or GS5. However, since the buildings on the east of New Bond Street are primarily within the GS3 and GS5 areas, the data for the north and south sections of this PLP profile will be included in the GS3 and GS5 reports respectively.

Figure 5.1. Locations where ground slope triggers have been exceeded.



PLP monitoring data from the kerb lines within the footprint of GS2 are presented in the following sections. The plots presented for each comprise:

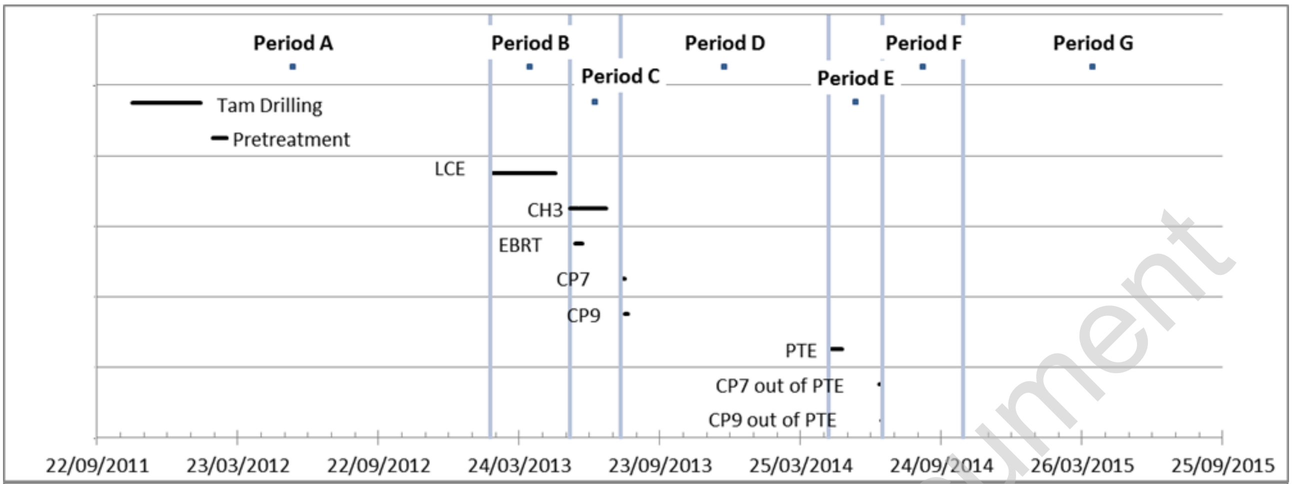
1. Summary of tunnel construction and associated construction periods.
2. Time settlement history.
3. Settlement profile plots with series as close to the end of each construction period as is available.
4. Time slope history over the full construction period with the distances between the points in metres shown in the legend in square brackets.
5. Time slope history since the completion of tunnelling i.e. construction Period G.

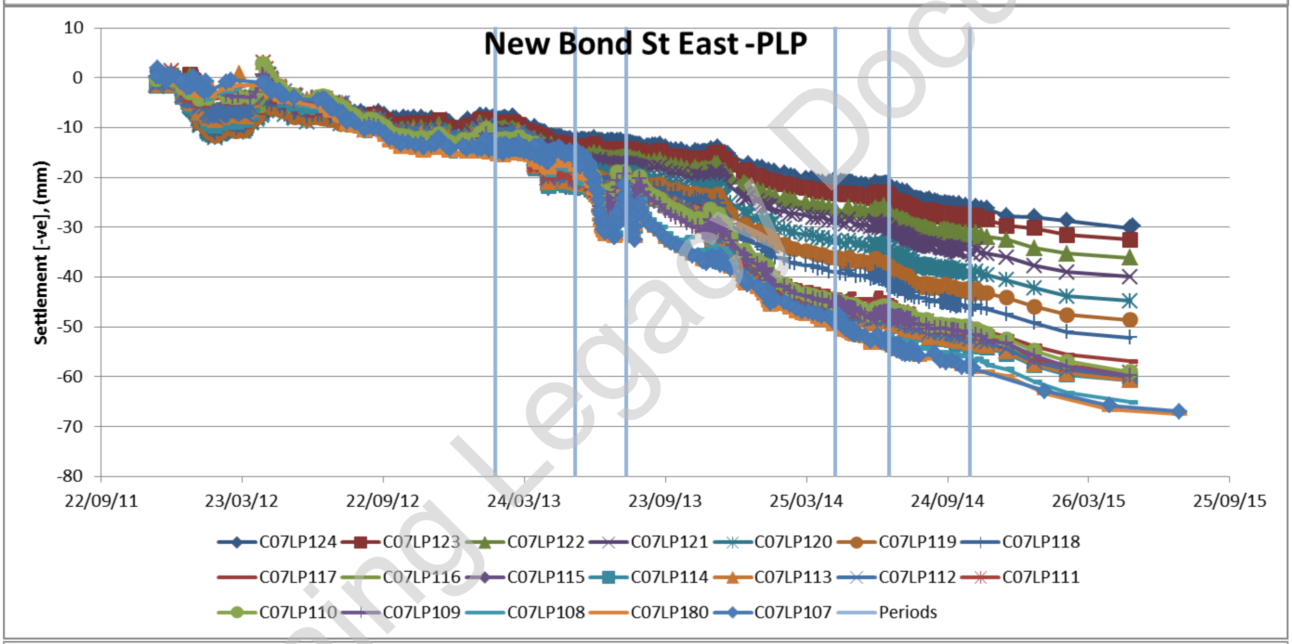
6. Deflection ratio plots are provided as necessary.

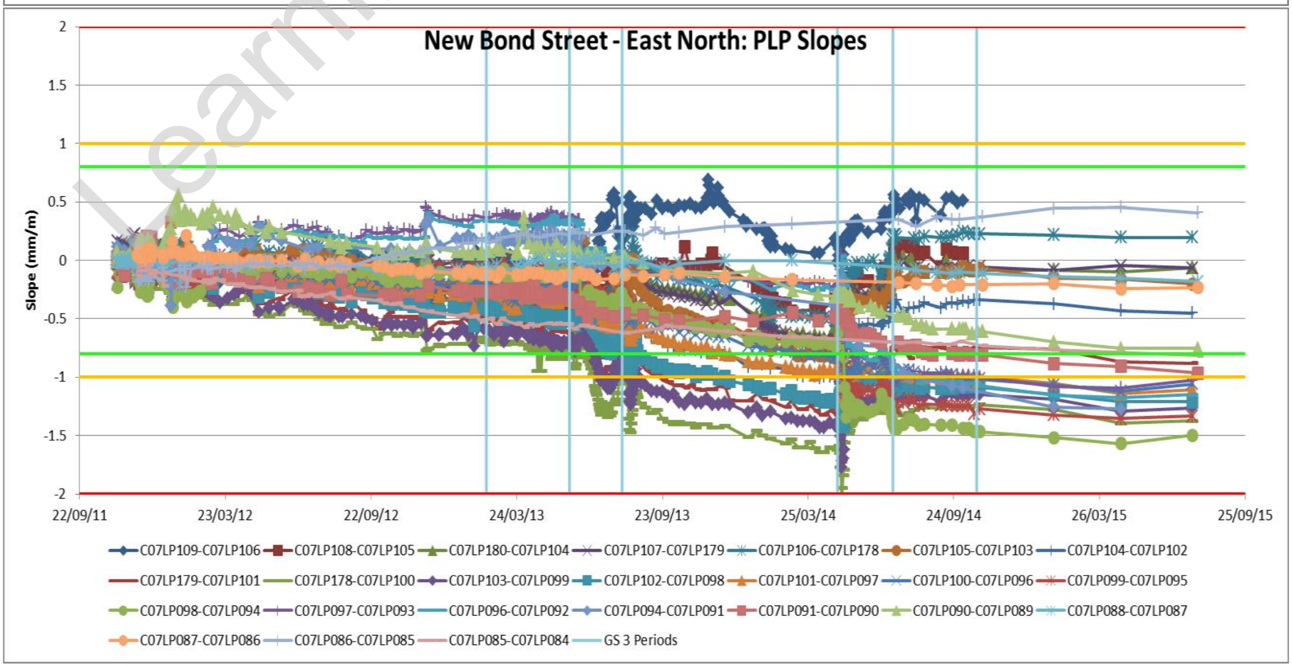
Table 5.1 Details of trigger breaches on PLP

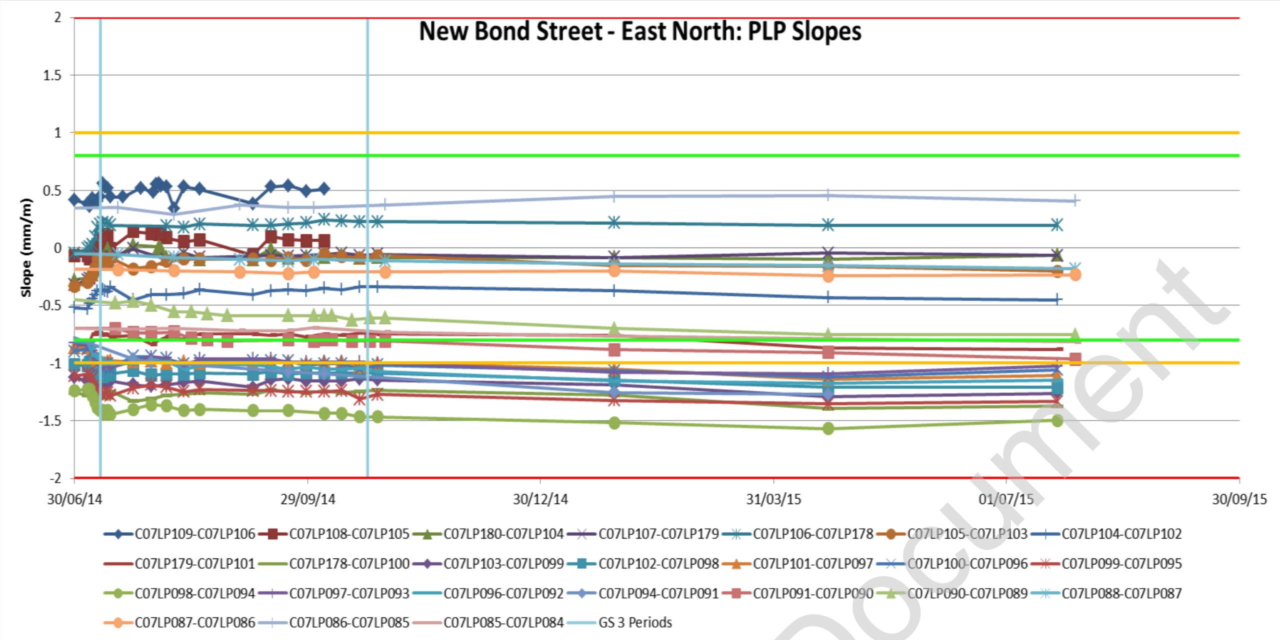
Instruments	Road	Slope			
		Amber		Maximum	Final
		Start	Finish	(mm/m)	(mm/m)
C07LP178-C07LP100	New Bond Street East	30/06/13	21/07/15	-1.95	-1.37
C07LP103-C07LP099	New Bond Street East	11/07/13	21/07/15	-1.77	-1.26
C07LP102-C07LP098	New Bond Street East	03/12/13	21/07/15	-1.43	-1.21
C07LP101-C07LP097	New Bond Street East	06/05/14	21/07/15	-1.64	-1.11
C07LP100-C07LP096	New Bond Street East	10/05/14	21/07/15	-1.12	-1.06
C07LP099-C07LP095	New Bond Street East	10/05/14	21/07/15	-1.36	-1.33
C07LP098-C07LP094	New Bond Street East	10/05/14	21/07/15	-1.57	-1.50
C07LP097-C07LP093	New Bond Street East	28/01/15	21/07/15	-1.09	-1.03
C07LP096-C07LP092	New Bond Street East	12/08/14	21/07/15	-1.18	-1.15
C07LP144 - C07LP142	Dering Street West	07/04/14	28/07/15	1.19	1.15
C07LP143 - C07LP141	Dering Street West	29/04/13	28/07/15	1.67	1.62
C07LP140 - C07LP154	Dering Street West	12/09/14	28/07/15	1.21	1.15

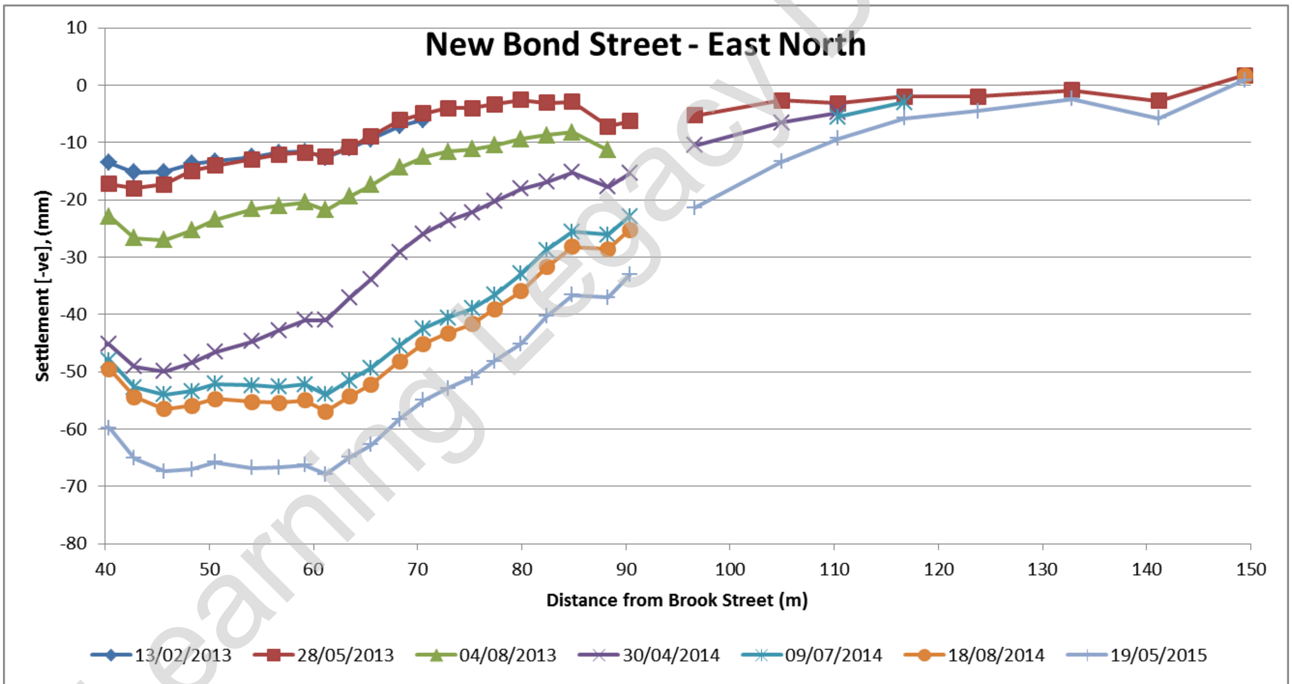
5.2. New Bond Street - East











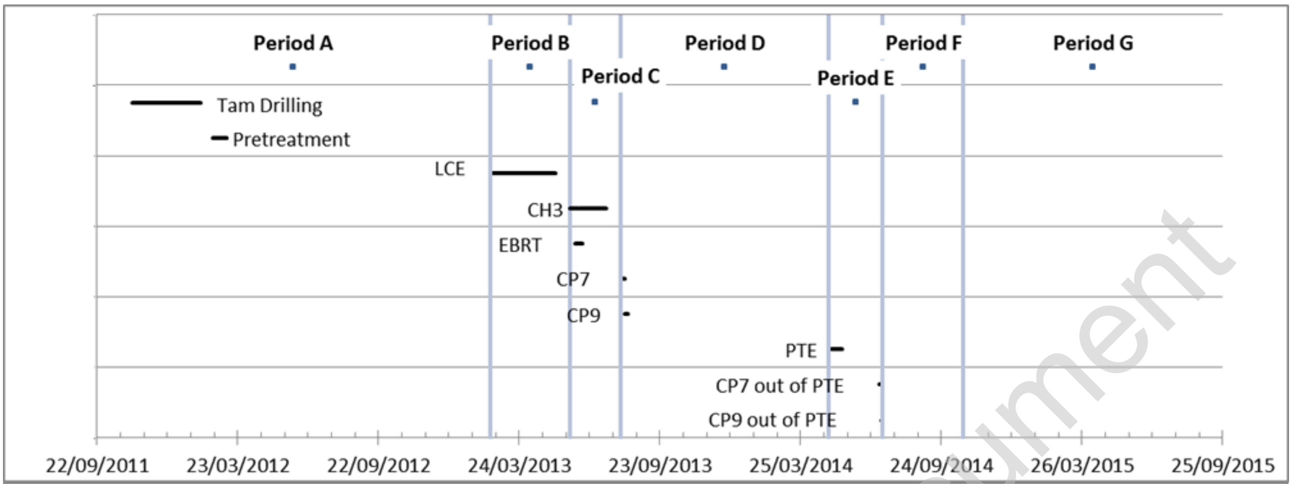
The following points are noted:

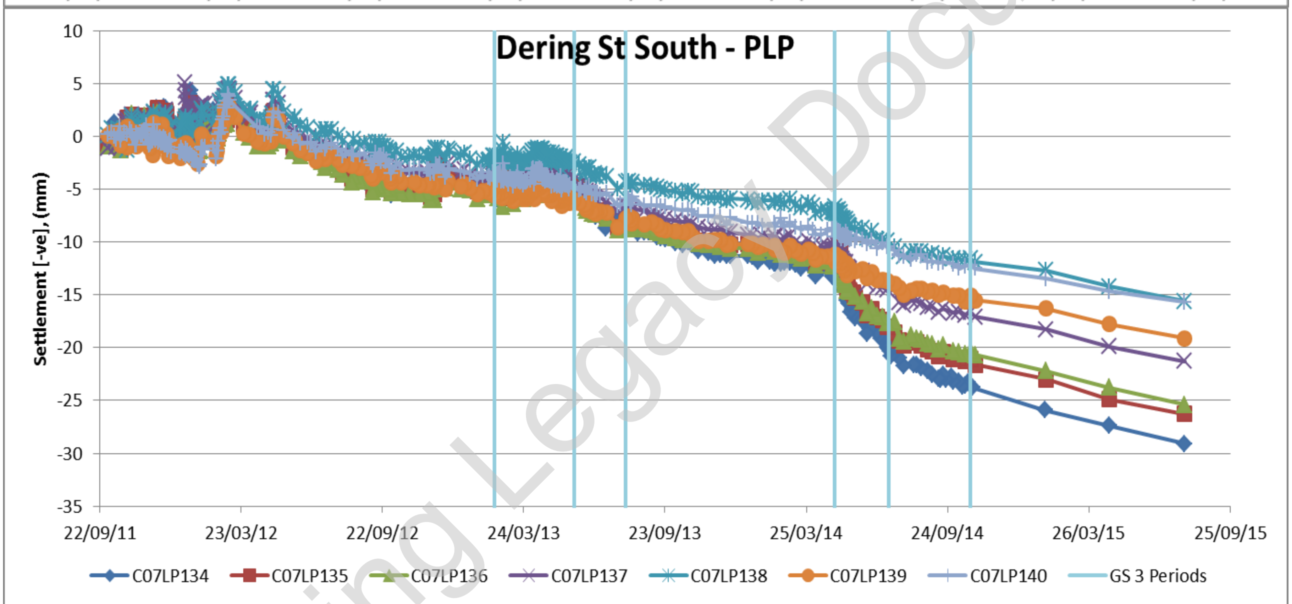
- The New Bond Street east façade is partly covered by GS3 but also partly by GS2 and GS5 arrays.
- The key events are the EBRT and CH3 in Period C and PTE in Period E. Settlement had increased to a maximum of 15mm prior to tunnelling and only increased by a few millimetres due to the LCE excavation. Settlement was less than 20mm prior to the EBRT and CH3 in Period C. During Period C the maximum settlement exceeded 30mm, but grout jacking reduced this to about 28mm at the end of the period. At the beginning of Period D, the construction of CP7 and CP9, together with grout jacking, produced negligible change in settlement. Over the remaining 7 months of Period D consolidation settlement of over 20mm increased the maximum settlement to 50mm. In Period E, the construction of PTE and the connections to CP7 and CP9 produced about 10mm increase, however, the location of the maximum settlement changed resulting in a maximum settlement of 53mm.
- Post construction settlement continued to increase and reached 59mm within about 3 months to October 2014 (Period F) and 67mm by July 2015 when monitoring was terminated.
- The rate of post construction settlement was approximately constant to the end of Period F. In Period G, from about October 2014, there has been an apparent small increase in rate albeit confirmed by few sets of readings.

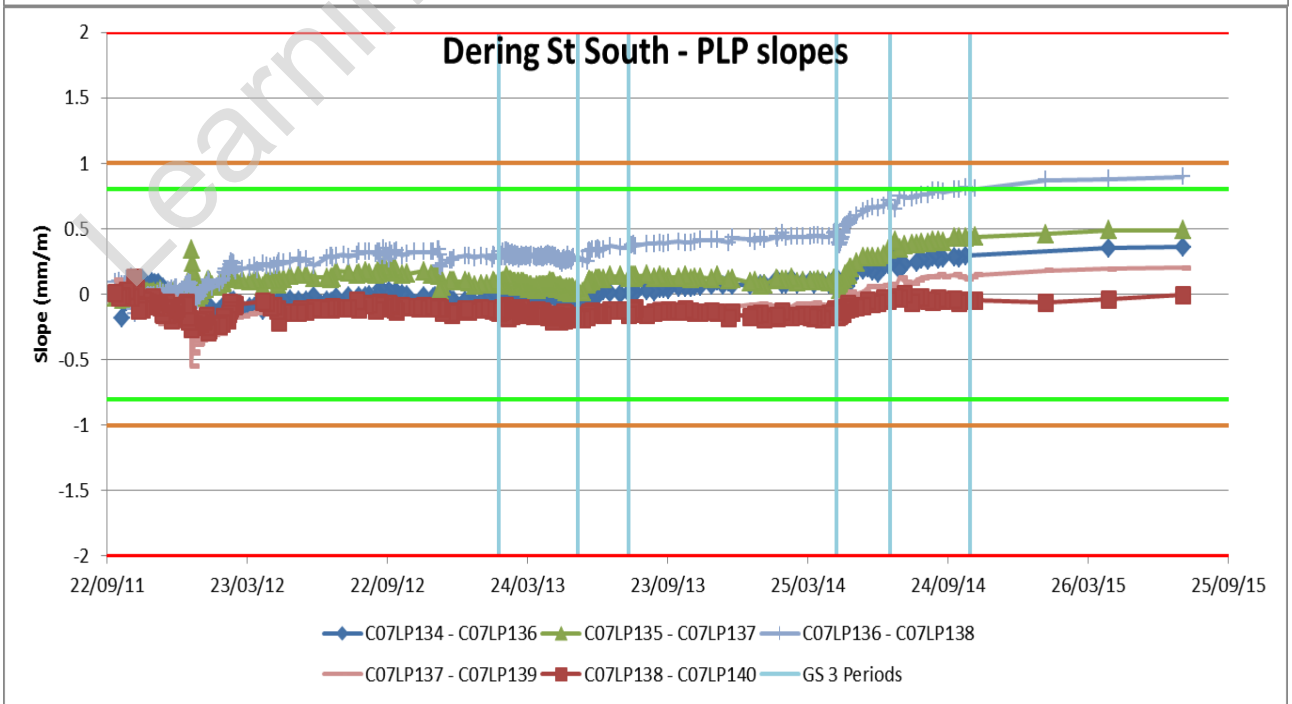
ETH excavation has continued in Period G. The maximum average rate of settlement over a 9 month period is 12mm/year.

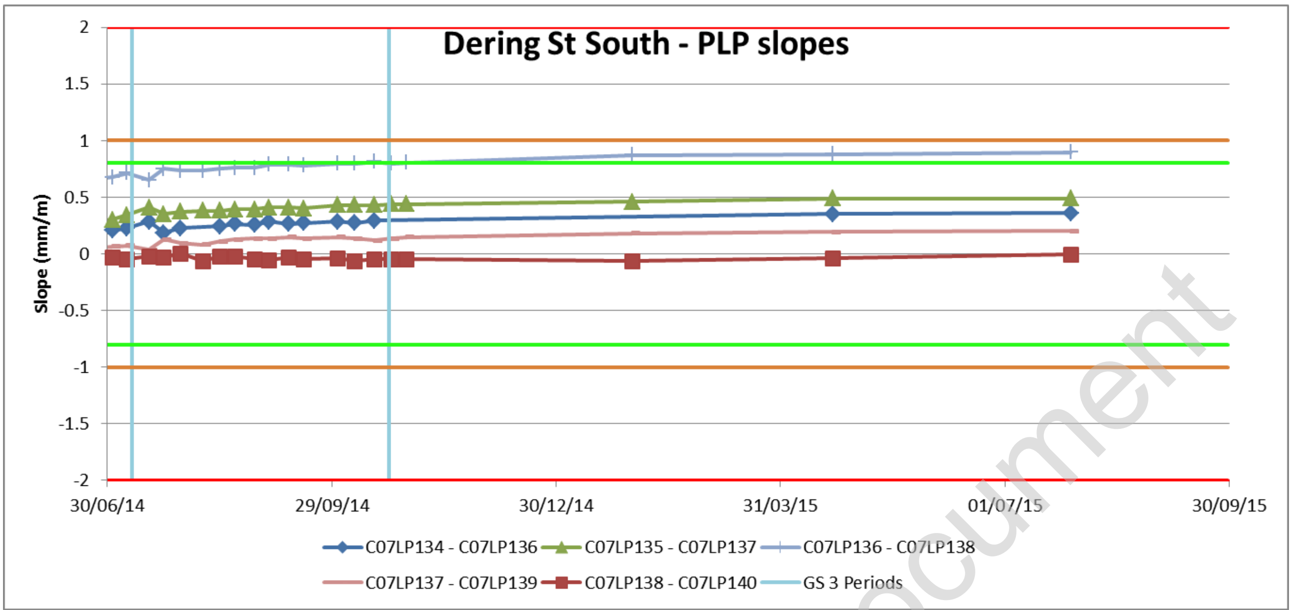
- The profile plot confirms that the consolidation settlement is relatively uniform over a wide area resulting in little change in slopes.
- Nine slope triggers have occurred as listed in Table 5.1. Post construction the slopes are constant or increasing very gradually. By inspection, there are no deflection ratio triggers.

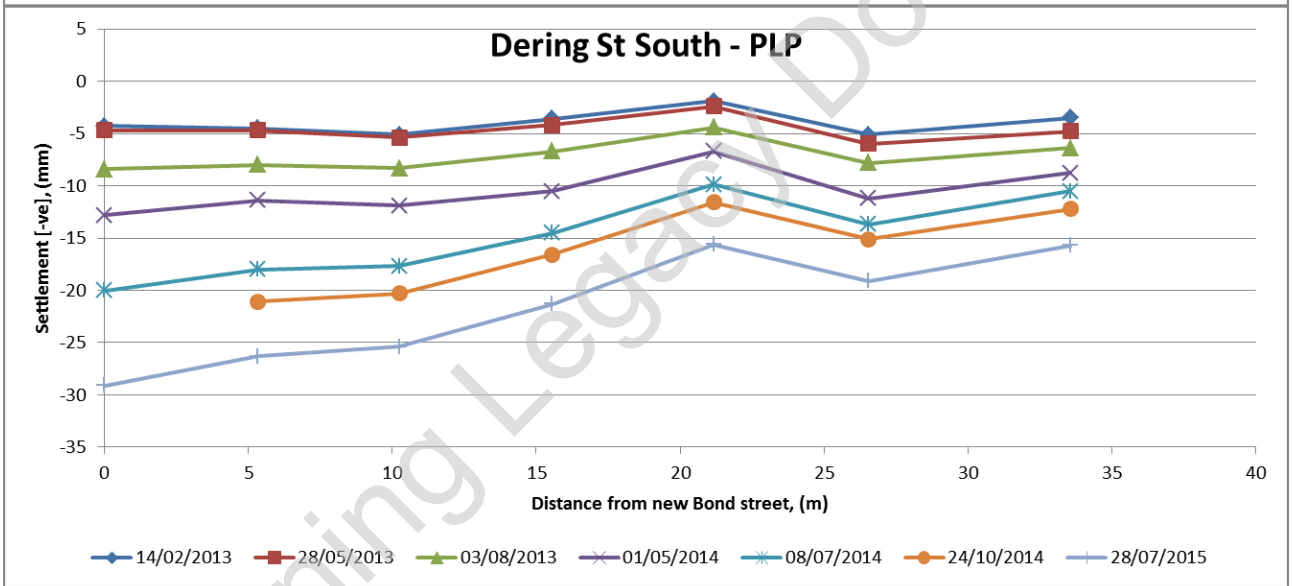
5.3. Dering Street - South







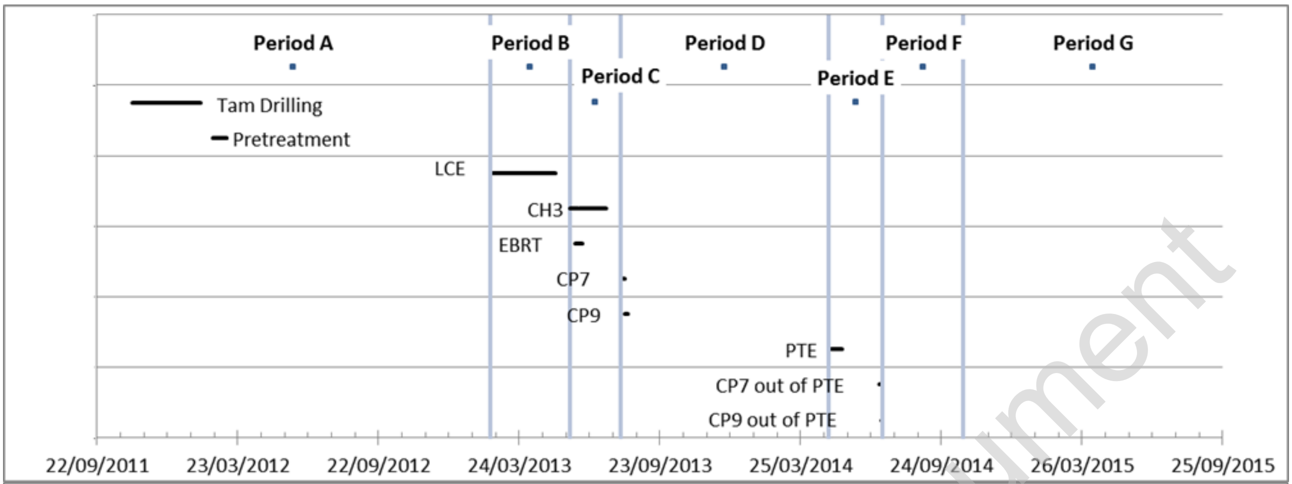


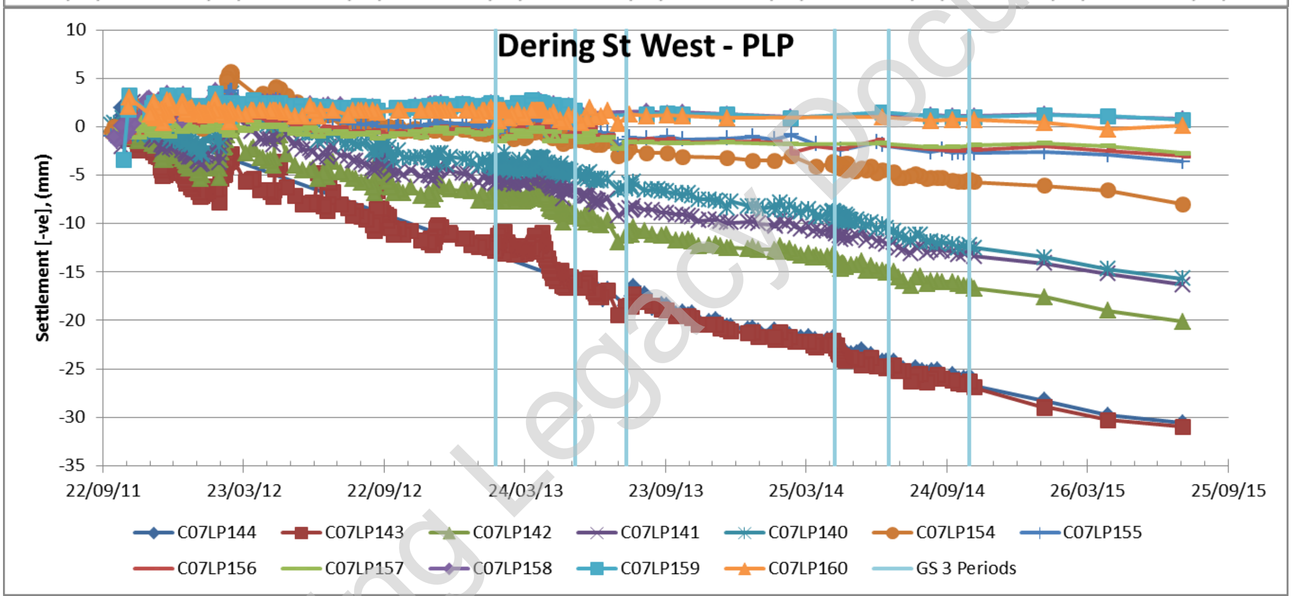


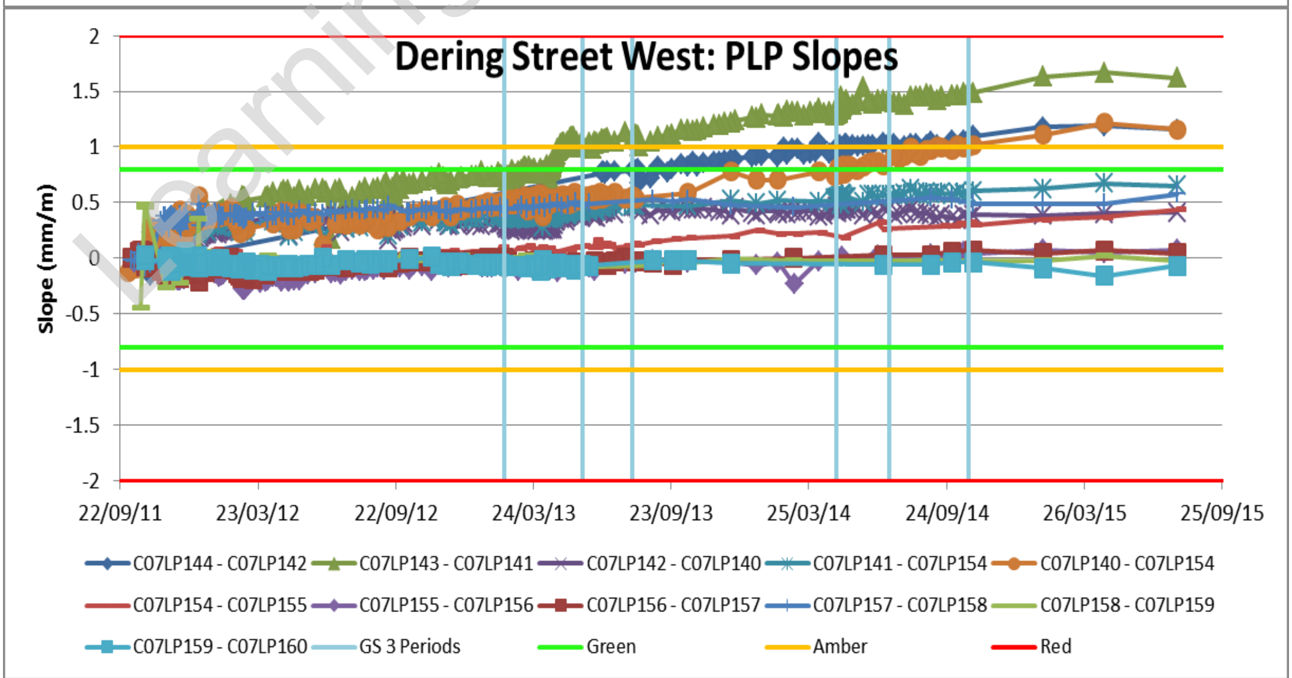
The following points are noted:

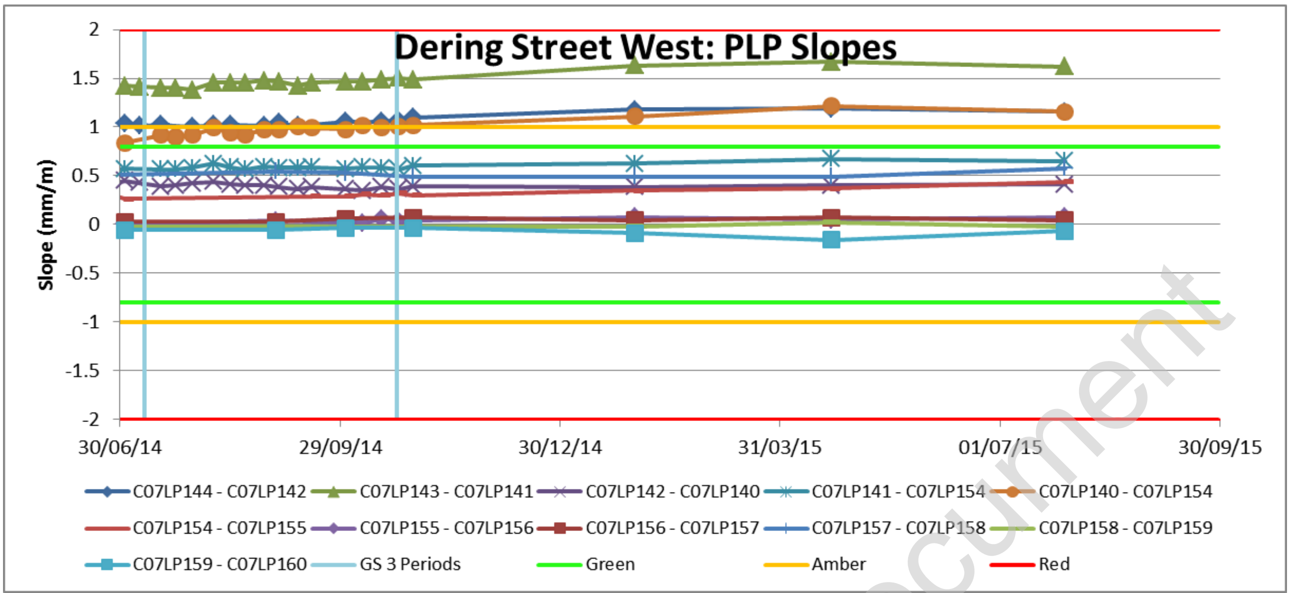
- The Dering Street south transect is fully within the plan extent of the GS3 array.
- The key events are the EBRT in Period C and PTE in Period E. In Period A heave is evident associated with TaM drilling and pre-treatment. During the remainder of Period A, settlement increased to 6mm prior to tunnelling. The construction of LCE in Period B with concurrent grouting produced negligible change in movement. The EBRT and subsequent consolidation settlement increased the maximum settlement to about 9mm at the end of Period D. As a result of PTE excavation in Period E settlement had increased to 20mm.
- Post construction consolidation increased settlement by ~3mm in 3 months (Period F) and a further 6mm in the following 9 months (Period G), equivalent to 8mm/year.
- The rate of post construction settlement has been approximately constant. It is noted that ETH excavation has continued within Period G.
- The profile plot confirms that the post tunnelling settlement is relatively uniform over a wide area resulting in little change in slopes.
- No slope triggers have occurred. The slopes are essentially constant within the repeatability of the data. By inspection, there are no deflection ratio triggers.

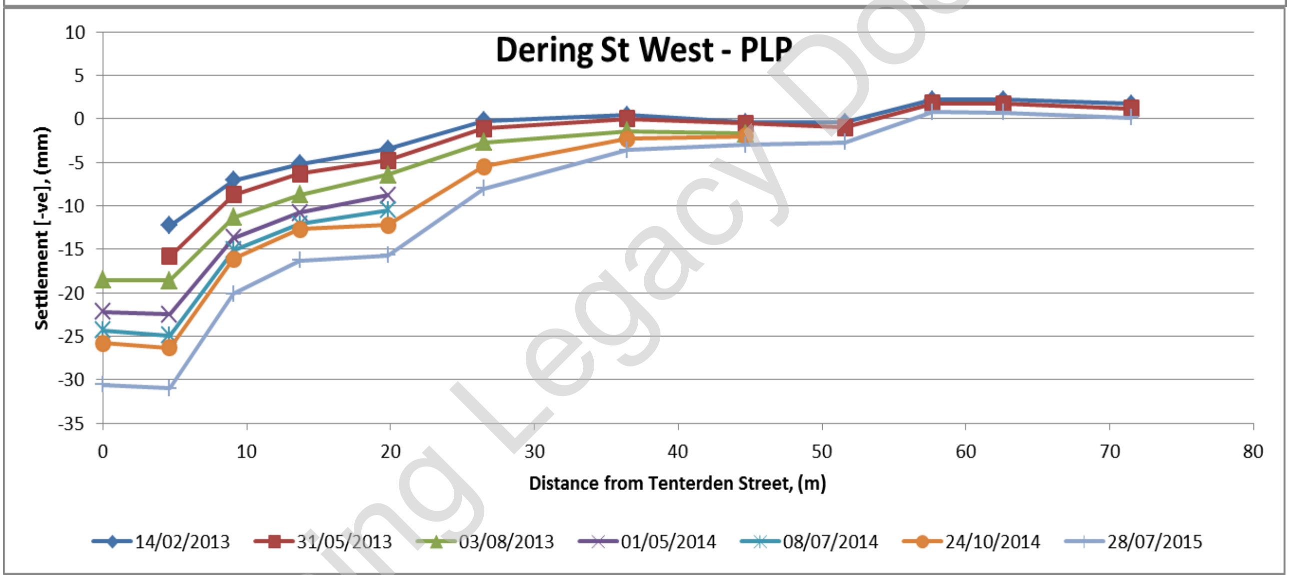
5.4. Dering Street - West







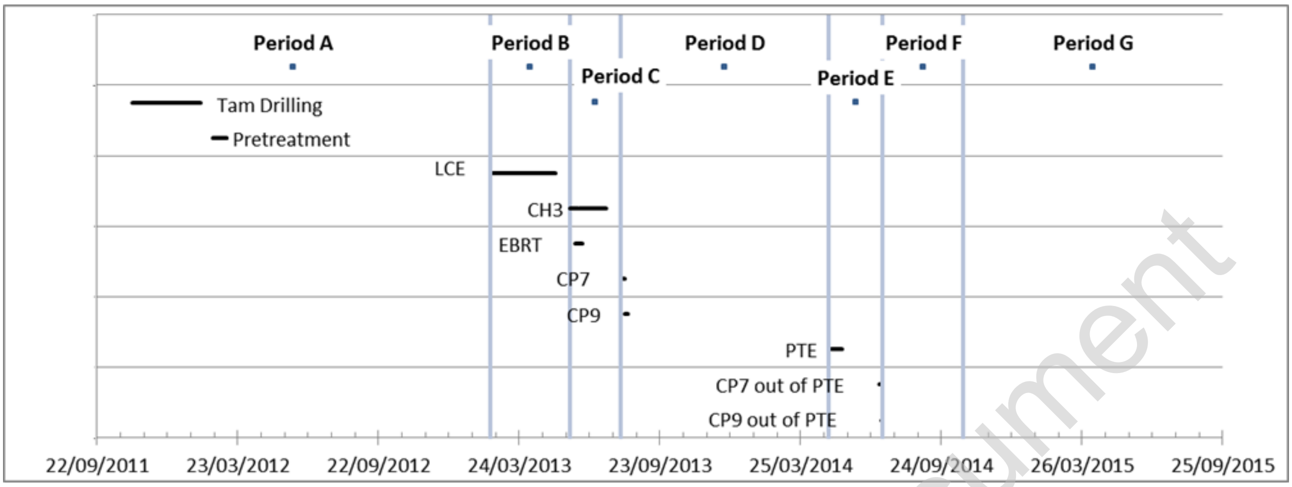


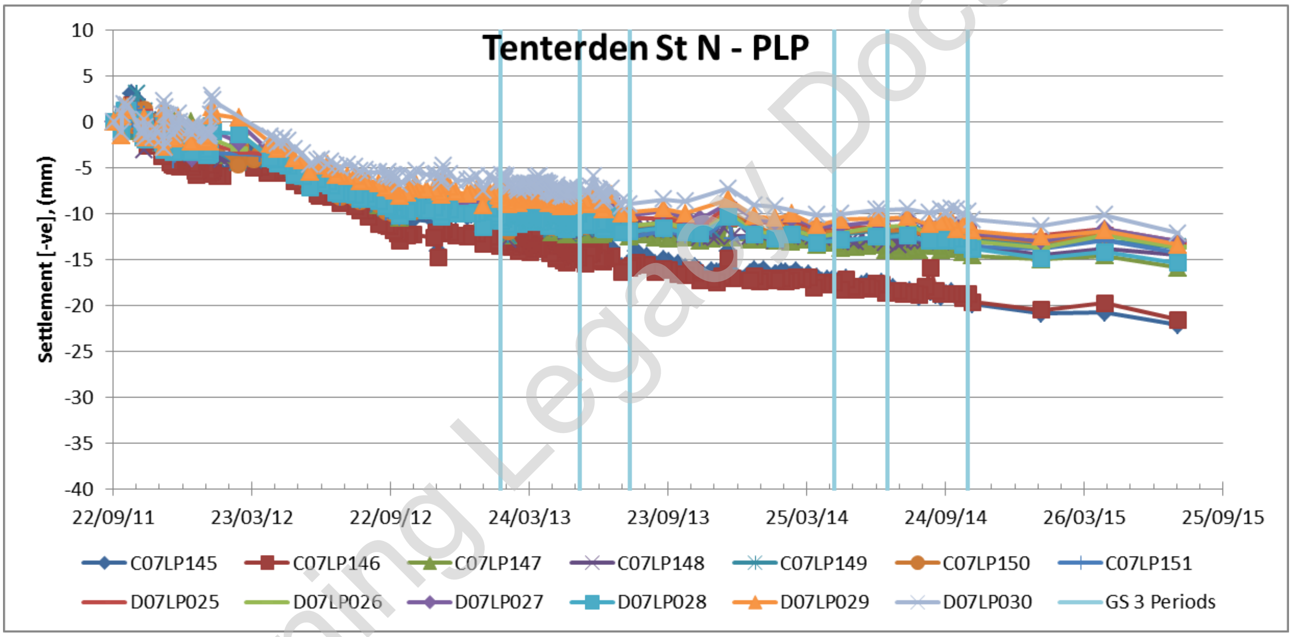


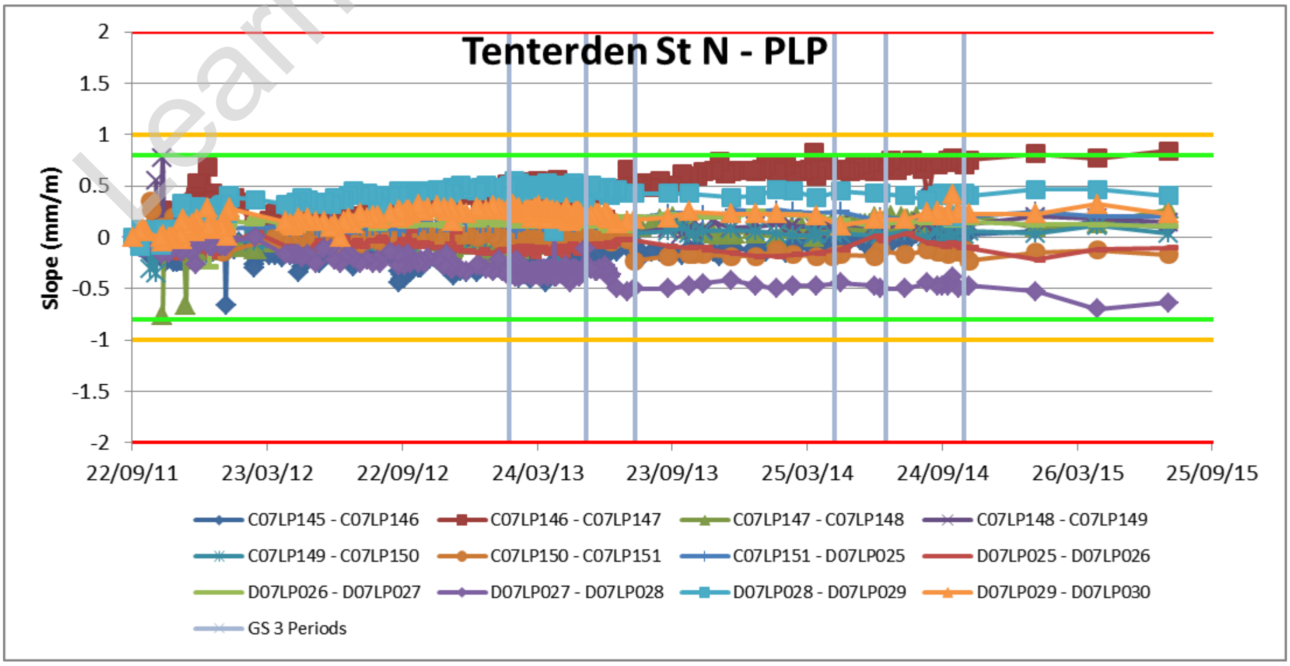
The following points are noted:

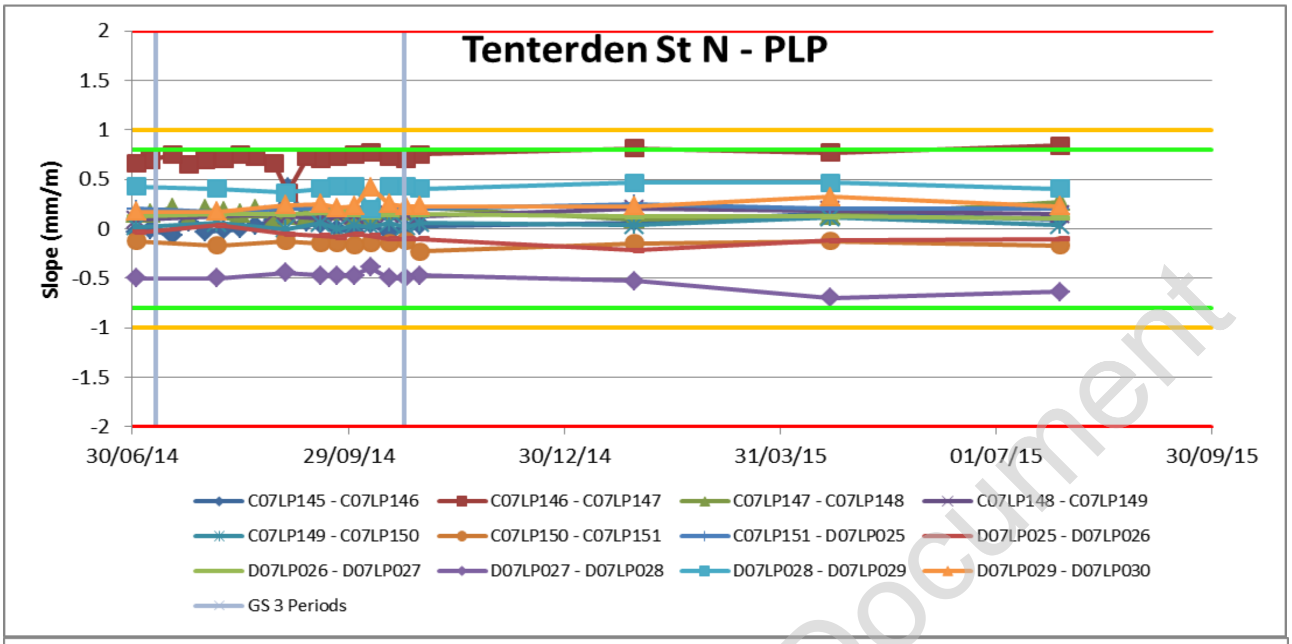
- The Dering Street west transect is mostly within the plan extent of the GS3 array which extends just to the north of the east-west arm of Dering Street (approximately 5m beneath the building line of the north façade).
- The key events are the LCE in Period B and PTE in Period E. In Period A settlement associated with TaM drilling and heave associated with pre-treatment are evident. During the remainder of Period A, the settlement increased despite a number of episodes of grout jacking, reaching 12mm prior to tunnelling.
- The construction of LCE in Period B with concurrent grouting produced an increase in movement to 16mm at the end of Period B. The EBRT (Period C) was driven through the back-filled (foam concrete) LCE and had no significant effect. Consolidation settlement (Periods C and D) was controlled by grout jacking and increased settlement by ~7mm to a maximum settlement to about 23mm at the end of Period D. As a result of PTE excavation in Period E settlement had increased to 25mm.
- Post construction consolidation increased settlement by ~2mm in 3 months (Period F) and a further 3mm in the following 9 months (Period G), equivalent to 4mm/year. The rate of post construction settlement has been approximately constant. It is noted that ETH excavation has continued within Period G.
- The profile plot confirms that the post tunnelling settlement is relatively uniform over a wide area resulting in little change in slopes.
- Three Amber slope triggers have occurred as detailed in Table 4.1. Post construction, the slopes are essentially constant within the repeatability of the data. By inspection, there are no deflection ratio triggers.

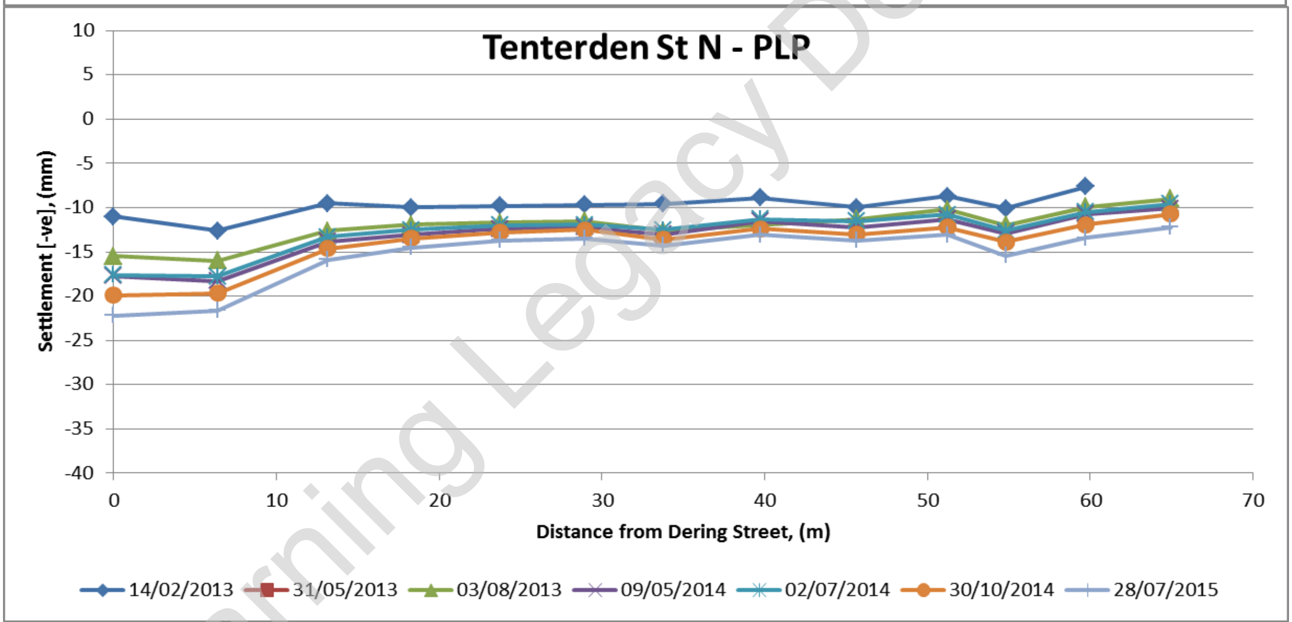
5.5. Tenterden Street - North











The following points are noted:

- The Tenterden Street north transect is on the boundary of the plan extent of the GS3 array.
- Movements are generally small, reaching only 18mm at the end of construction. The majority (~13mm) settlement was recorded prior to the commencement of tunnelling. Early in Period A 5mm settlement associated with TaM drilling and up to 4mm heave associated with pre-treatment are evident. During the remainder of Period A, the settlement increased probably associated with works by others.
- The construction of LCE in Period B produced a maximum of 3mm settlement. The EBRT (Period C) was driven through the back-filled (foam concrete) LCE and North-west shaft of the ETH and had no significant effect. Consolidation settlement increased settlement to a maximum settlement to about 18mm at the end of Period E.
- Post construction consolidation increased settlement by ~1mm in 3 months (Period F) and a further 3mm in the following 9 months (Period G), equivalent to 4mm/year. The rate of post construction settlement has been approximately constant. It is noted that ETH excavation has continued within Period G.
- The profile plot confirms that the post tunnelling settlement is relatively uniform over a wide area resulting in little change in slopes.
- No slope triggers have occurred. Post construction, the slopes are essentially constant within the repeatability of the data. By inspection, there are no deflection ratio triggers.

6. DISCUSSION

The preceding presentation of settlement monitoring data shows that the Compensation Grouting Performance Requirements (CGPR) on slope has been exceeded in a number of locations within the footprint of the arrays installed from Grout Shaft 3. The data also show that, in some locations the slopes continue to increase, albeit generally at a slow and decreasing rate.

Tunnelling was completed in July 2014, and the final episode of grout jacking was undertaken in June 2014. The increase in post construction movements was reviewed on a daily, weekly and monthly basis at SRG and CTC meetings and it was been concluded that further grouting to reduce movements could not be justified and therefore none was undertaken. An abridged version of this report was submitted in October 2014, 3 months after the end of tunnelling to justify de-commissioning of the grout shaft: this report was accepted by CRL and the grout shaft was subsequently de-commissioned.

It is noted that the prime purpose of compensation grouting is to reduce the volume loss settlements associated with tunnelling since the associated slopes and curvatures are used to determine the need for protective measures: in general, this objective has been achieved, however, a number of particular issues have become apparent as the works have progressed:

- Small movements occurred prior to the commencement of tunnelling due to installation of the compensation grouting. Pre-treatment reversed these movements within the constraints of the Works Information which limits uplift to 5mm;
- More significant settlements developed between the completion of pre-treatment and the start of tunnelling due to works by others (ETH works);
- Grout jacking to reverse settlements although necessary to comply with the CGPR is not always the optimal course of action: the reversal of movements of structure is not a linear elastic situation, there is the potential for significant damage to occur even if the recorded settlements are negligible;
- The tunnel layout and the grout shaft location are far from ideal: the exclusion zones around these structures limited the ability to carry out concurrent grouting at the start of LCE1 from the North-west shaft.;
- Although slope triggers have been exceeded, there have been no deflection ratio amber triggers.
- Grout jacking has been undertaken on numerous occasions to reduce settlements and slopes in various locations; up to 300mm equivalent thickness of grout has been injected below the corner of Dering Street and Tenterden Street.
- All subsequent monitoring data is included in this report up until further monitoring was de-scoped under C300-PMI-1858 from CRL. Residual rates of settlement between 4 mm/year and 12 mm/year are recorded with the greater values located in the west of the GS3 array area.

7. CONCLUSION

It was concluded in October 2014 that no further post construction grouting from GS3 was required and the Grout Shaft and associated automatic monitoring systems have been decommissioned. The key factors leading to this conclusion were:

- Following the completion of tunnelling and compensation grouting: ongoing post construction settlements have been under continual review at daily, weekly and monthly review meetings. No grouting has been deemed necessary;
- The potential for additional movements as a result of the ongoing ETH excavation have been considered based on the assessments carried out by C122 for CRL: BFK and CRL agree that the movements are likely to be considerably less than these values based on observed performance to date;
- Settlements which have occurred which caused exceedance of the CGPR does not necessarily require grout jacking to reverse these movements: it has been shown on a number of occasions that damage can worsen even though slopes and deflection ratios are decreased. BFK has always considered that the *raison d'etre* of the SCoGM is to minimise damage notwithstanding the contractual implication of exceeding Performance Requirements.

Appendix A

Assumptions used to produce contour plots of grout intensity

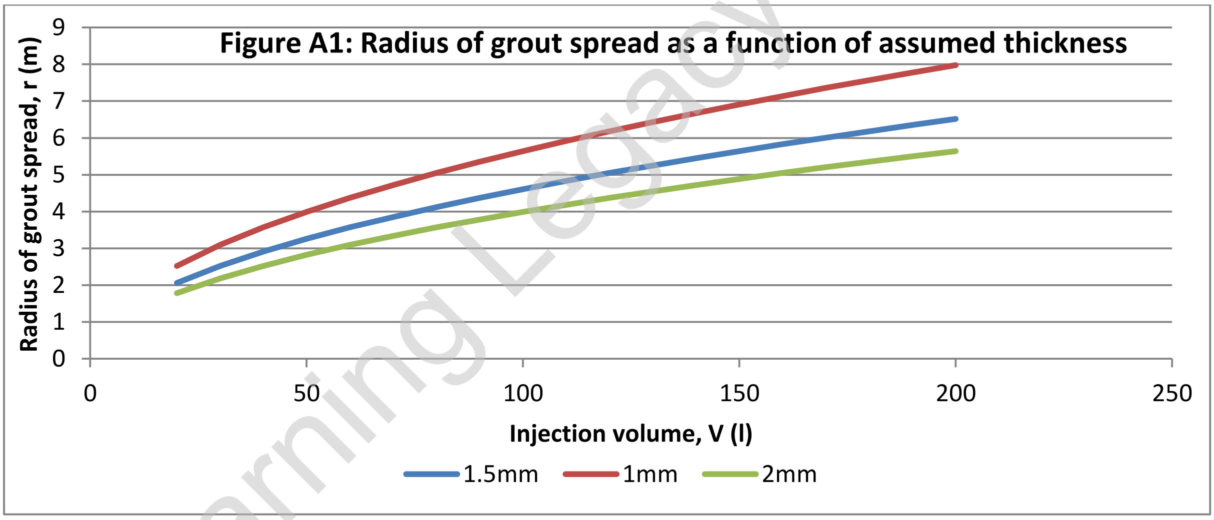
A method of producing a visualisation of the quantity and distribution of grout injected during compensation grouting is useful in interpreting performance. For each injection the volume and the location of the port used are known. The model used is intended to approximate the distribution of grout within 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 determined by the stress conditions at the time of injection which is constantly changing during the construction process. It is known that in London Clay 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:

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



Observations 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.

Appendix B

Enlarged version of Figures 4.1 and 5.1 showing location of monitoring points and slope triggers


C07LB119
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C07LB118
C07LB117
C07LB116
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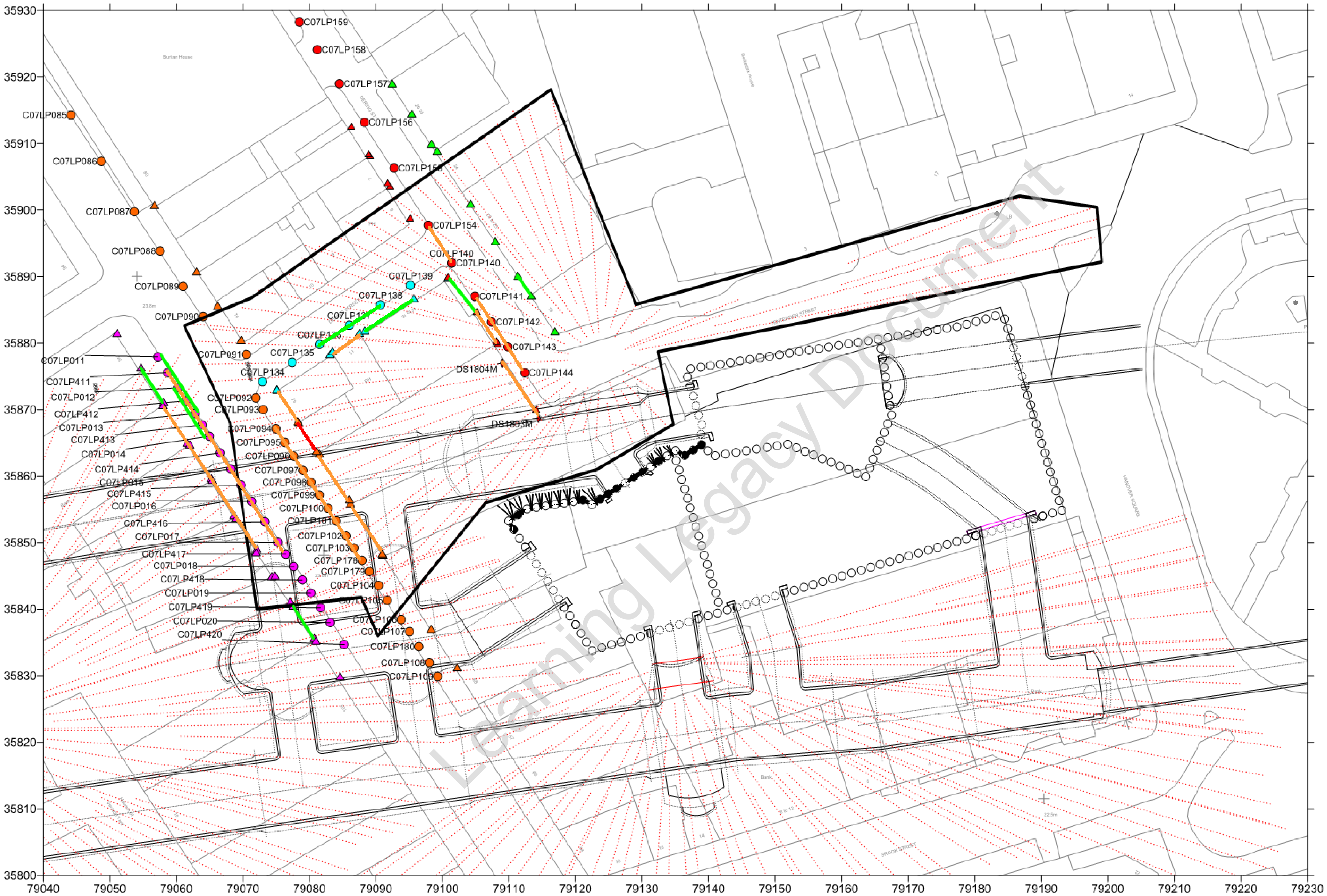
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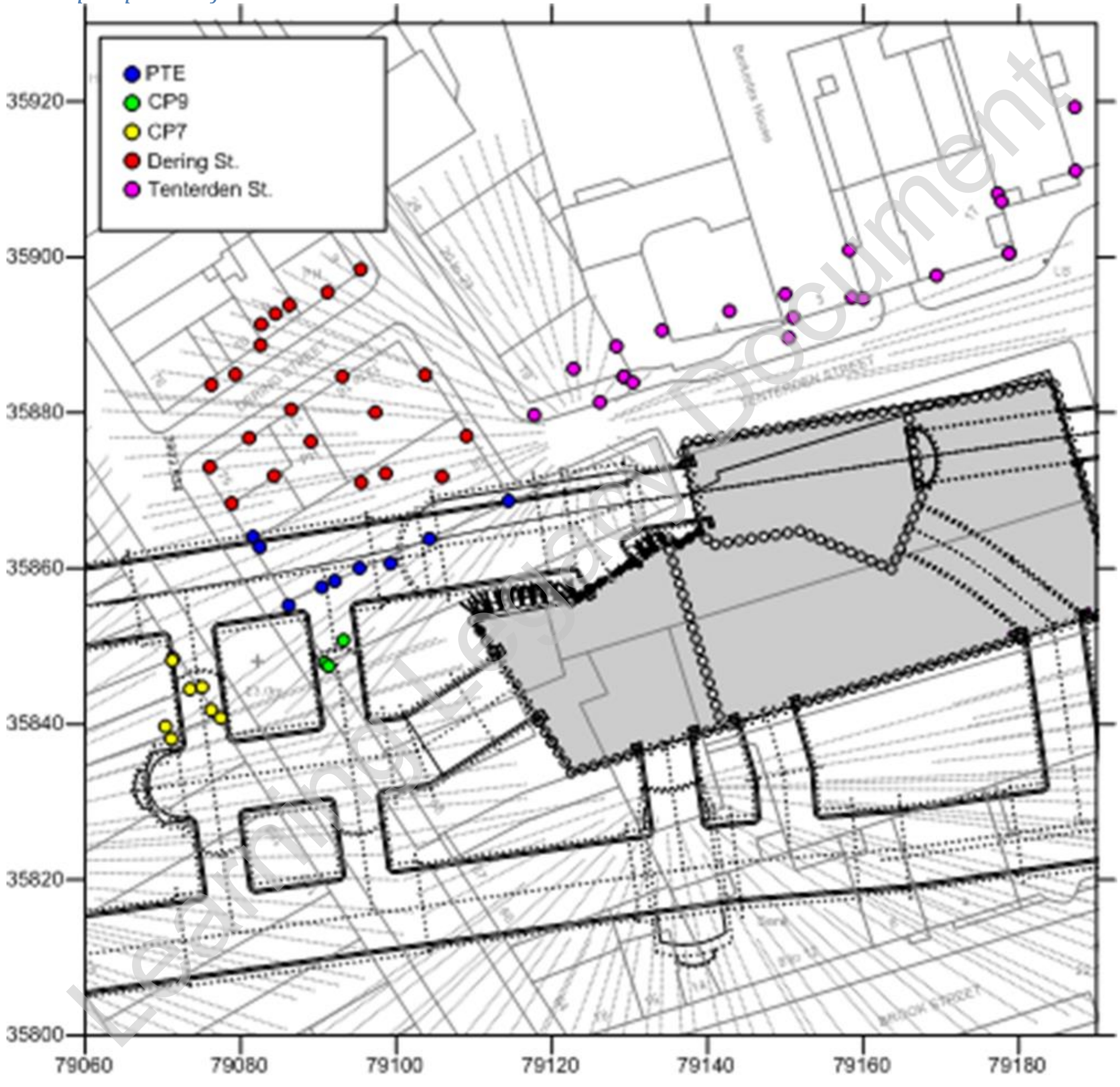
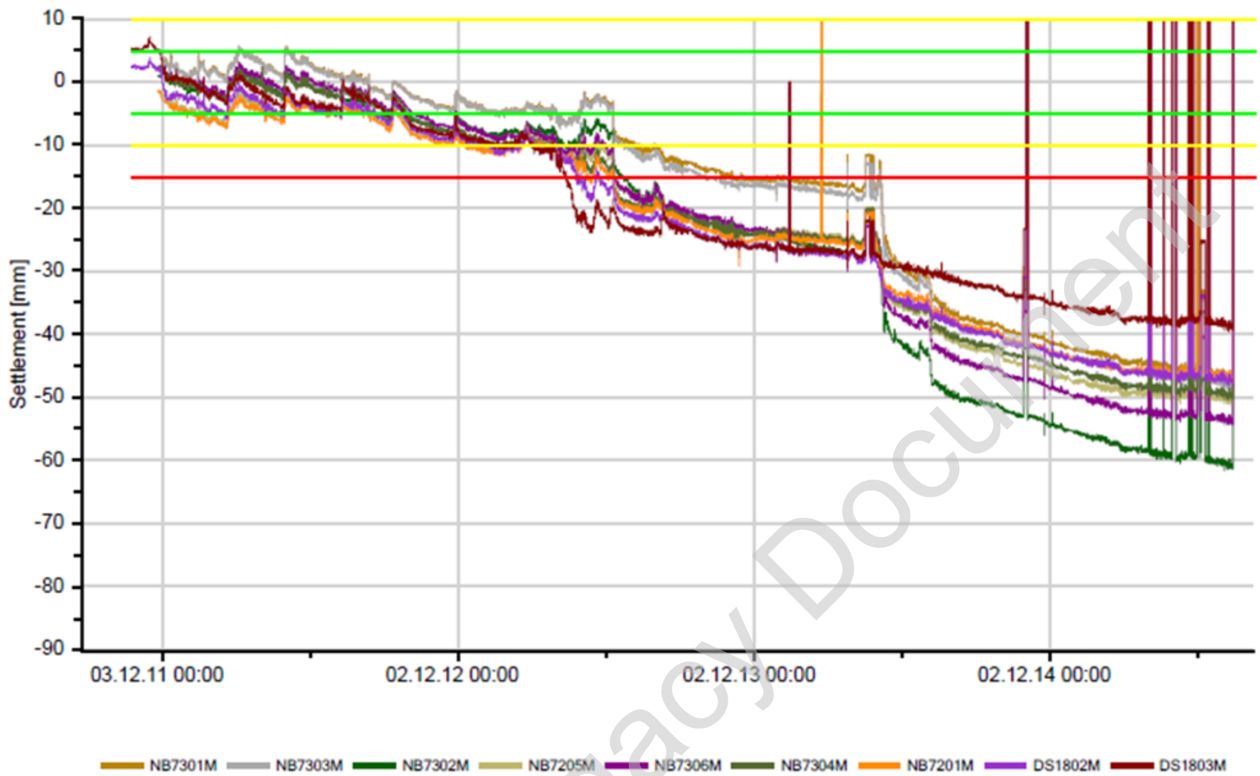
Appendix C

Example plots of HLC data



PTE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0
-10
-20
-30
-40
-50
-60
-70
-80
-90
Settlement [mm]
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02.12.13 00:00
02.12.14 00:00
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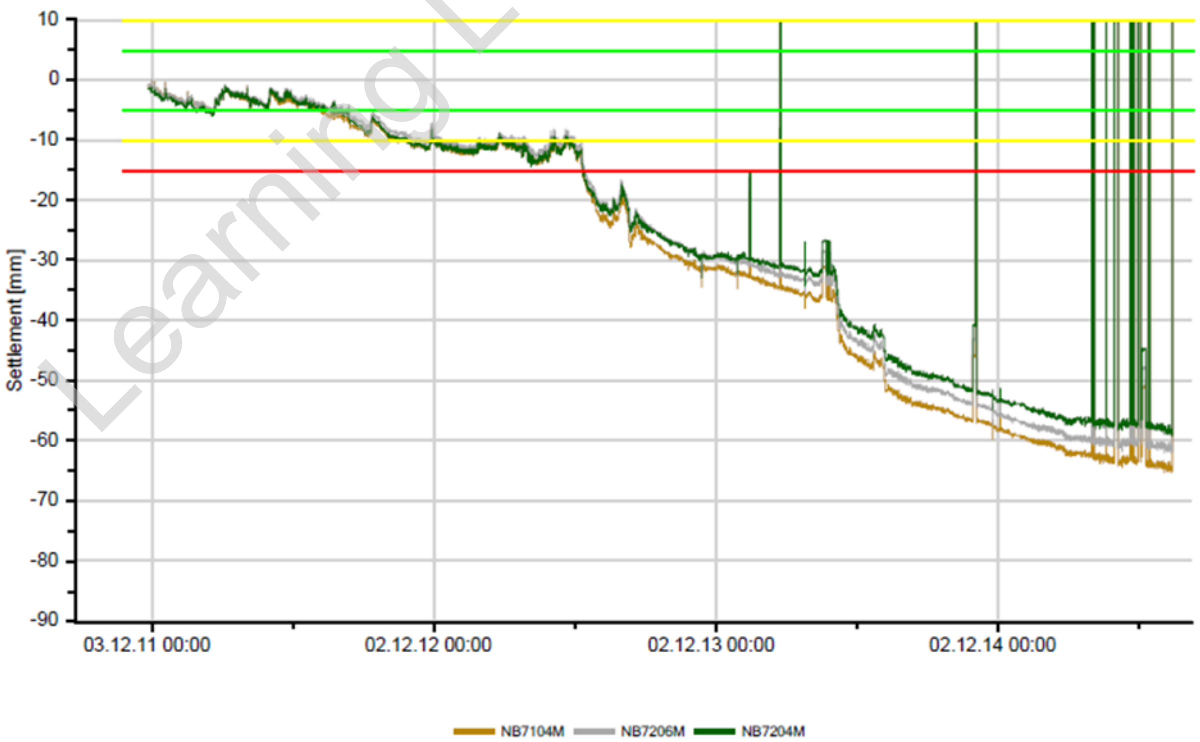
NB7303M
NB7302M
NB7205M
NB7306M
NB7304M
NB7201M
DS1802M
DS1803M

CP9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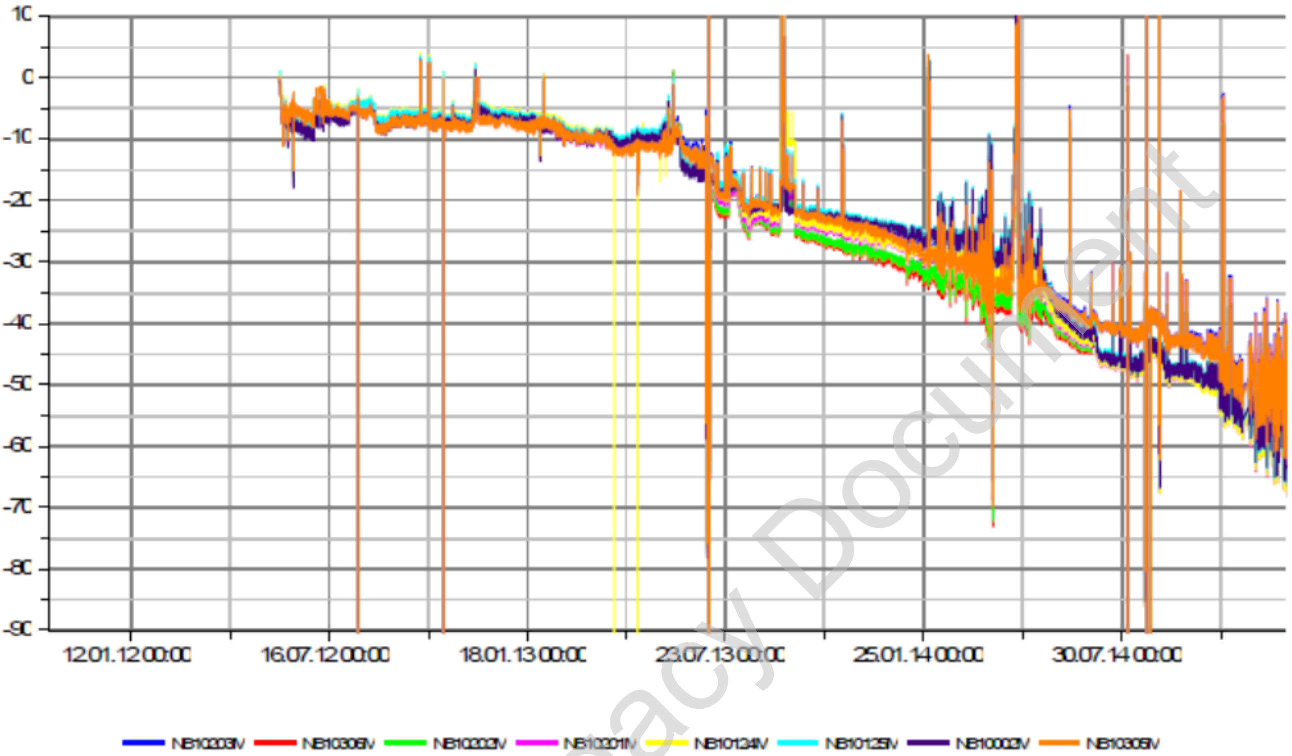
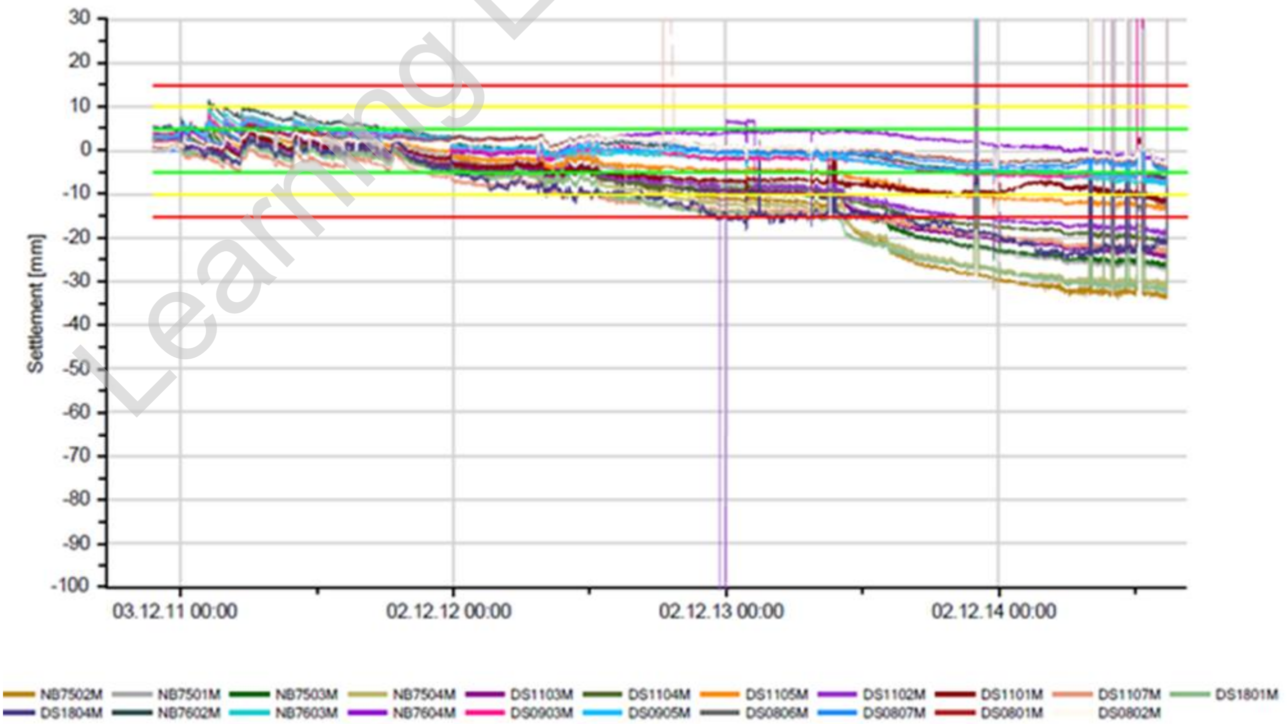
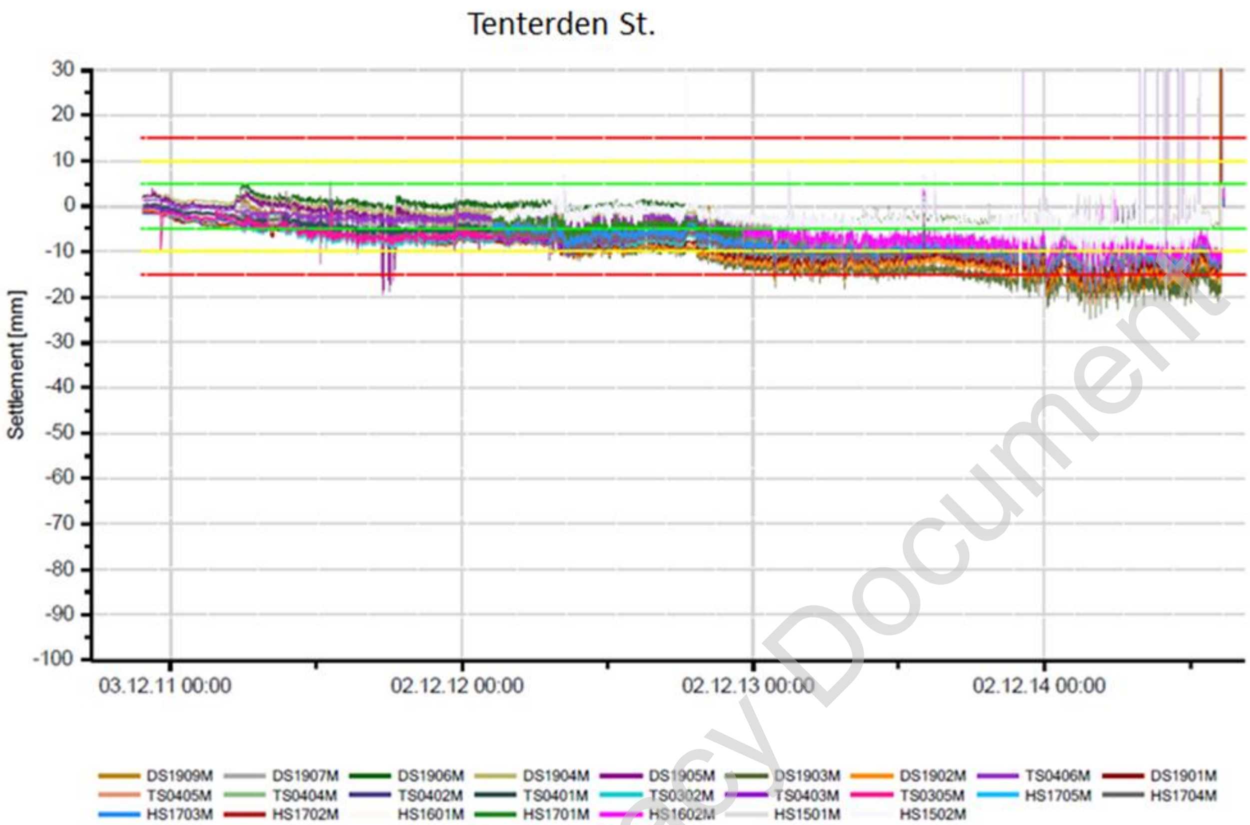
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
Settlement [mm]
03.12.11 00:00
02.12.12 00:00
02.12.13 00:00
02.12.14 00:00
NB7104M
NB7206M
NB7204M

CP7



Dering St.




Tenterden St.
Settlement [mm]
30
20
10
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
03.12.11 00:00
02.12.12 00:00
02.12.13 00:00
02.12.14 00:00
DS1909M
DS1907M
DS1906M
DS1904M
DS1905M
DS1903M
DS1902M
TS0406M
DS1901M
TS0405M
TS0404M
TS0402M
TS0401M
TS0302M
TS0403M
TS0305M
HS1705M
HS1704M
HS1703M
HS1702M
HS1601M
HS1701M
HS1602M
HS1501M
HS1502M