C300/410

Western Tunnels & Caverns Project

Report

Grouting Summary & I &M Final Report - TCR GS7

CRL Document No. **C300-BFK-C4-RGN-CRT00_ST005-51231**

Contract MDL reference: C13.016

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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):

Stakeholder Organisation	Job Title	Name	Signature	Date	Acceptance
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Contents

1. PURPOSE OF THIS REPORT

A number of summary reports (or written submissions) are required by the Works Information within the Compensation Grouting (KC21 C122-OVE-Z4-RSP-CR001-00010) and Instrumentation and Monitoring (KX10 C122-OVE-Z4-RSP-CR001-00007) 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 7 and associated monitoring at TCR 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 (C122-OVE-C2-RSP-C125-00001) Clauses 3.2.5.1 and 3.2.5.2.

All BFK excavation (tunnelling) works within the plan extent of the compensation grouting arrays from TCR Station Grout Shaft 7 were completed by May 2014. An abridged version of this report was issued in August 2014 (C300-CCM-08749) in the form of a presentation, about 3 months after the end of tunnelling, to justify de-commissioning of the grout shaft: this report was accepted by CRL (C300-PMC-09405) and the grout shaft was subsequently de-commissioned.

This report aims to summarise the relevant construction, compensation grouting and monitoring information for Grout Shaft 7 at TCR Station and includes manual monitoring up to September 2015 when the manual monitoring in this area was de-scoped under C300-PMI-01858. 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 the instrumentation. 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 GS7 area are included in Appendix B. Data from tiltmeters installed in 4-6 Soho Square is also presented in Appendix B. A separate report is provided for the ATS network (C300-BFK-C4-RGN-CRT00_ST005-53008).

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

- H&S file – submitted separately for construction and 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.

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.

2. CONSTRUCTION WORKS PROGRESS

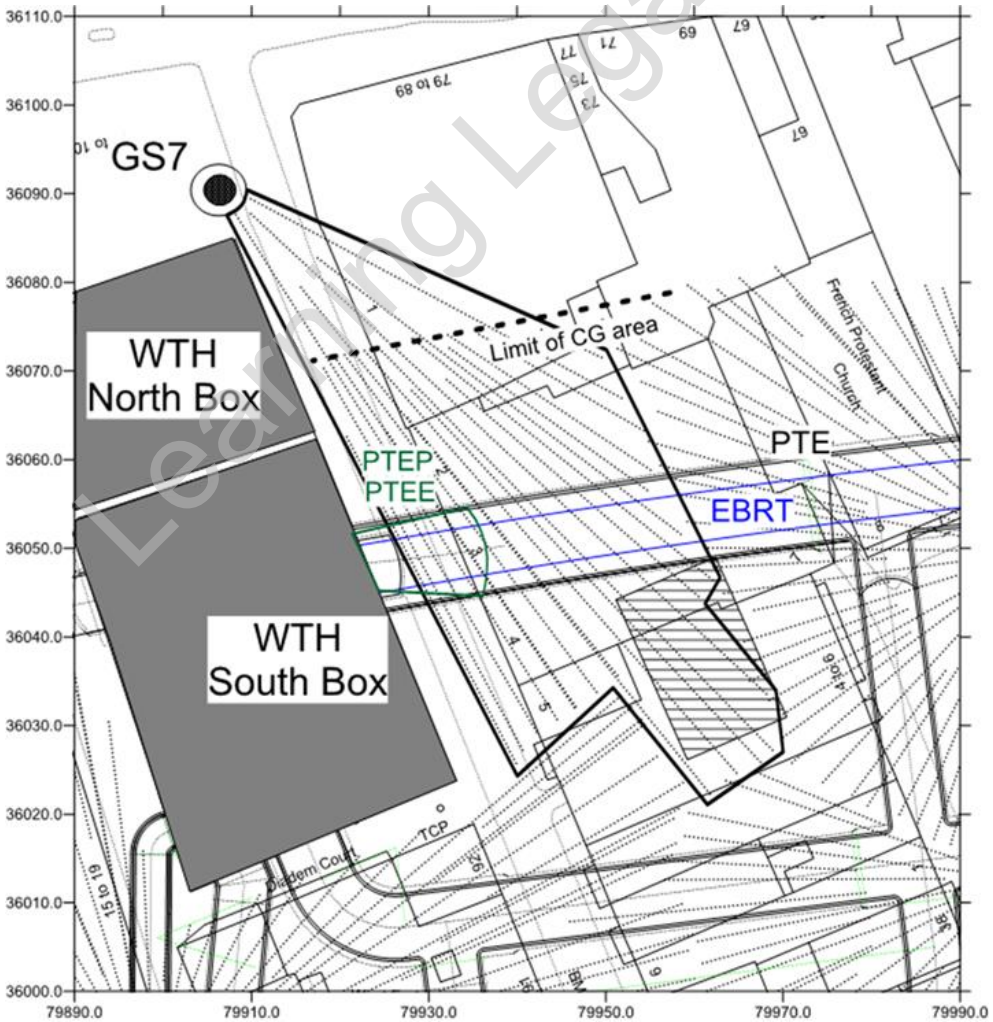
2.1. Tunnels

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 7 at TCR Station.

Table 2-1. Progress of C300/C410 works at TCR GS7 area.

	TUNNEL	ABB.	START DATE	END DATE
Period A	GS7 TaM Drilling	GS7 Drill	17/02/2012	19/03/2012
	WTH South Box Excavation	WTH	17/04/2012	28/09/2012
Period C	Platform Tunnel East Pilot	PTEP	29/03/2013	06/04/2013
	Platform Tunnel East Enlargement	PTEE	15/04/2013	27/04/2013
Period D	Eastbound Running Tunnel	EBRT	02/08/2013	08/08/2013
Period E	WTH North Box Excavation	WTH	02/02/2014	20/04/2014
Period F	Platform Tunnel East	PTE	25/04/2014	30/05/2014

Figure 2.1.1 Tunnels within extent of grout array from TCR GS7



2.2. Other construction works

Works by BFK prior to the commencement of tunnelling included:

- Drilling for installation of TaMs
- Pre-treatment grouting
- Excavation of Western Ticket Hall (WTH) box

Works by Others prior to the start of tunnelling included:

- Sinking of Grout Shaft 7
- Construction of Western Ticket Hall (WTH) diaphragm-walls

Works by Others during the monitoring period comprised:

- Re-developments such as 4-6 Soho Square and 1 Dean Street.

2.3. Compensation Grouting

The volume of grout injected from TCR GS7 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 6m^3 injected prior to tunnelling, concurrent grouting 37m^3 and grout jacking just over 2m^3.

Figures 2.3 to 2.5 show contours of the total grout intensity for each of the three types of grouting (pre-treatment, concurrent and jacking respectively) and a cumulative total of all grout injected from TCR GS7 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 WTH is clearly evident in the contours.

Table 2-2 Construction Periods for works in TCR GS7 area

Period	Start Date	End Date	Main Works
A	17/02/2012	29/09/2012	GS7 Drill, WTH South Box Excavation
B	29/09/2012	29/03/2013	Pre-treatment
C	29/03/2012	01/08/2013	Platform Tunnel East Pilot, Platform Tunnel East Enlargement, Concurrent Grouting
D	01/08/2013	08/08/2013	Eastbound Running Tunnel
E	08/08/2013	24/04/2014	WTH North Box Excavation
F	24/04/2014	31/05/2014	Platform Tunnel Eastbound – Enlargement of TBM pilot, Concurrent & grout jacking
G	31/05/2014	30/09/2015	-

Figure 2.3.1 Volume of grout injected from TCR GS7 by grouting type

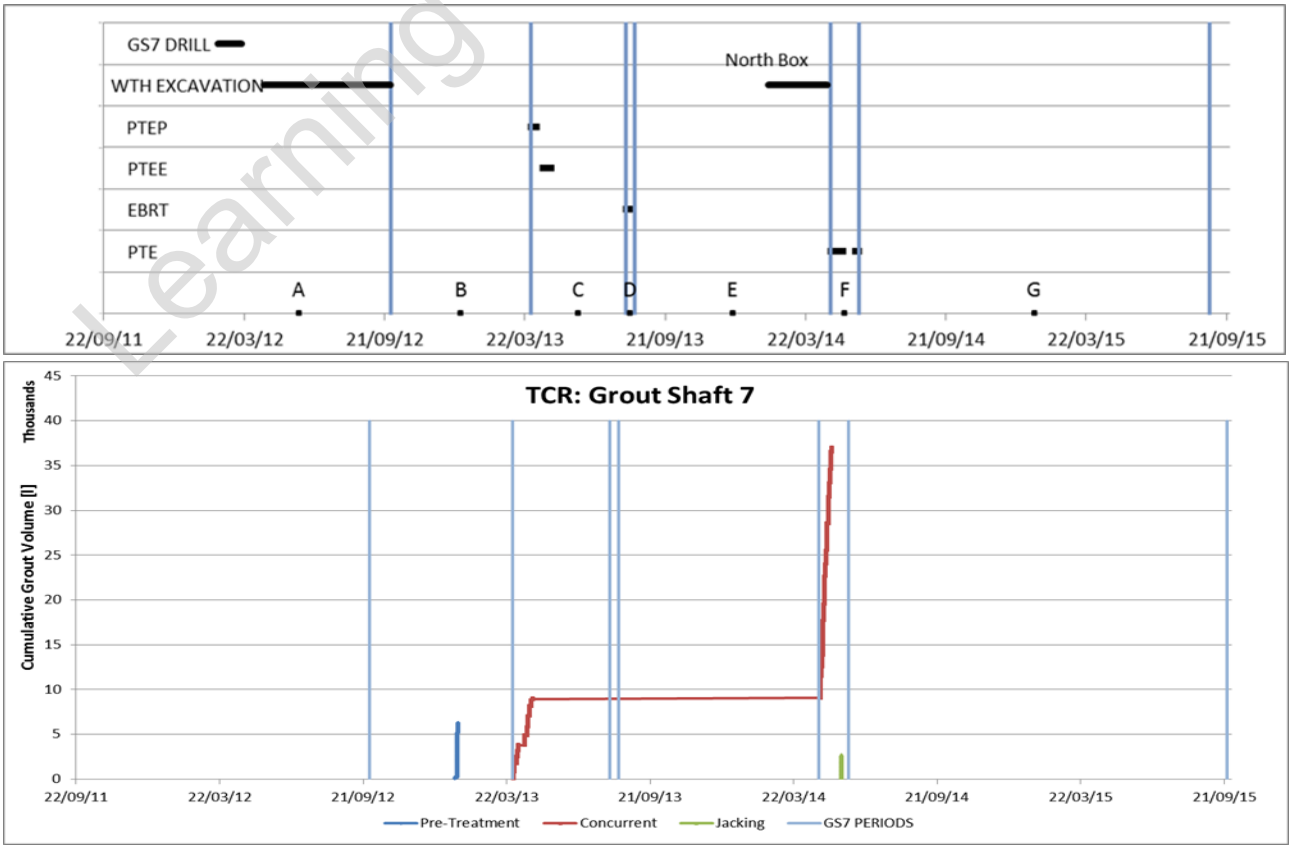


Figure 2.3.2 Distribution of grout injected from TCR GS7: Pre-treatment grouting. Grout Intensity (mm).

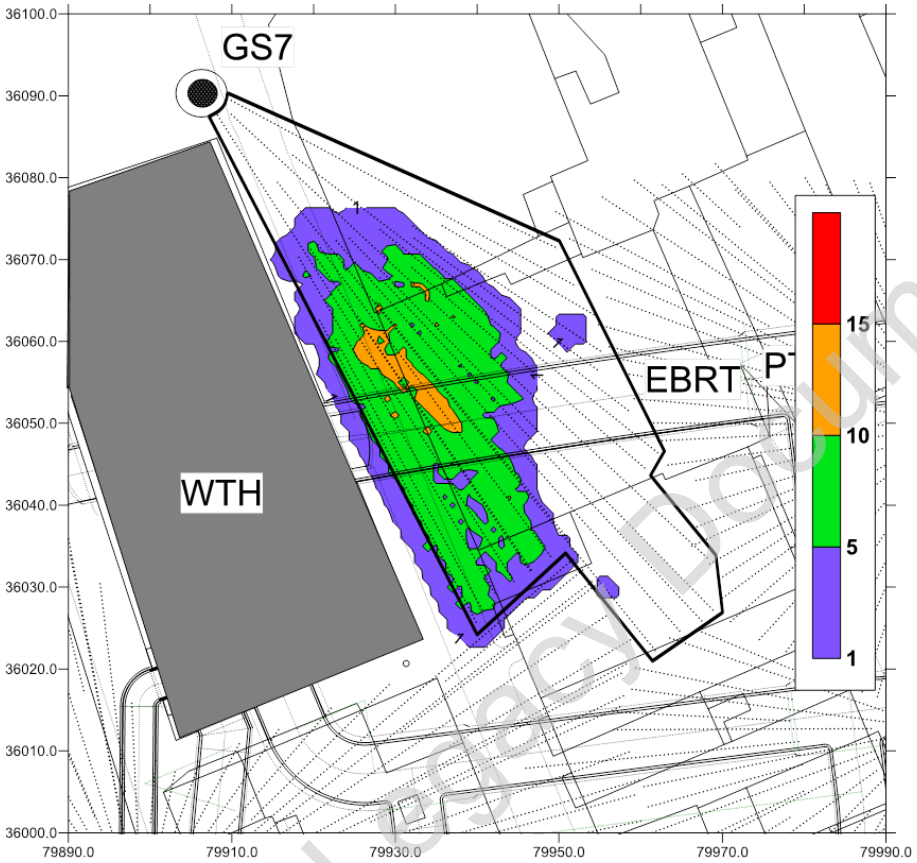


Figure 2.3.3 Distribution of grout injected from TCR GS7: Concurrent grouting. Grout Intensity (mm).

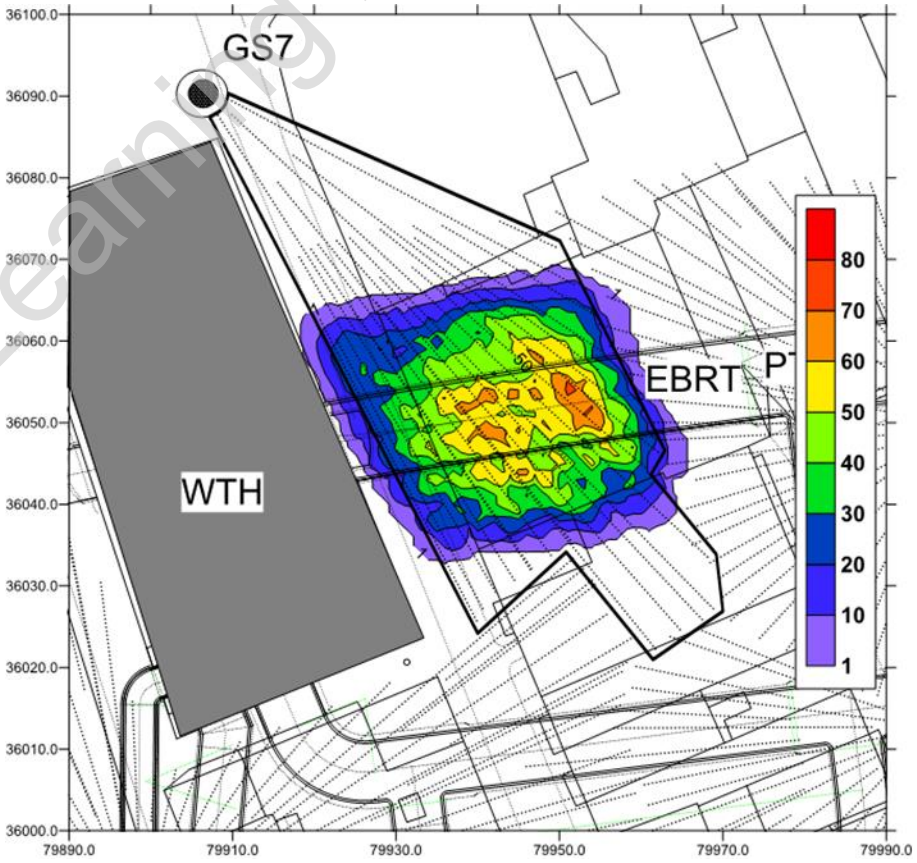


Figure 2.3.4 Distribution of grout injected from TCR GS7: Jack grouting. Grout Intensity (mm).

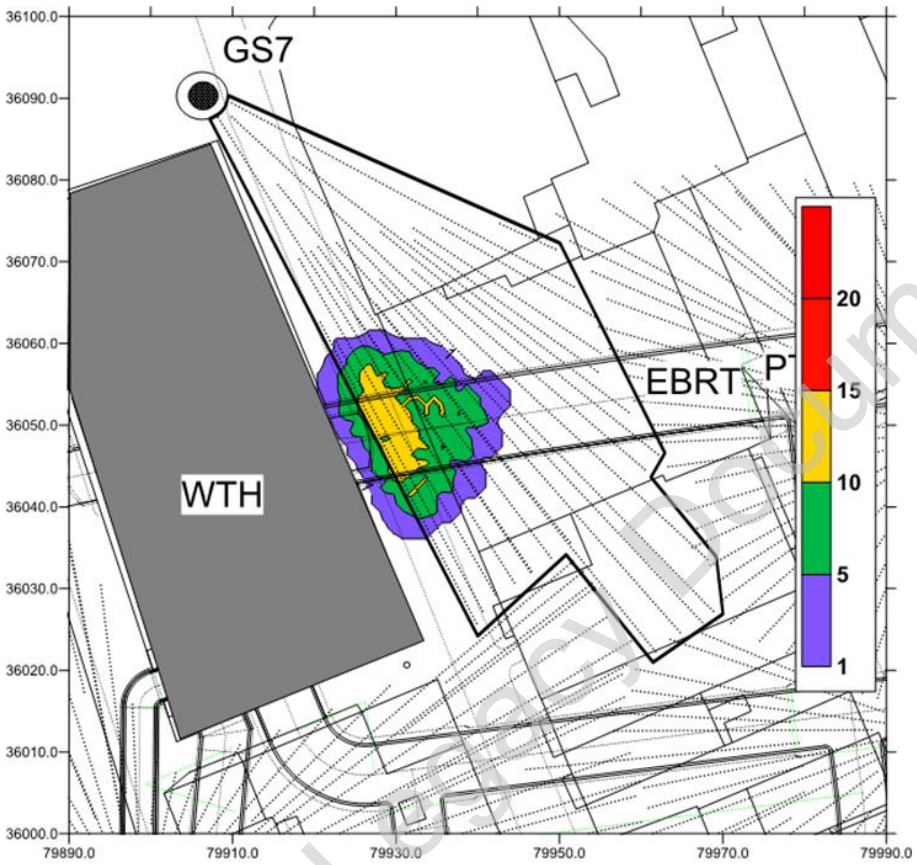
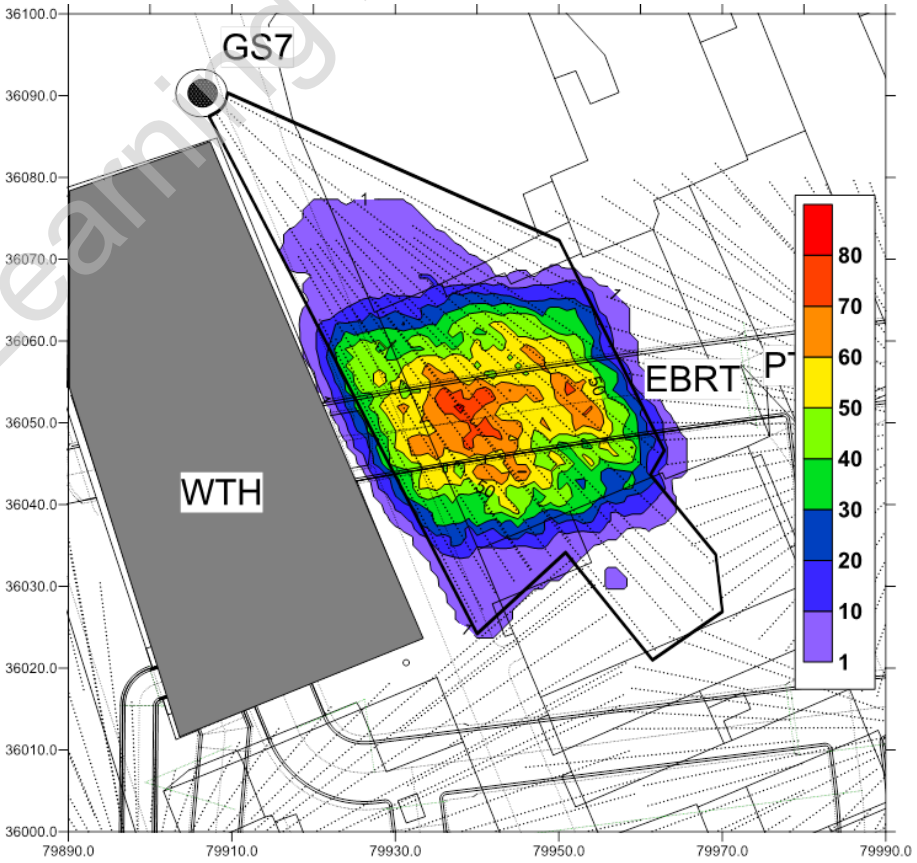


Figure 2.3.5 Distribution of grout injected from TCR GS7: All grouting. Grout Intensity (mm).



3. COMPARISON OF OBSERVED AND PREDICTED SETTLEMENT

3.1. Settlement Overview

Contours of total predicted short term greenfield settlement (supplied by C122) is shown in Figure 3.1.1. The measured settlement to May 2014, including consolidation settlement during the period of construction is shown in Figure 3.1.2.

The following points are noted:

- Settlements are substantially less than the predicted values, notwithstanding that the observed movements include a significant proportion of consolidation settlement over the 3 ½ year construction period.
- The spacing of the contours (the slopes) is much less severe than indicated by the predicted contour.

Figure 3.1.1Predicted greenfield settlement contour (supplied by C122)

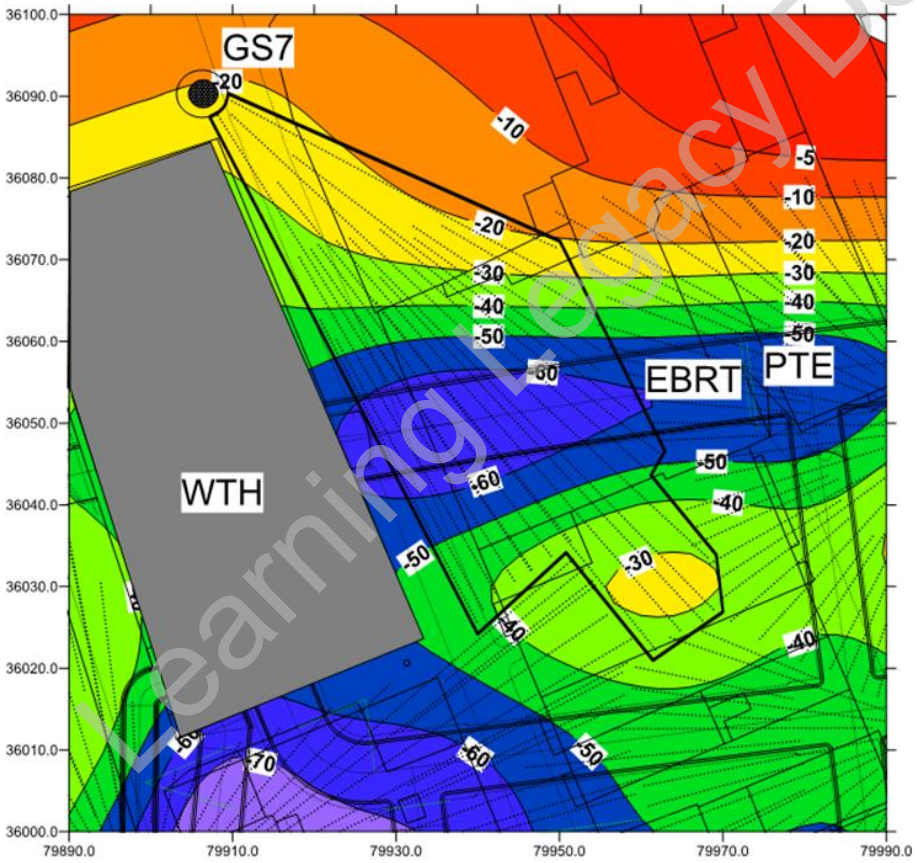
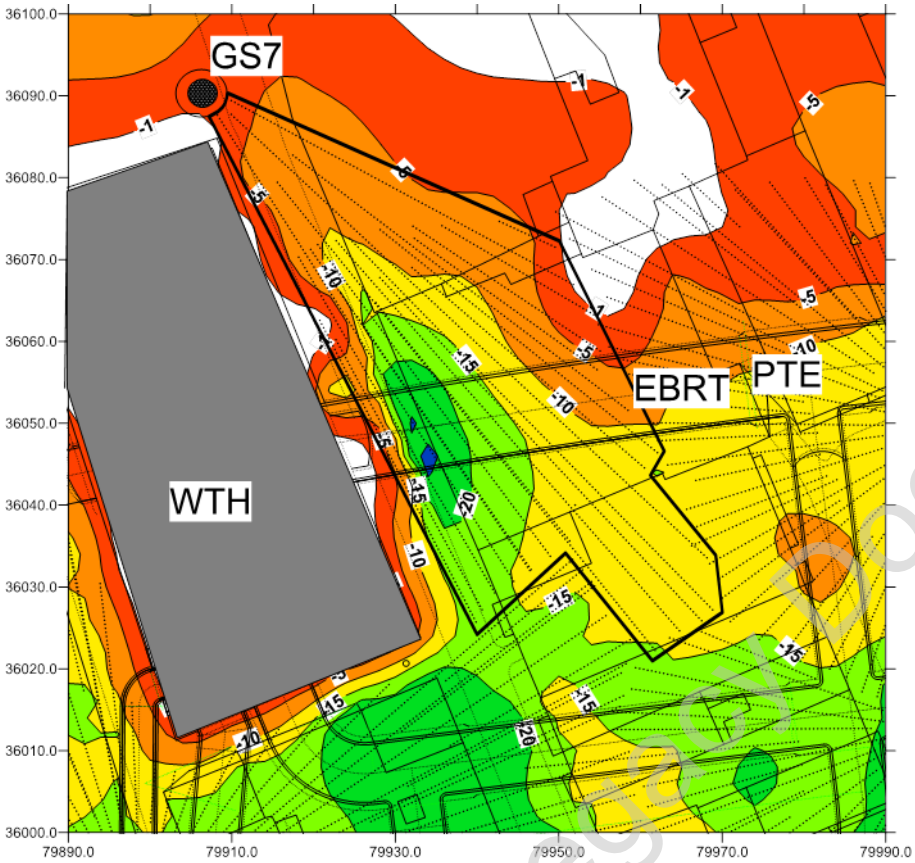


Figure 3.1.2 Observed settlement contour in May 2014 (End of Construction – Period F)



In order to compare the predicted and actual movements at various stages of construction, the overall monitoring data which extends from December 2011 to September 2015, has been divided into a number of periods, based largely on the progress of tunnel excavation. The dates of construction activities in each period 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 (where relevant);
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 (where relevant);
5. Contour of grout intensity for grout jacking within the Period (where relevant).

3.2. Period A: 17/02/12 – 29/09/12 WTH Excavation, GS7 Drilling

BFK works comprised the drilling of TaMs from TCR GS7 and the WTH (south box) excavation. Greatest settlement is opposite the centre of the WTH east wall where ~8mm settlement is indicated. No grouting was carried out in Period A. heave was generated during TaM drilling with water flush, however, this had dissipated by the end of Period A (refer to Sections 4 and 5 for more detail).

Figure 3.2.1 Period A: Predicted greenfield settlement (supplied by C122)

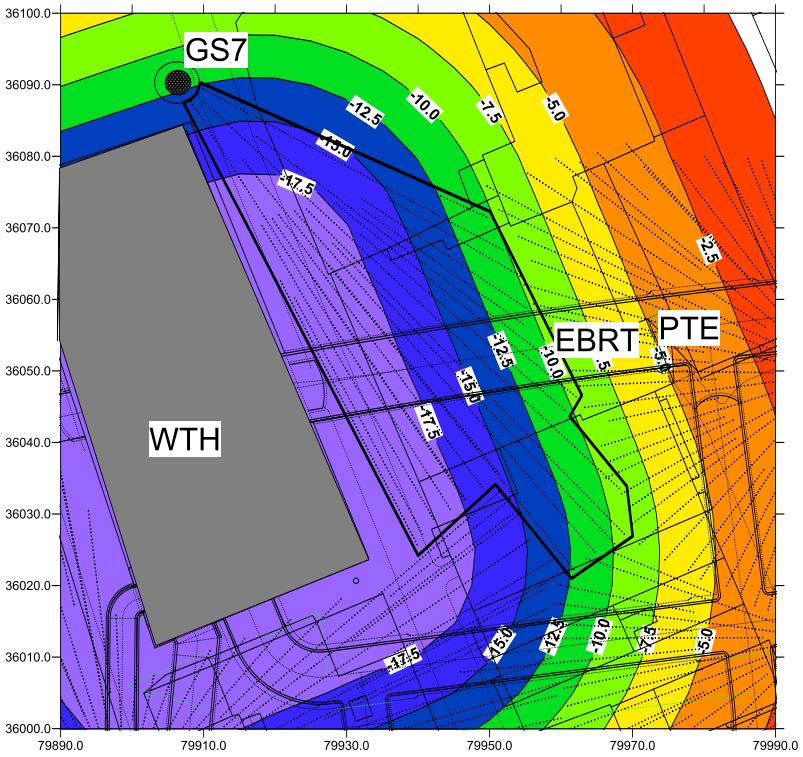
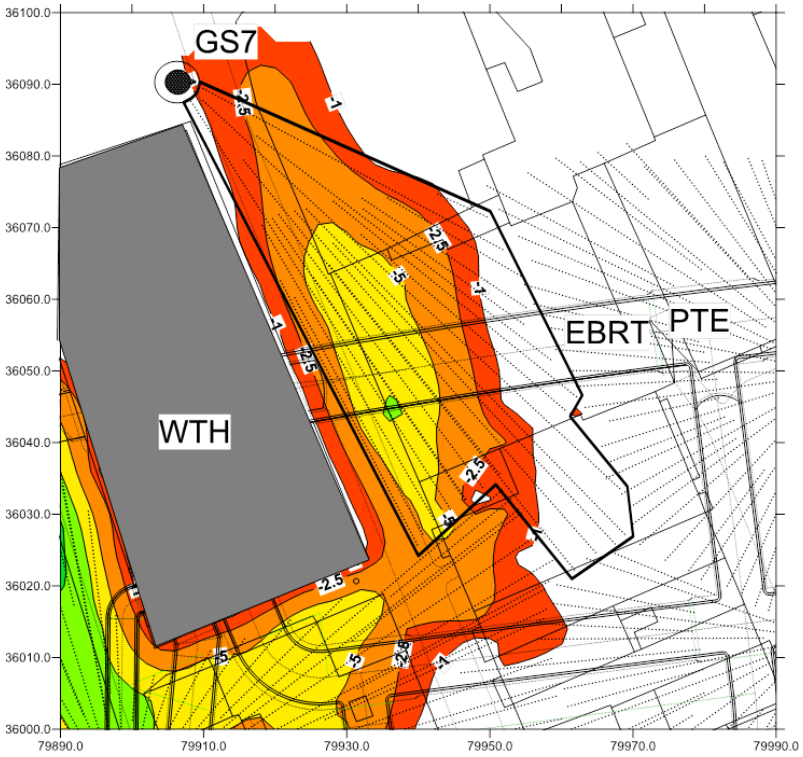


Figure 3.2.2. Period A: Total measured settlement



3.3. Period B: 29/02/12 – 29/03/13 Pre-treatment, No Tunnelling

Figure 3.3.1 Period B: (a) Change in measured settlement. (b) Total measured settlement

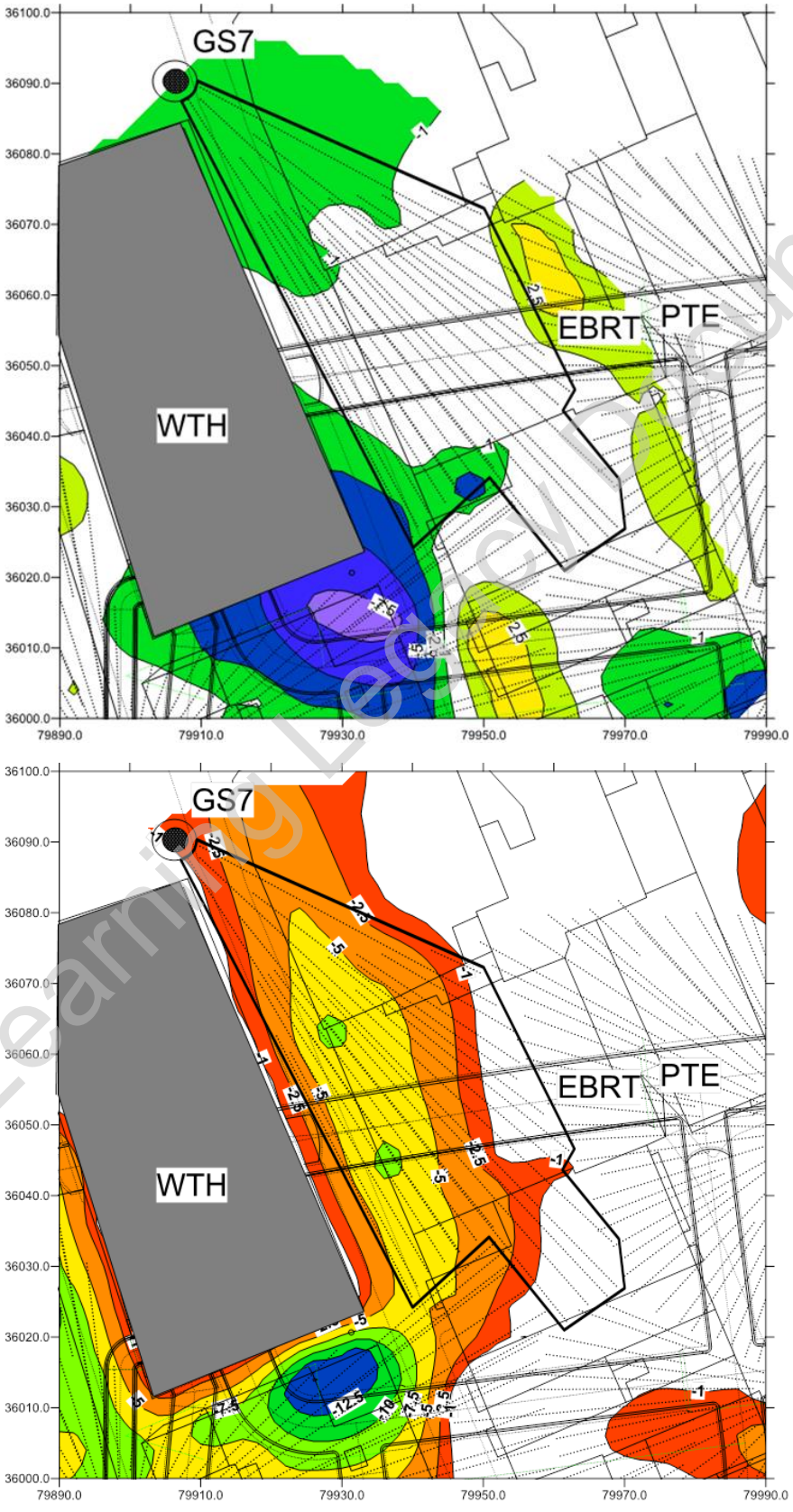
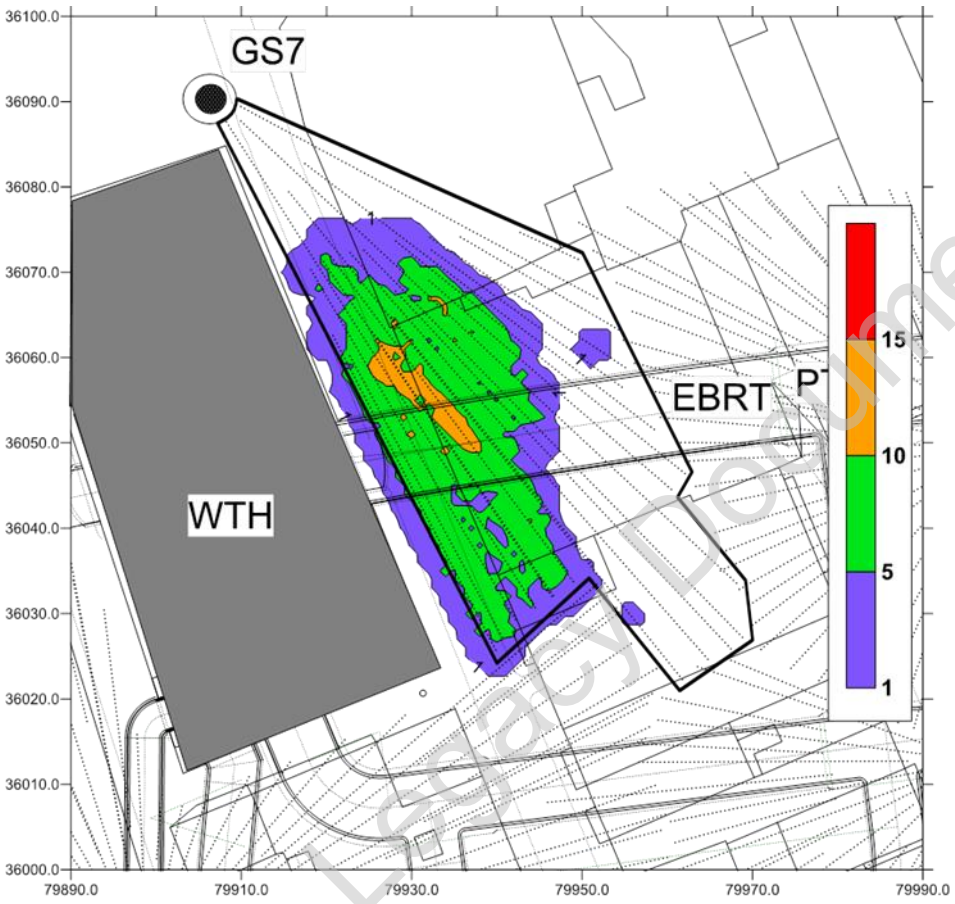


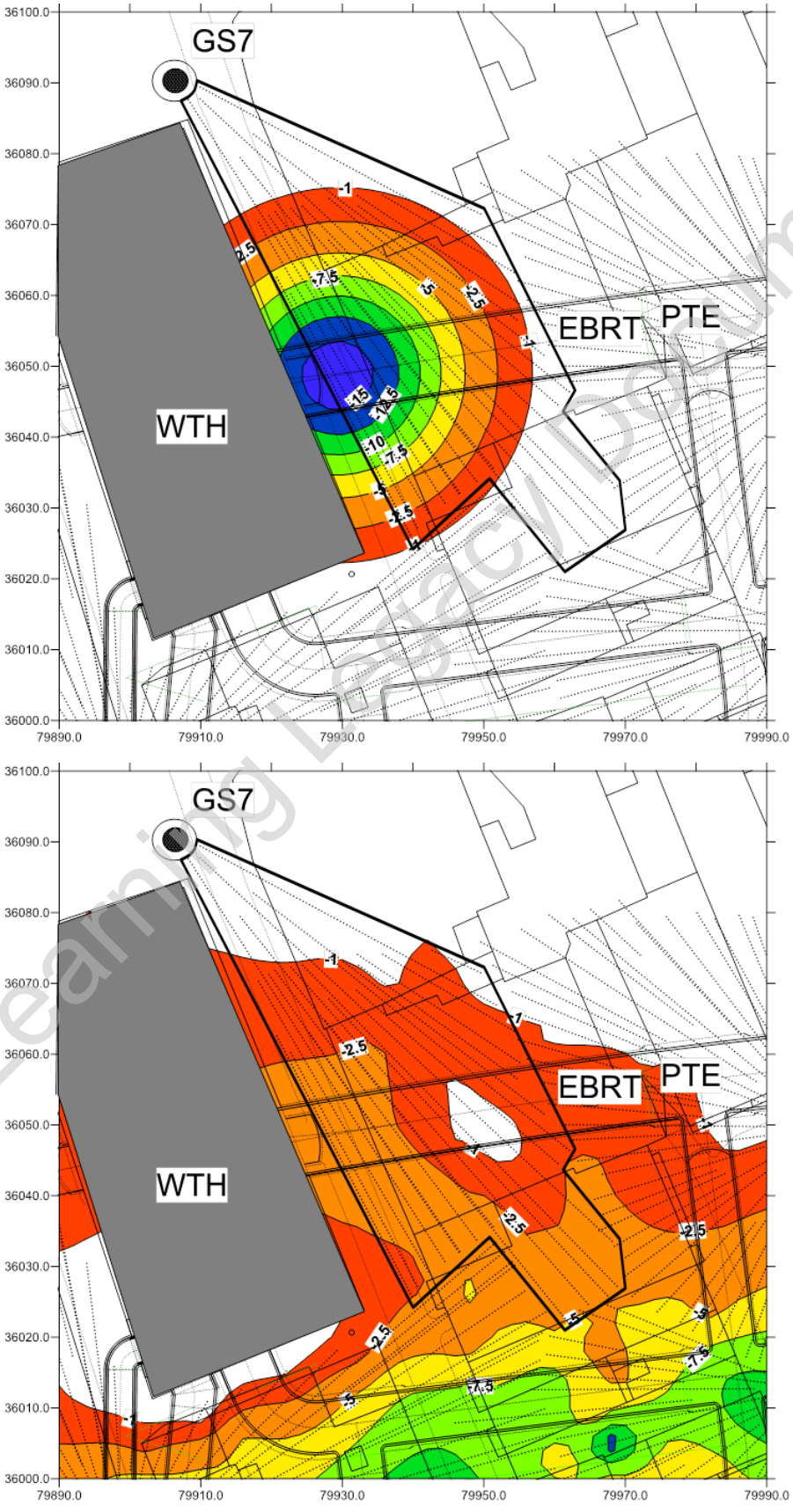
Figure 3.3.2 Period B: Distribution of grout injected from TCR GS7: Pre-treatment grouting. Grout Intensity (mm).



No significant activities were carried out during Period B except the pre-treatment grouting, as per Figure 3.3.2. The change in settlements within the GS7 area is minimal during the period (see Figure 3.3.1 a), but the effect of tunnelling (CH1) and pre-treatment grouting in the adjacent GS1 shaft area is evident.

3.4. Period C: 29/03/13 – 01/08/13 Platform Tunnel Eastbound, Concurrent grouting

Figure 3.4.1 Period C: (a) Predicted greenfield settlement. (b) Change in measured settlement. (c) Total measured settlement



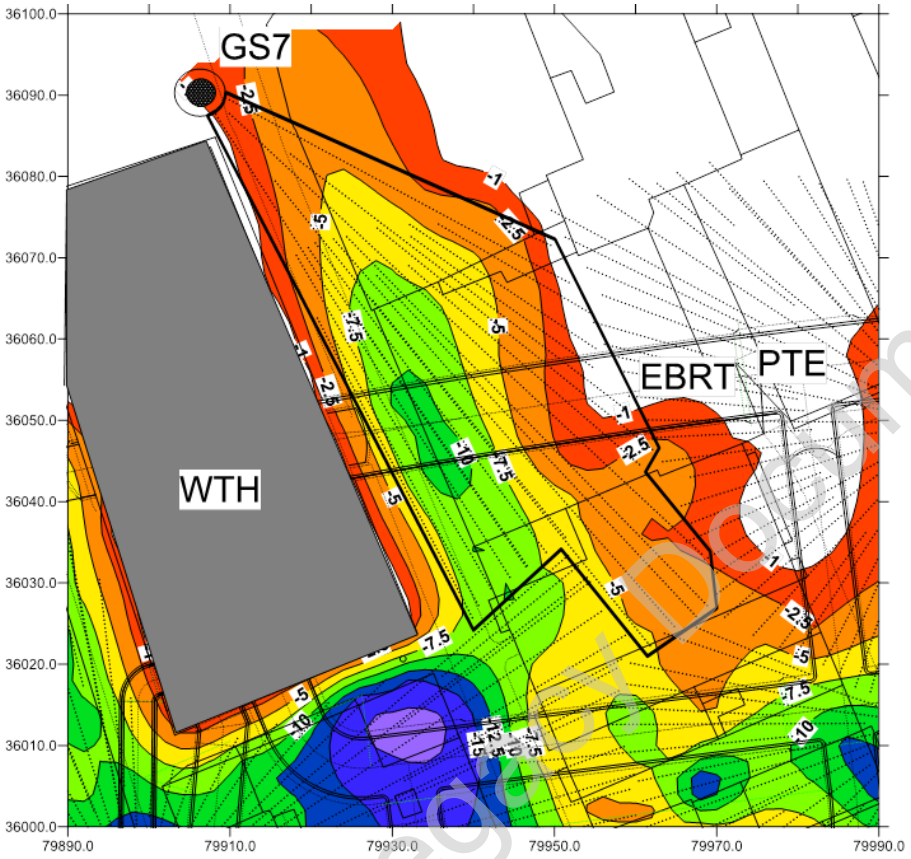


Figure 3.4.2 Period C: Distribution of grout injected from TCR GS7: Concurrent grouting. Grout Intensity (mm).

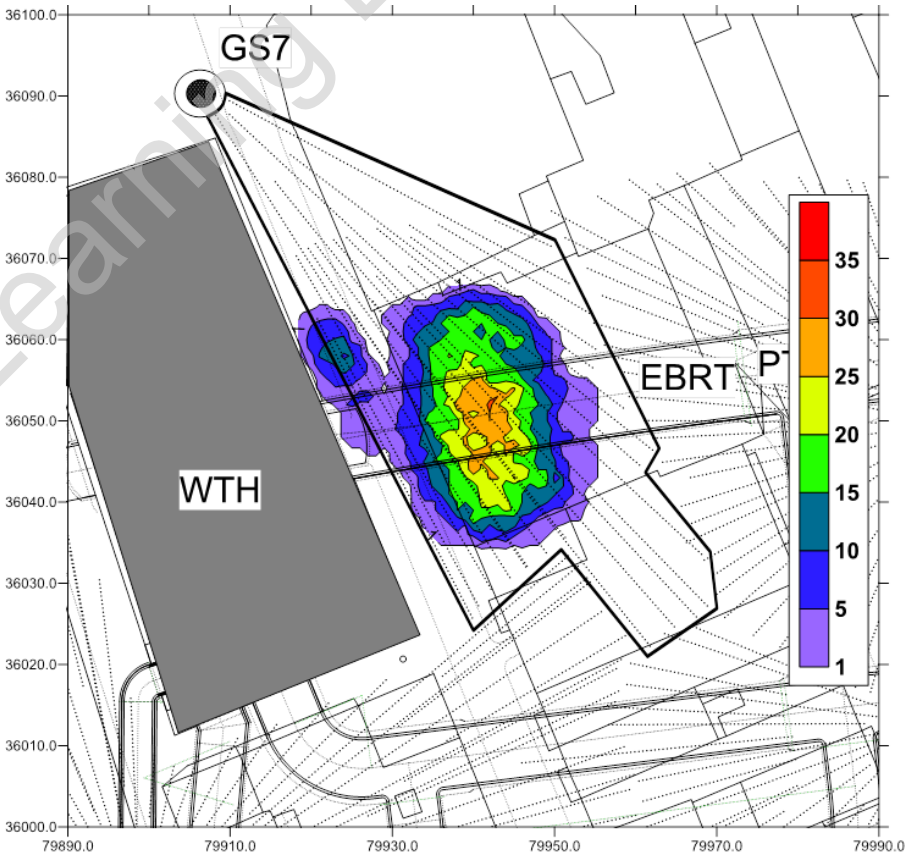
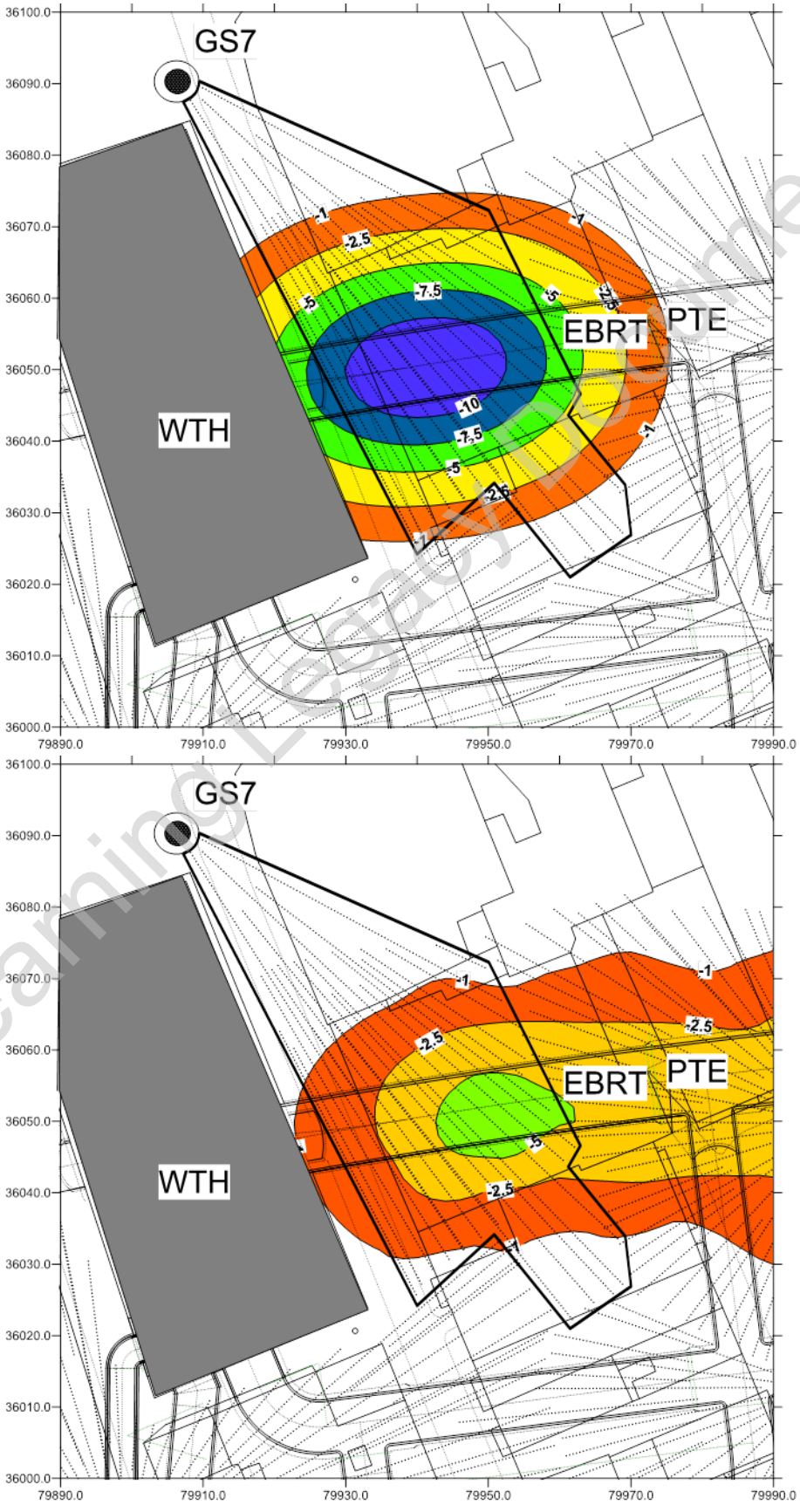


Figure 3.4.1(a) shows the predicted settlements due to tunnelling for PTEP and PTEE (max. 17mm). The measured settlements reported in Figure 3.4.1(b) are less than 5mm in the zone of influence of these tunnels. The concurrent compensation grouting carried out during Period C, as illustrated Figure 3.4.2, was effective in limiting settlement to very small values. Total settlement increased to just over 10mm (Figure 3.4.1(c)).

3.5. Period D: 07/08/13 – 08/08/13 Eastbound Running Tunnel

Figure 3.5.1 Period D: (a) Predicted greenfield settlement. (b) Change in measured settlement. (c) Total measured settlement



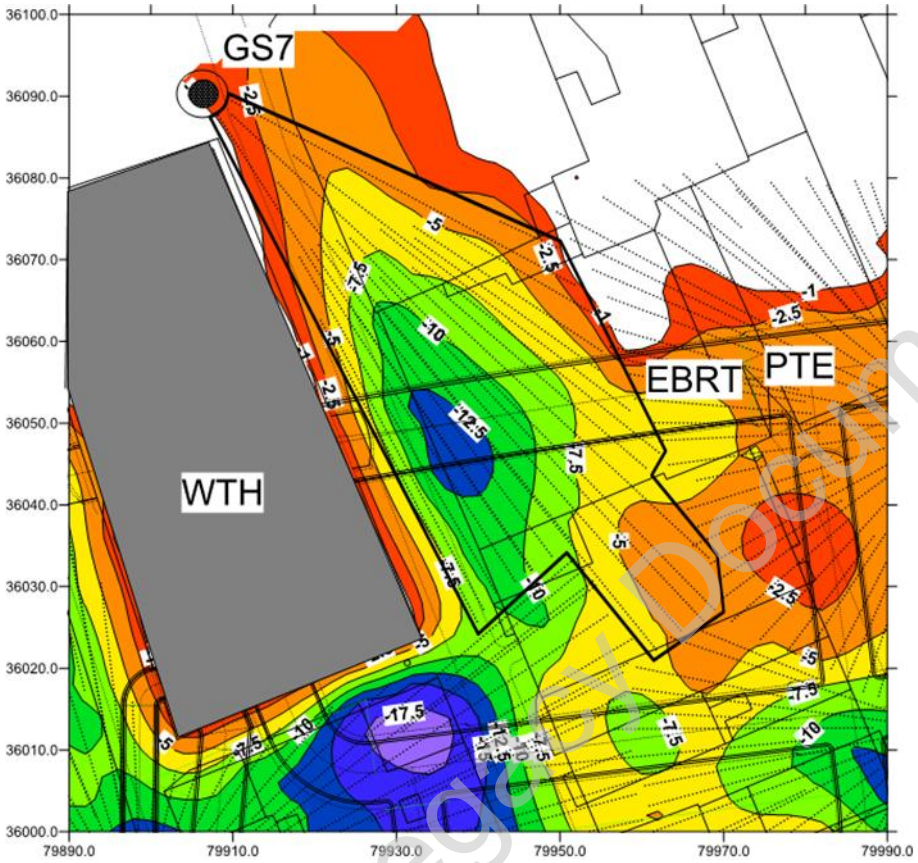
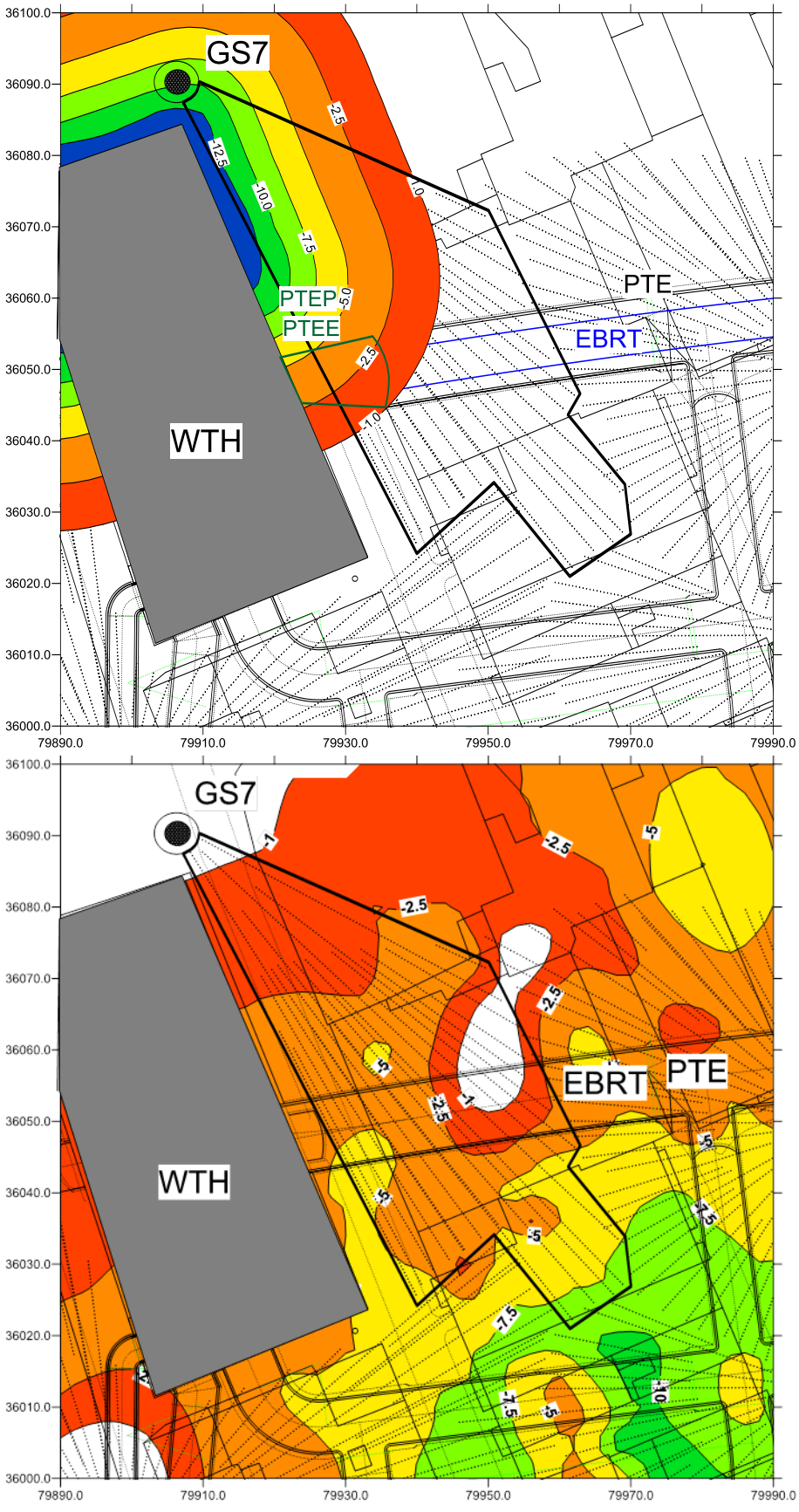
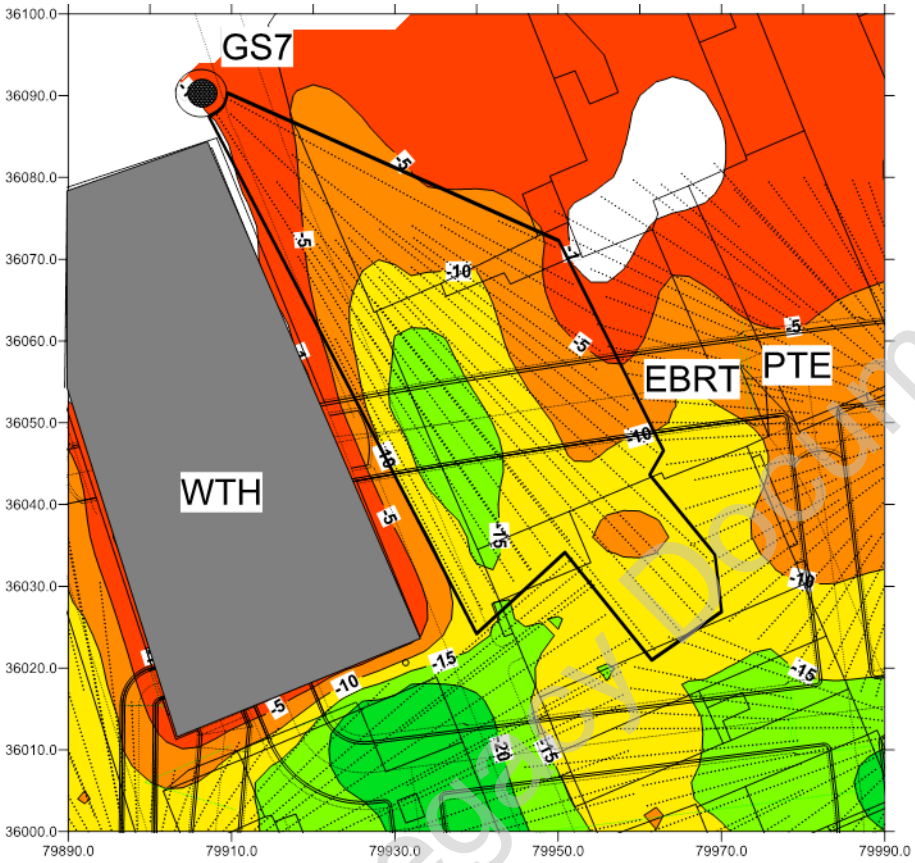


Figure 3.5.1(a) shows the predicted settlements due to EBRT with a maximum of about 12mm. The measured settlements reported in Figure 3.5.1(b) are less than 7mm. Since no grouting was undertaken, it is evident that the volume loss achieved was significantly less than the specified value of 1%. Total settlement increased to just over 12.5mm (Figure 3.5.1(c)).

3.6. Period E: 08/08/13 – 24/04/14 WTH North Box

Figure 3.6.1 Period E: (a) Predicted greenfield settlement. (b) Change in measured settlement. (c) Total measured settlement

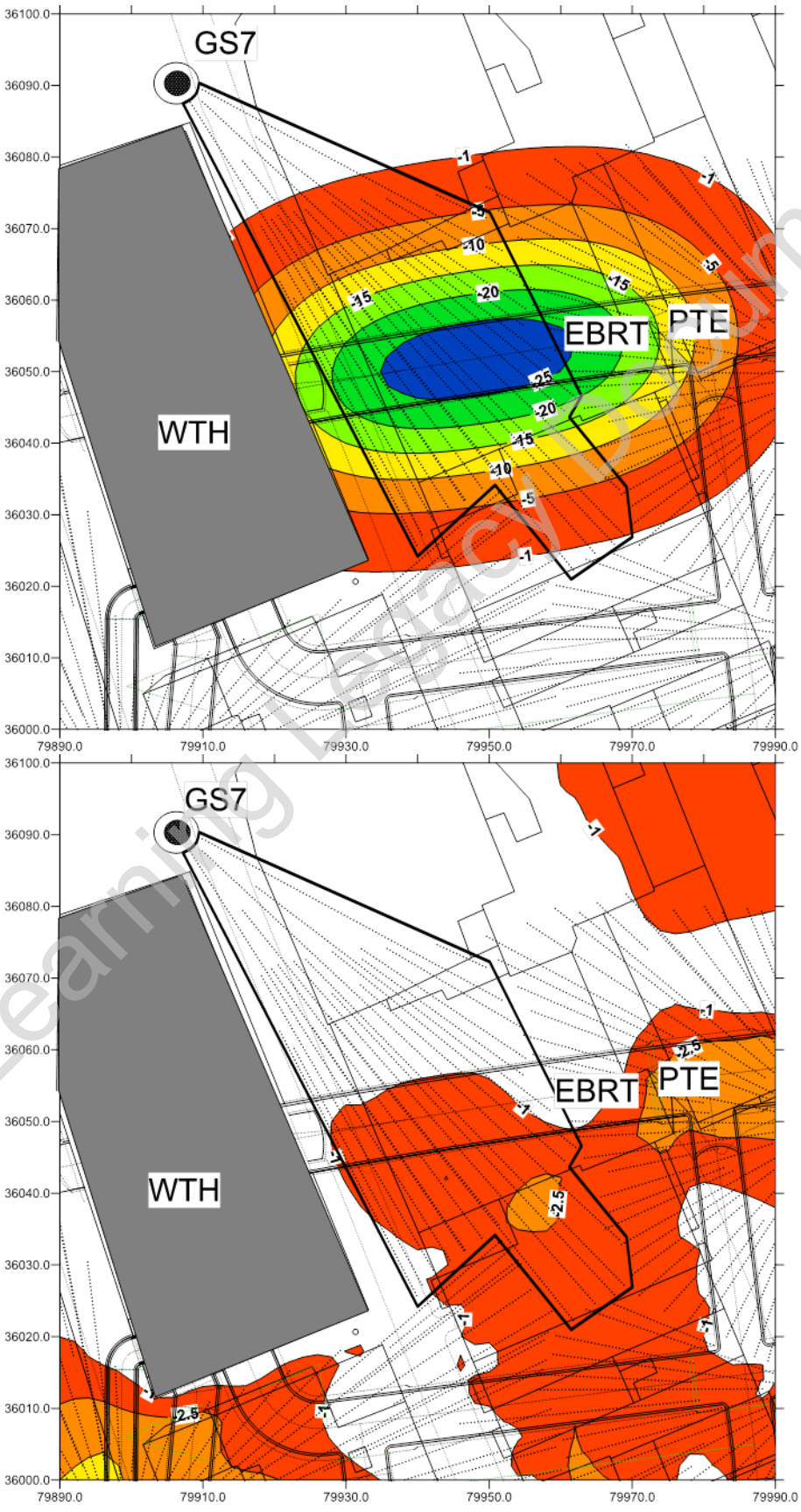




Excavation of the WTH north box was carried out in Period E, with predicted settlement of ~13mm (Figure 3.6.1a). The change in settlements during the period (see Figure 3.6.1 b) is small <5mm with the maximum movement adjacent to the south box over the PTE and is considered to be due to consolidation rather than excavation of the north box. Total settlement increased to just over 15mm (Figure 3.6.1(c)).

3.7. Period F: 24/04/14 – 31/05/14 Platform Tunnel Enlargement, Concurrent & Grout Jacking

Figure 3.7.1 Period F: (a) Predicted greenfield settlement. (b) Change in measured settlement. (c) Total measured settlement



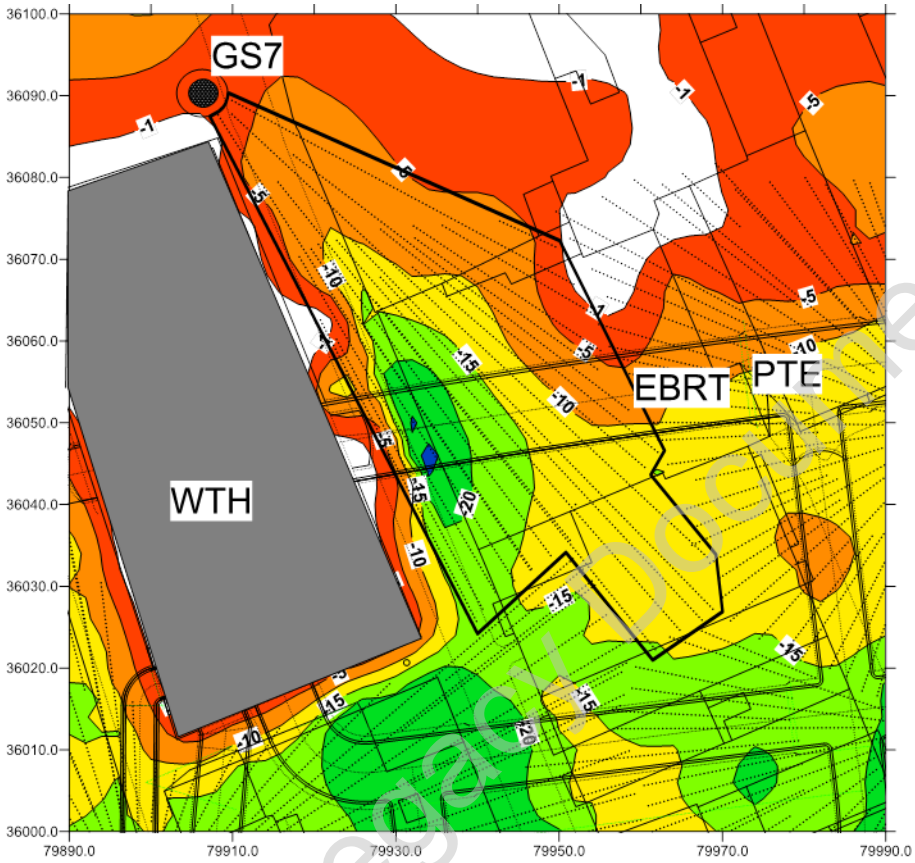


Figure 3.7.2 Period F: Distribution of grout injected from TCR GS7: Concurrent grouting. Grout Intensity (mm).

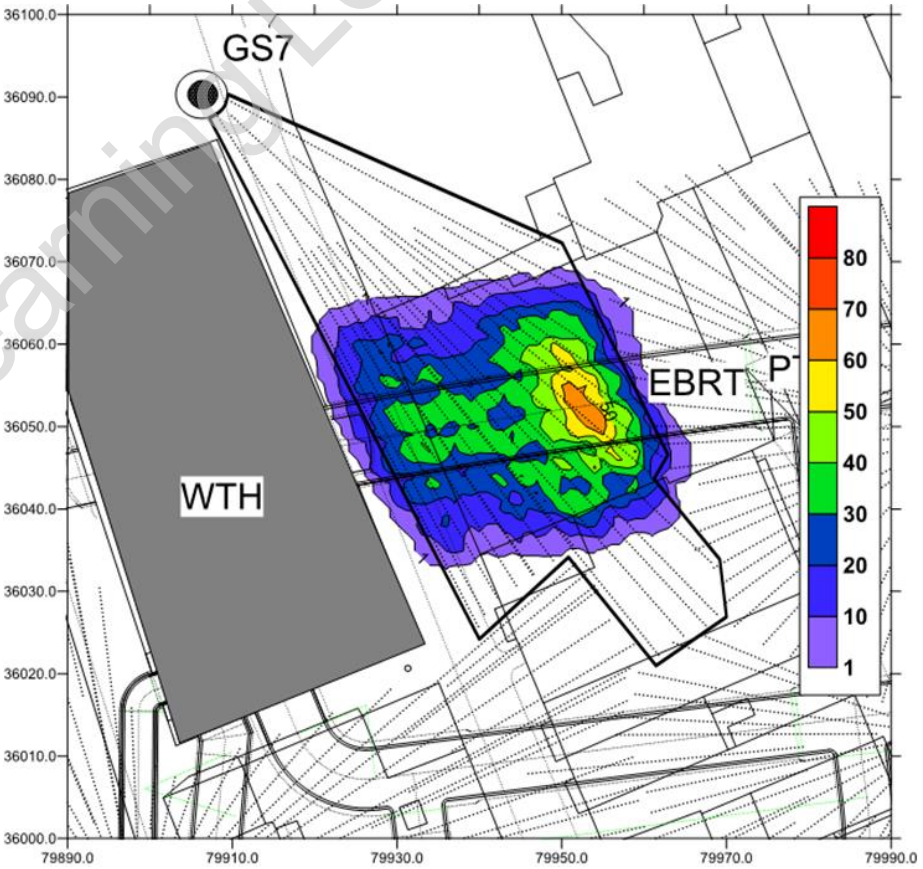


Figure 3.7.3 Period F: Distribution of grout injected from TCR GS7: Grout jacking. Grout Intensity (mm).

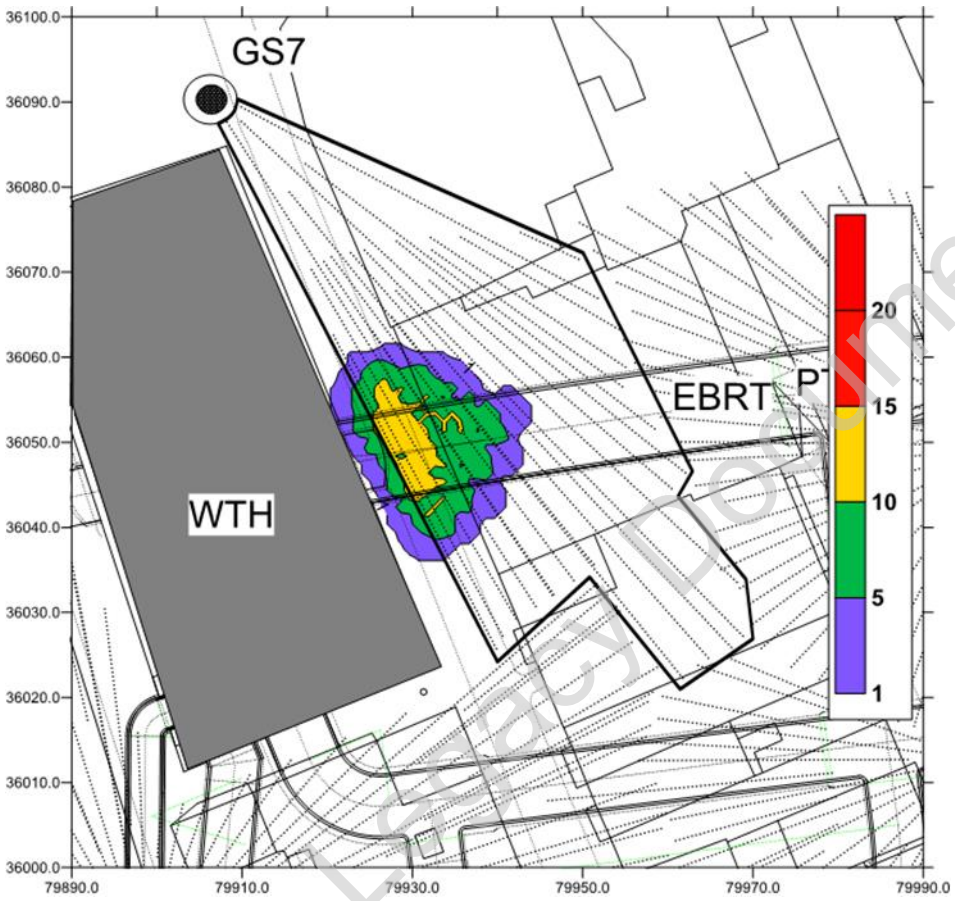
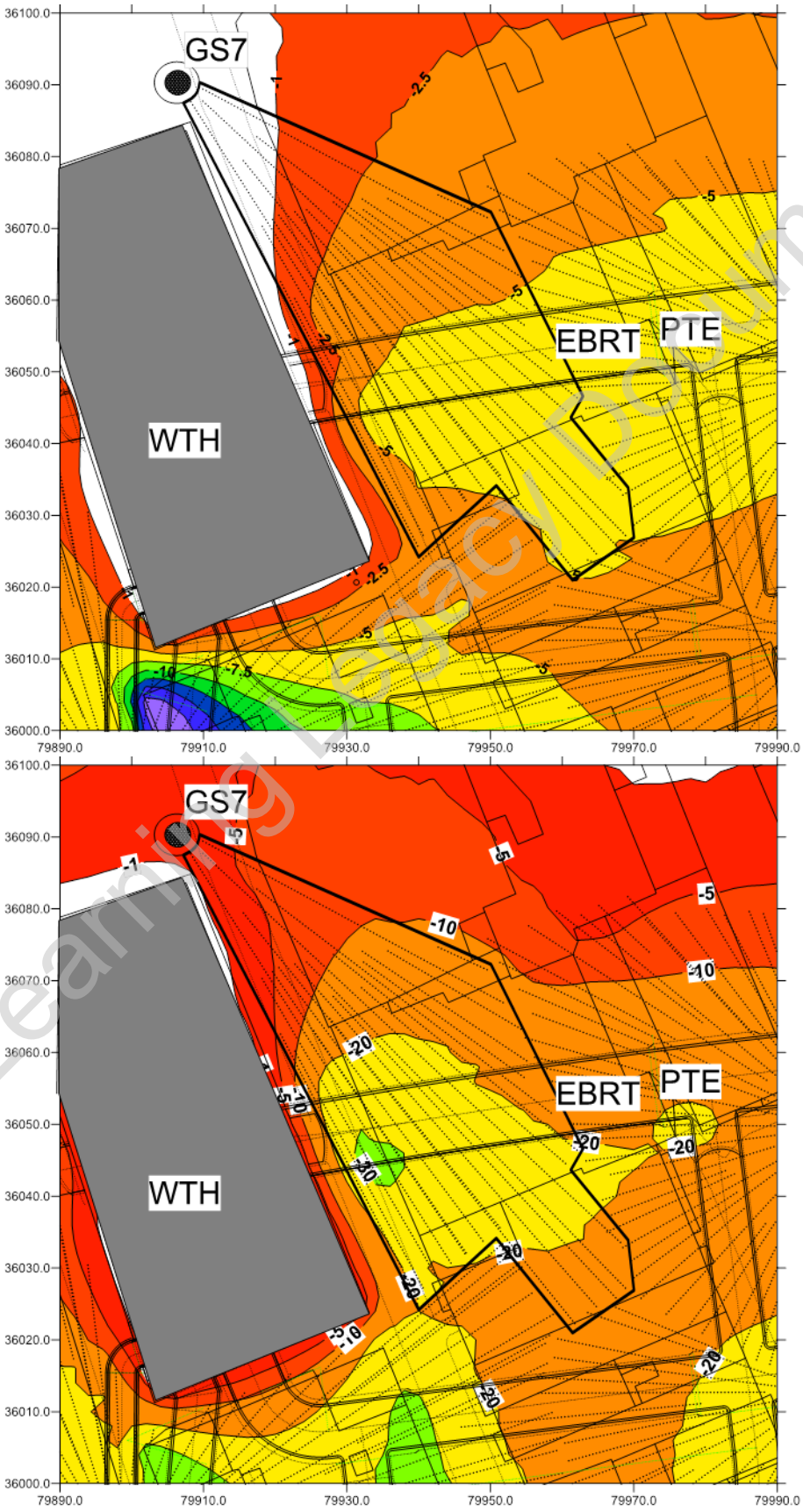


Figure 3.7.1(a) shows the predicted settlements due to the SCL enlargement of the EBRT for the PTE (max. 29mm). The measured settlements illustrated in Figure 3.7.1(b) are very small (<3mm) as a result of the concurrent grouting and jack grouting carried out within the period (see Figures 3.7.2 and 3.7.3). Total settlement increased to just over 25mm (Figure 3.7.1(c)).

3.8. Period G: 31/05/14 – 30/09/15 Post Construction

Figure 3.8.1 Period G: (a) Observed settlement in Period G; (b) Total settlement



The increase in settlement over the 16 months between May 2014 and September 2015 (Period G) are shown in Figure 3.8.1a, and has a maximum value of <7mm within the GS7 area, equivalent to a rate of 5mm/year. The total settlements when manual monitoring was de-scoped under C300-PMI-01858 are shown in Figure 3.8.1b, with a local maximum of 30mm and more generally 10 – 20mm.

4. BUILDING SETTLEMENT AND SLOPES

4.1. Slope triggers

The locations of BRE monitoring of building facades within the GS7 area are shown on Figure 4.1. A larger version of Figure 4.1 is included in Appendix C.

Slope triggers are as follows:

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

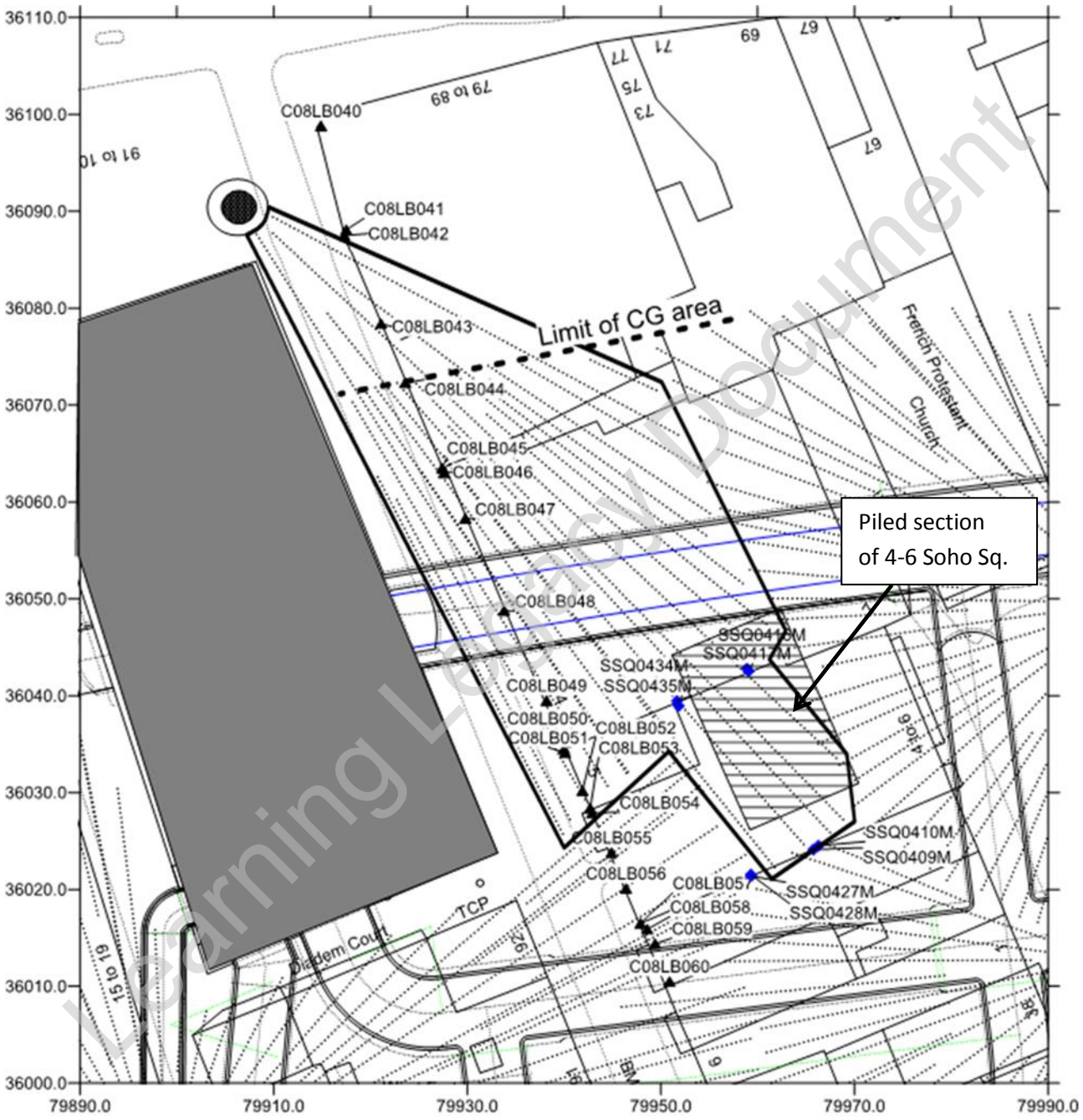
No Amber or Red slope trigger levels have been exceeded, and consequently no deflection ratios triggers can have been exceeded.

BRE monitoring data from the single building facade within the footprint of GS7, namely Dean Street East, is presented in the following section. The plots presented comprise:

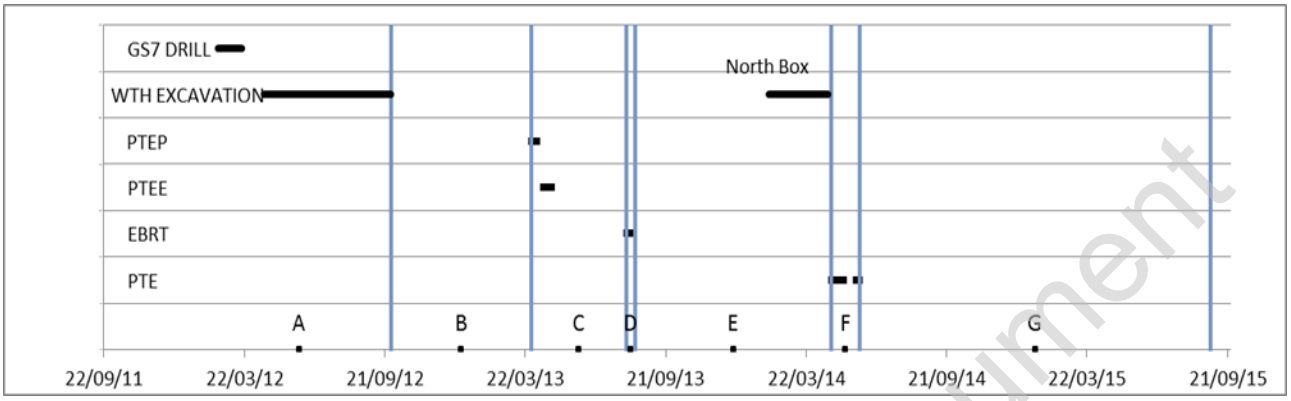
1. Summary of tunnel construction and associated construction periods
2. Time settlement history
3. Settlement profile plots with series as close to the end of each construction period as is available
4. Time slope history over the full construction period with the distances between the points in metres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

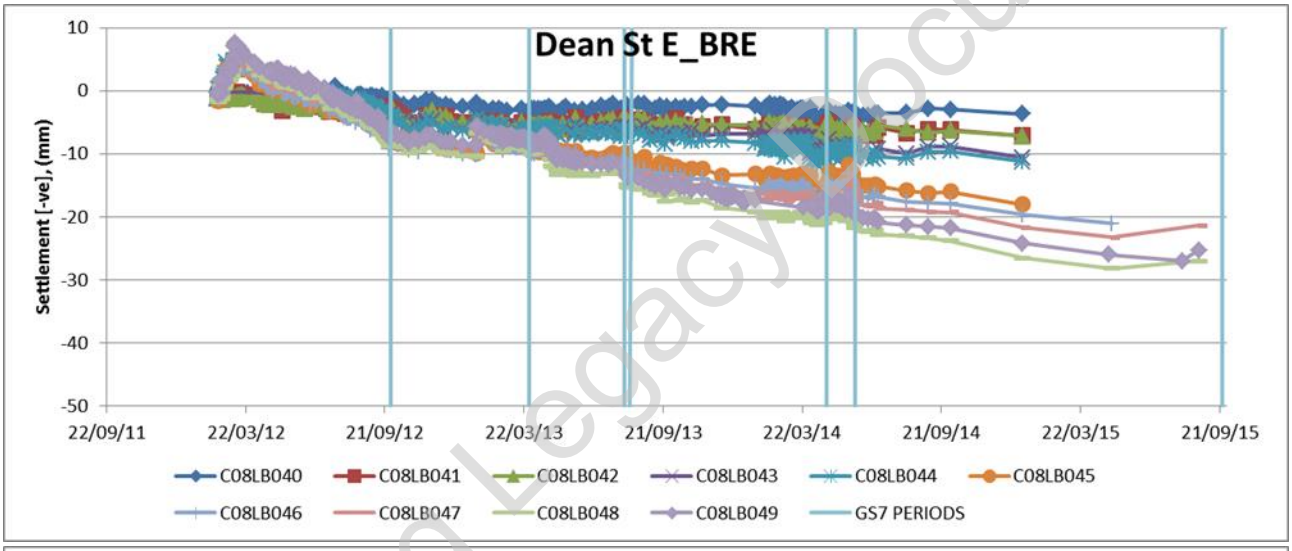
The TaMs installed from GS7 were extended below a partially piled section of 4-6 Soho Square, although no grouting was undertaken in this area. HLC were installed on the columns supported by piles and on the adjacent brickwork of the ground bearing arches, to record any differential movement. Selected data is presented, the locations of which are shown on Figure 4.1. All HLC data presented is based on daily means.

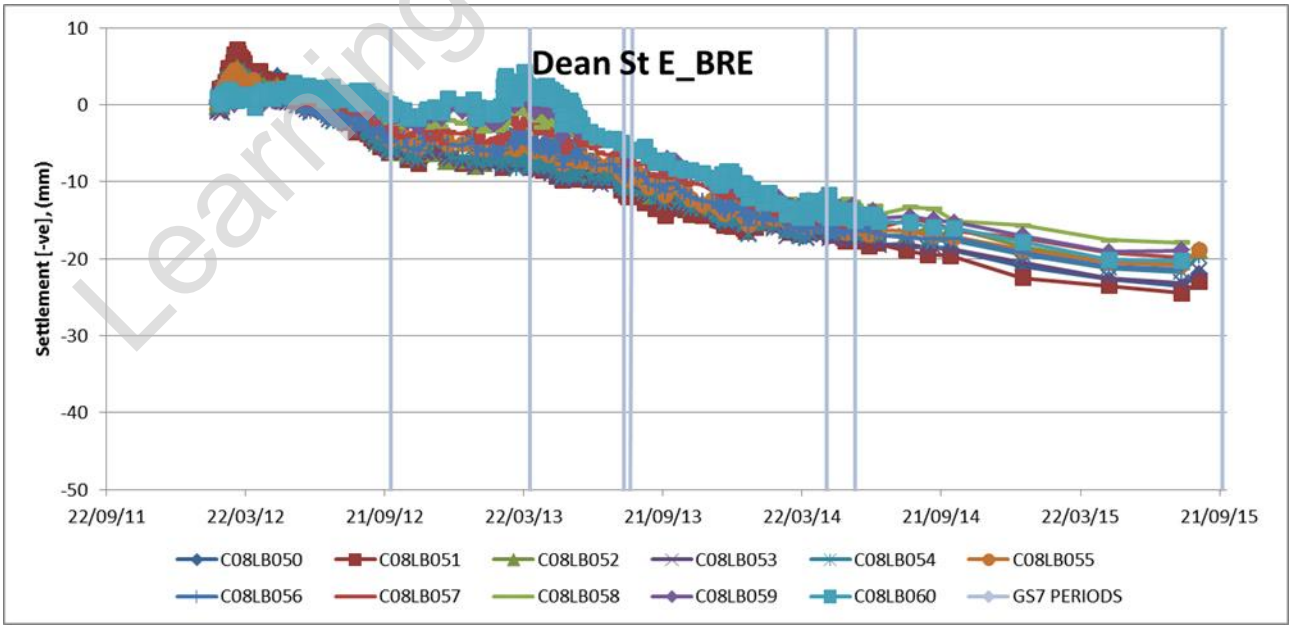
Figure 4.1.1 Locations of building monitoring.

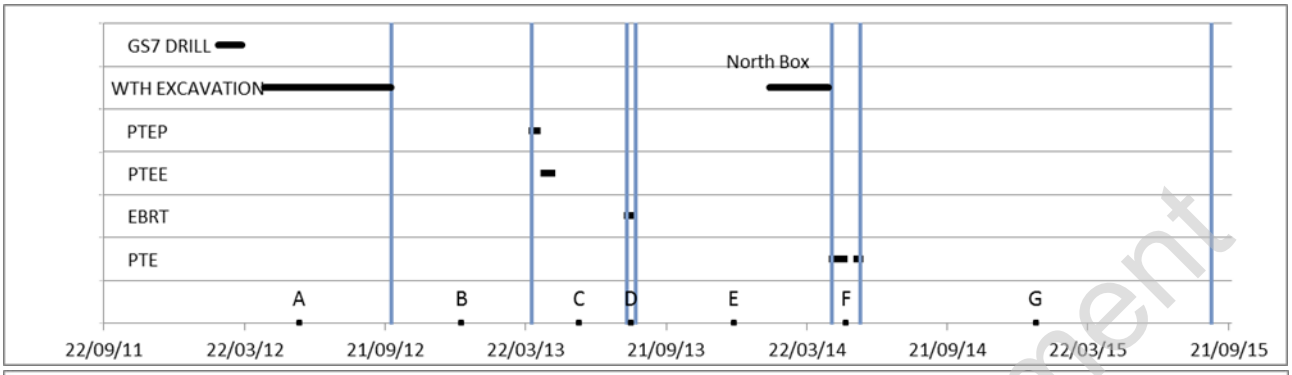


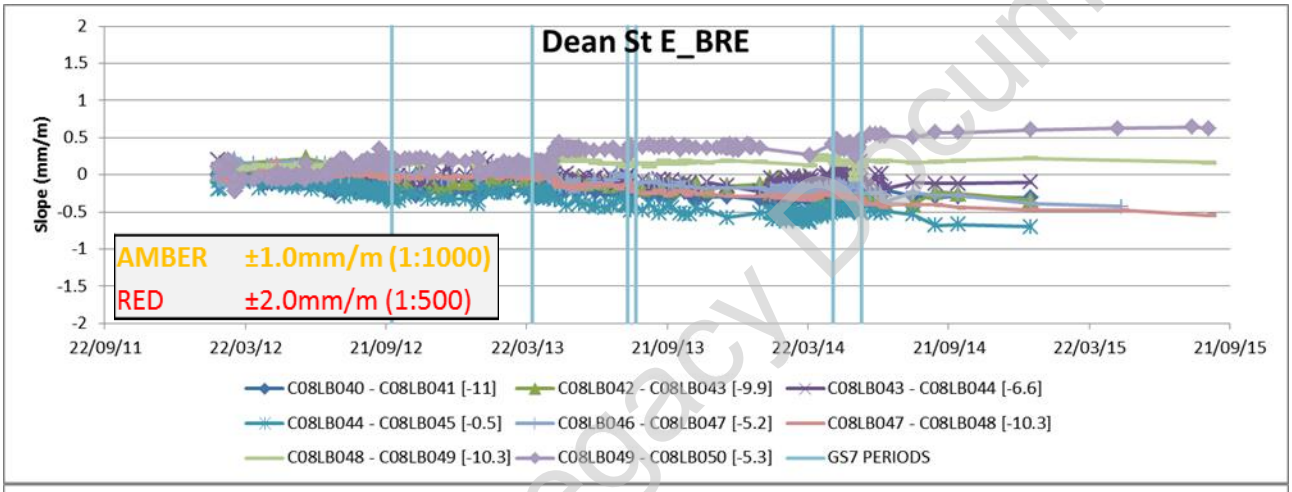
4.2. Dean Street East - North

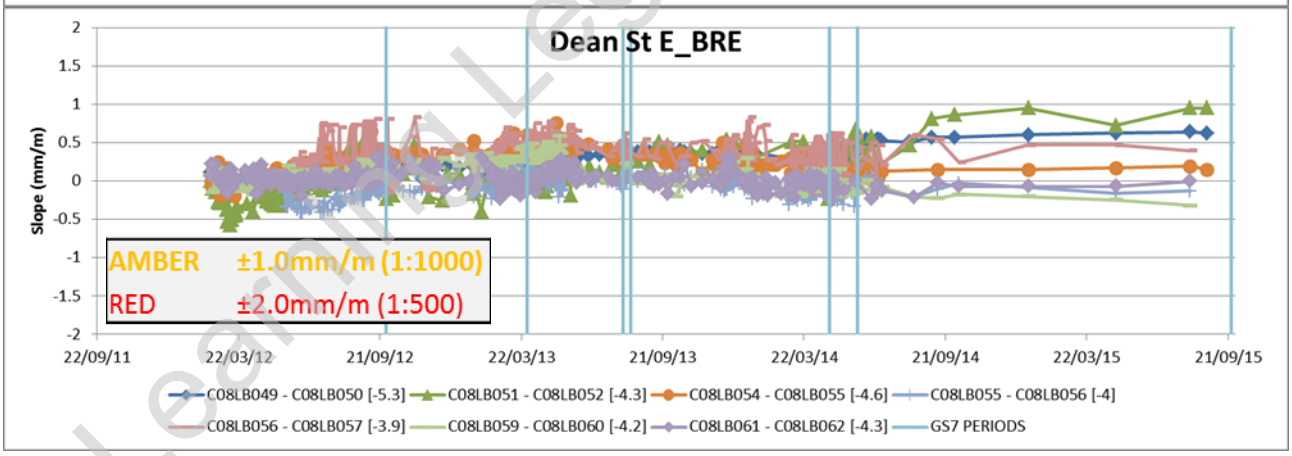


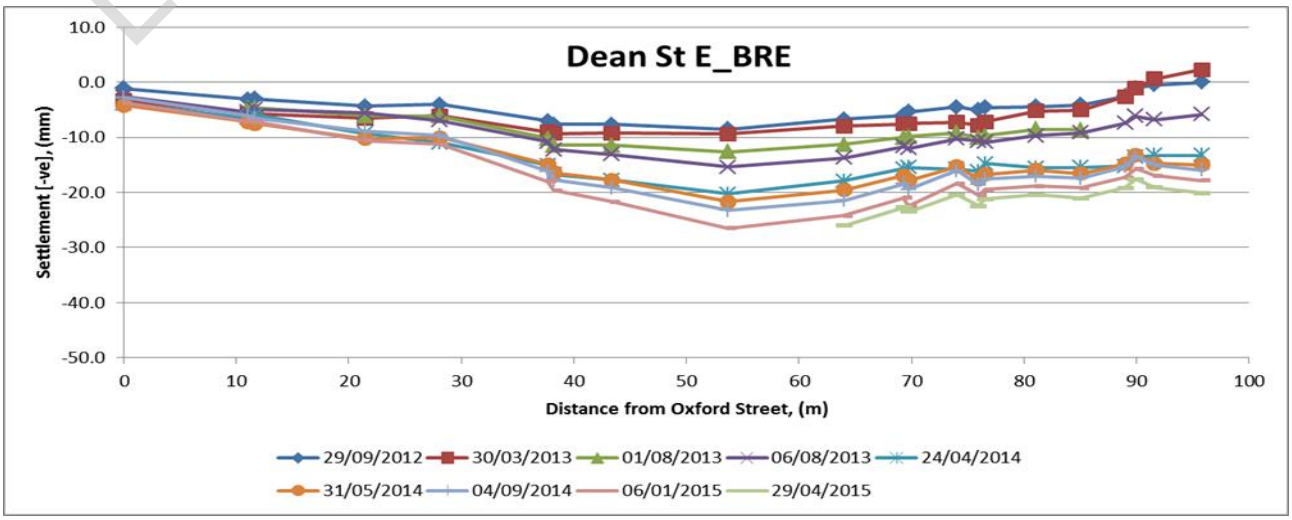








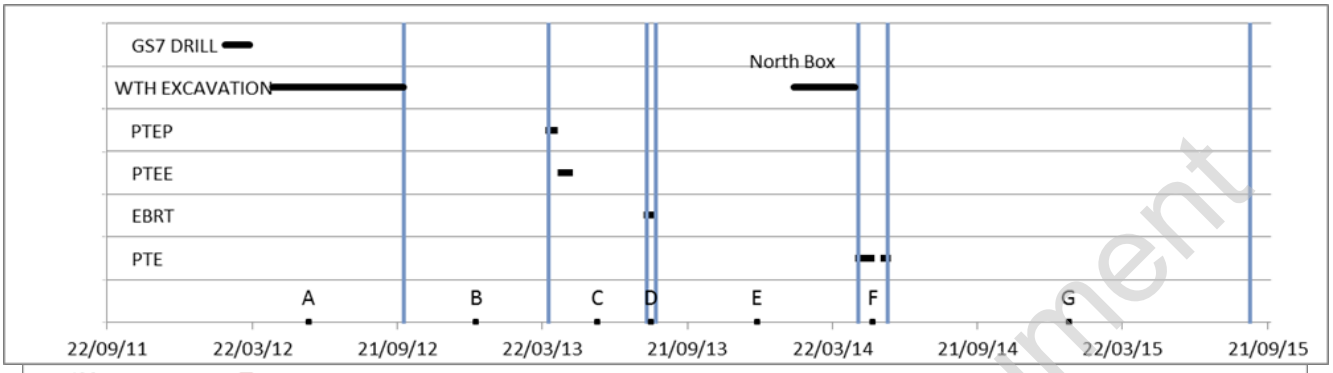


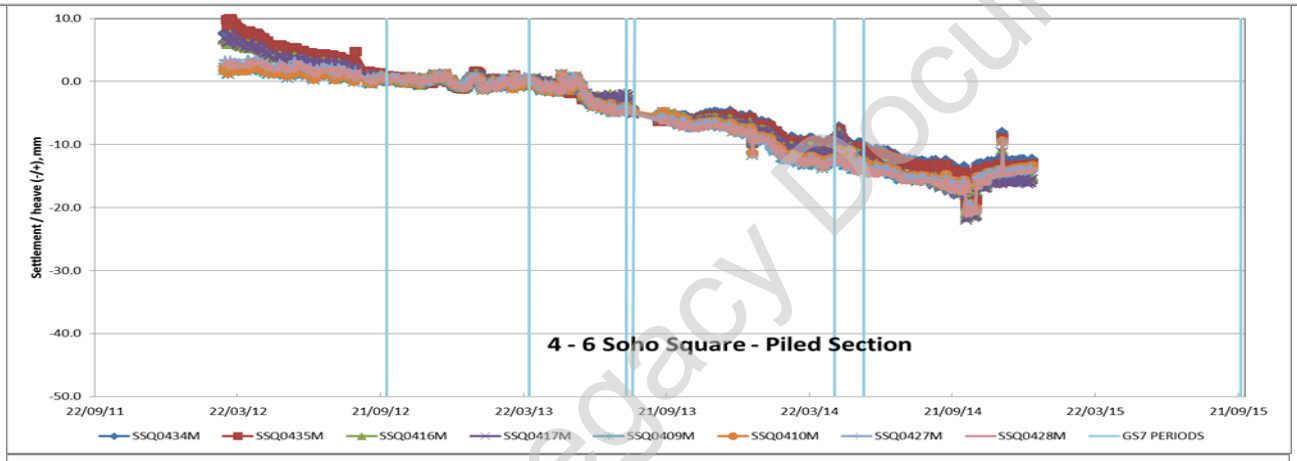


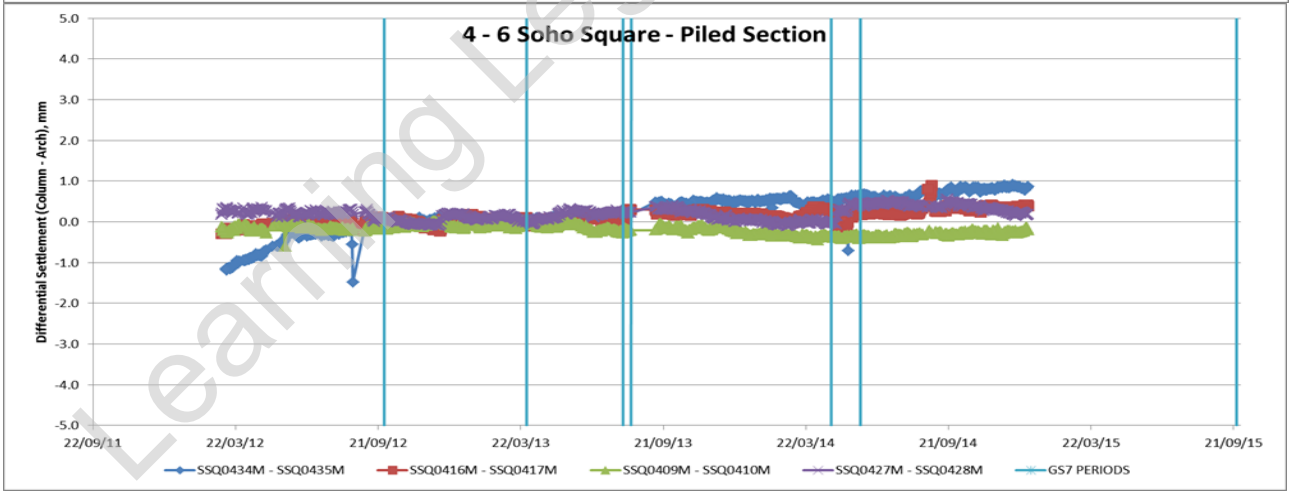
The following points are noted:

- The northerly part of the Dean Street east façade is outside the specified compensation grouting zone although a limited number of ports were installed. The façade is within the plan extent of the GS7 array between distances 28m and 77m.
- In Period A, up to 8mm heave was generated during TaM drilling using the water flush method. Subsequent dissipation together with excavation of the WTH south box produced a settlement of less than 10mm at the end of the Period.
- Minor increases in settlement are evident associated with the PTEE and EBRT, but the majority of the increase in settlement during construction is time dependent and not associated with any particular construction activity. The maximum recorded settlement was 10mm at the end of Period B, increasing to 15mm at the end of Period D and just over 20mm at the end of construction (Period F).
- The rate of post construction settlement shows a small tendency to a reducing rate to the end of Period G. It is noted that re-development of the building between 0 and 28m distance (1 Dean Street) commenced during the monitoring period and no further readings were possible on points C08LB040 - C08LB045 after January 2015.
- No Amber or Red slope triggers have been exceeded.
- The profile plot confirms that the consolidation settlement is relatively uniform over a wide area resulting in little change in slopes.

4.3. 4-6 Soho Square







The following points are noted:

- Data are presented from pairs of HLC from 4 locations: each pair includes one HLC on a column supported on piles and one HLC on ground bearing brickwork arches. The HLC were installed after the start of drilling (in March 2012) since the building was being refurbished. Temporary manual levelling was undertaken prior to the commissioning of the HLC and adjustments have been made based on this data.
- The only noticeable construction event related settlement occurs in Period C and is related to works outside the GS7 area (CH1Ext and CL1 excavation – see GS1 and GS2 reports). There is also an apparent increase in the rate of movement in Period E at around the time of the

WTH North Box excavation. However, given the distance of the piles from the excavation, it is considered that there is no causative link.

- Differential movement is minor throughout with the ground bearing structure settling up to 1mm more than the piled structure.

5. GROUND SETTLEMENT AND SLOPES

5.1. Slope Triggers

The locations of PLP monitoring of kerb lines and sub-surface monitoring using "Deep Pins" within the GS7 area are shown on Figure 5.1. A larger version of Figure 5.1 is included in Appendix C.

Slope triggers are as follows:

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

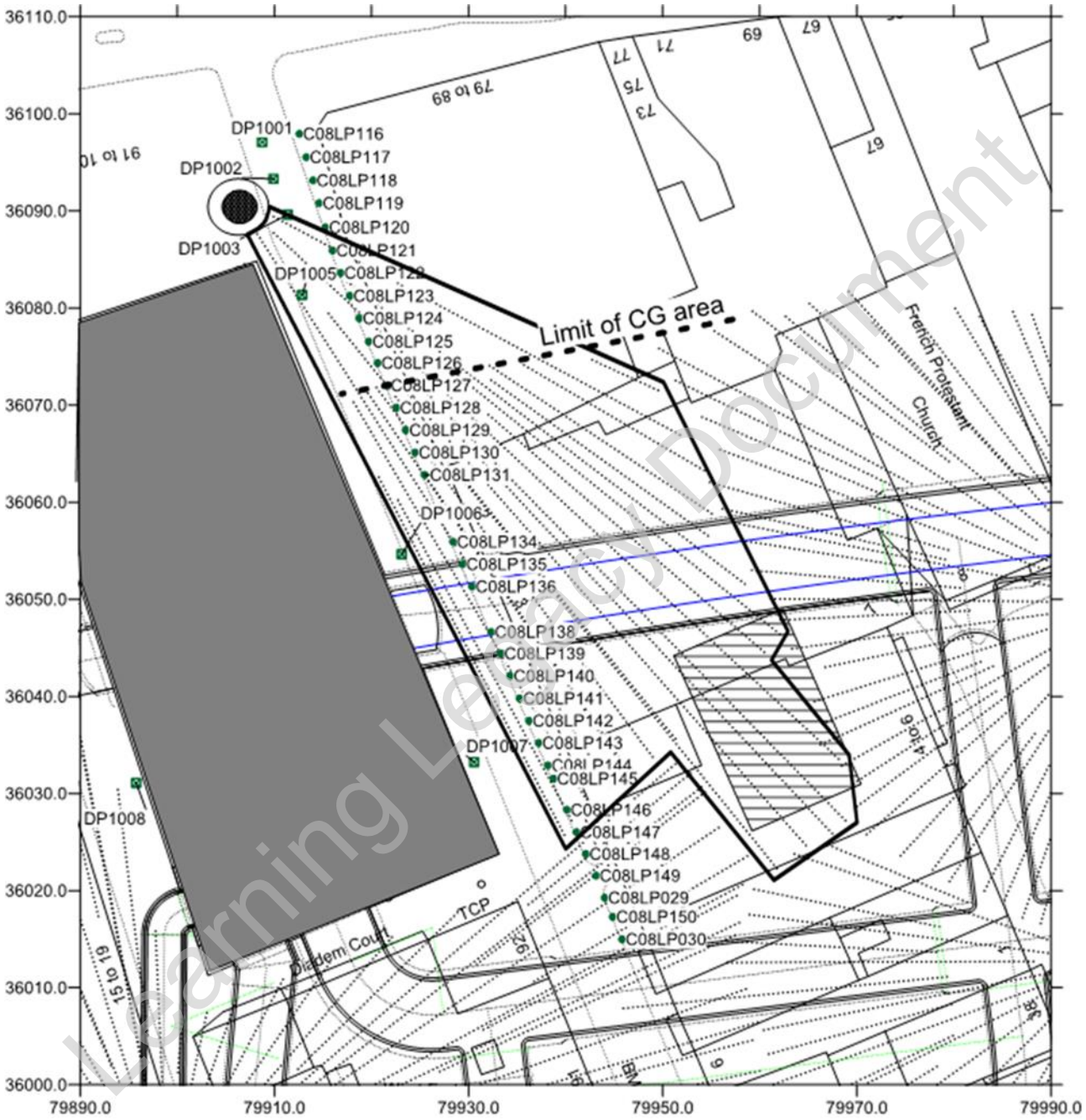
PLP monitoring data from the kerb line within the footprint of GS7 is presented in the following section, namely Dean Street East. The plots presented comprise:

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

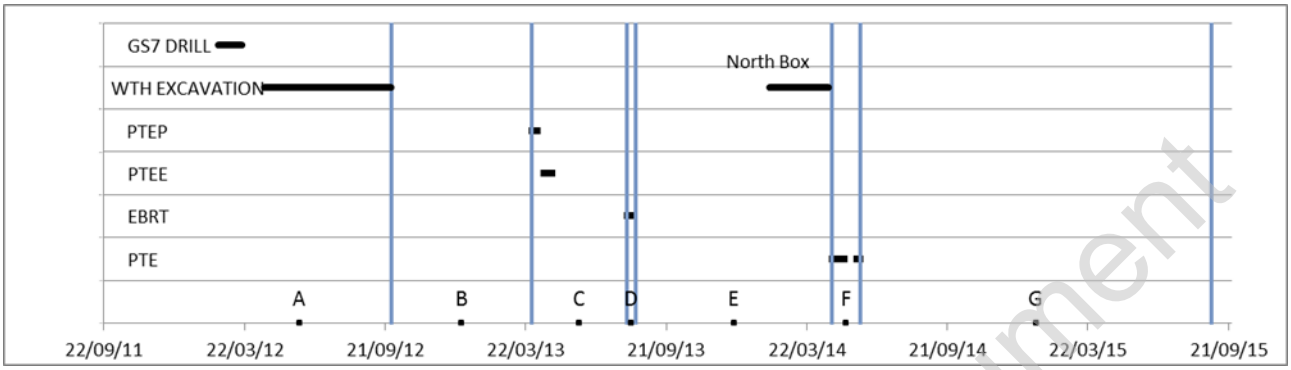
No Amber or Red slope triggers were exceeded during construction, although a number of locations have slopes close to the Amber value as a result of post construction movements. Since there are no Amber slope triggers, there can be no exceedances of the Deflection ration trigger. It is noted that C422 was constructing the permanent internal structure and removing temporary props in the WTH during this period.

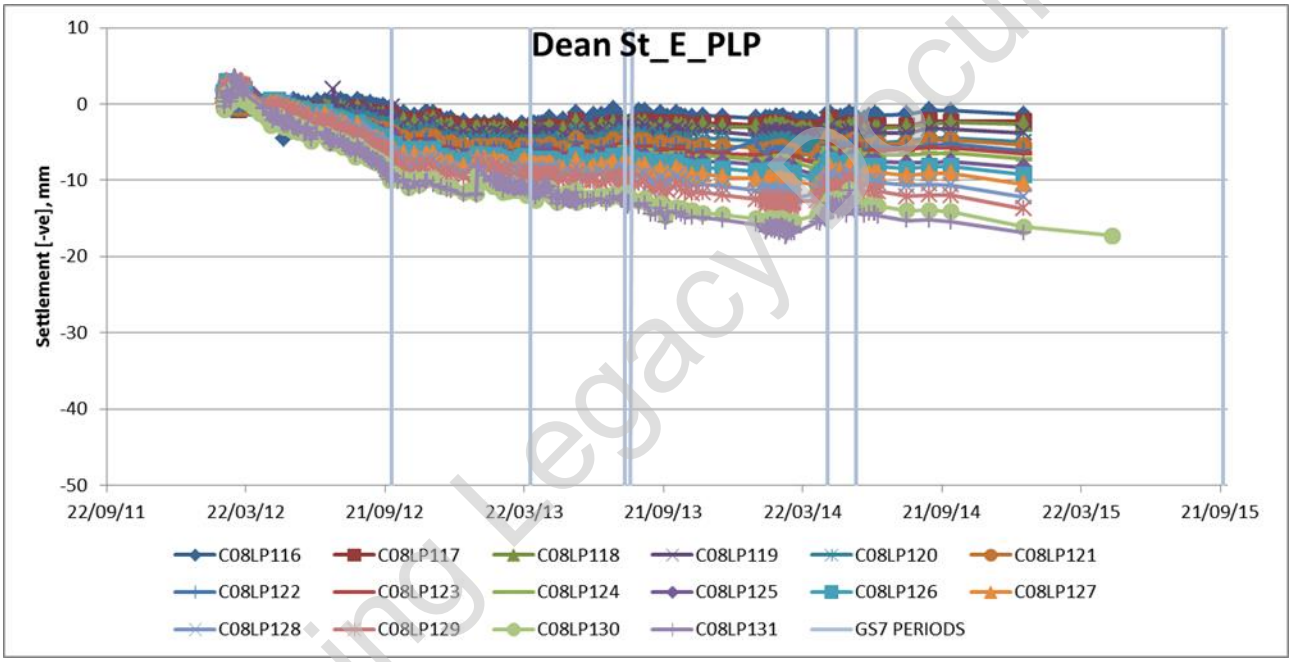
A time plot for the Deep Pins (Shallow Datums) installed in Dean Street is also presented.

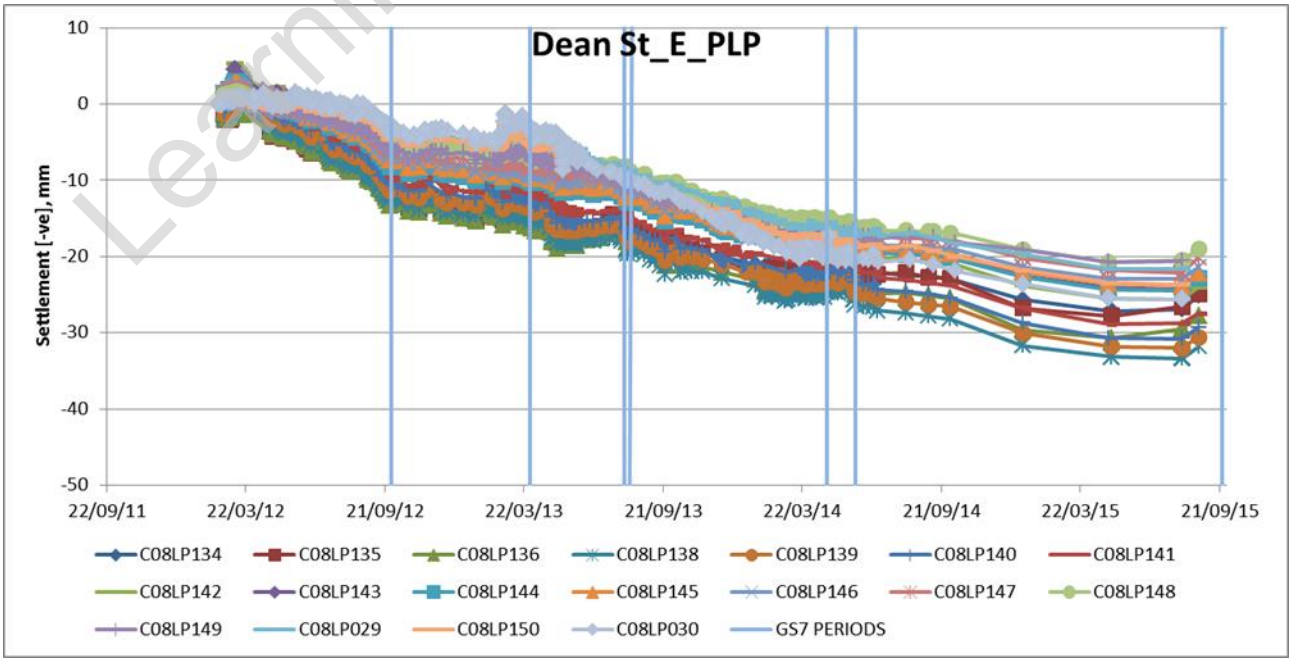
Figure 5.1.1 Location of PLP in GS7 area

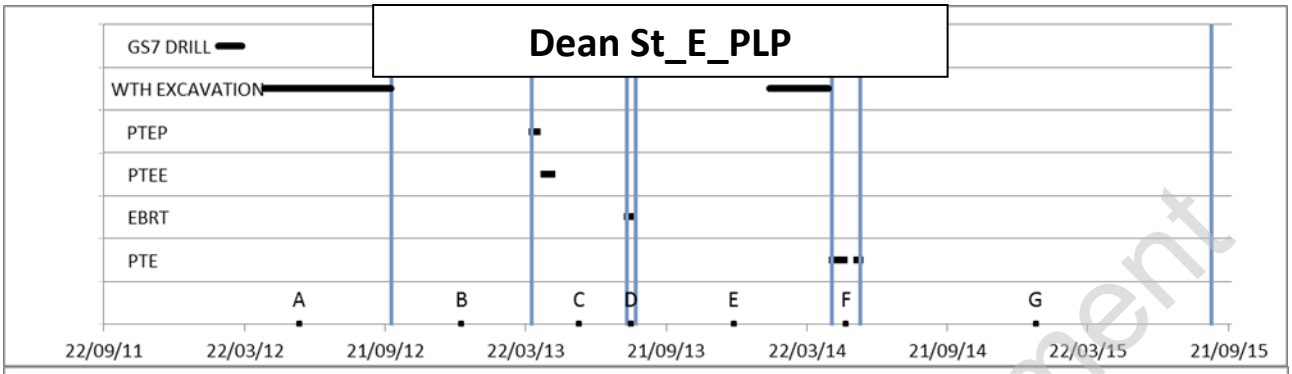


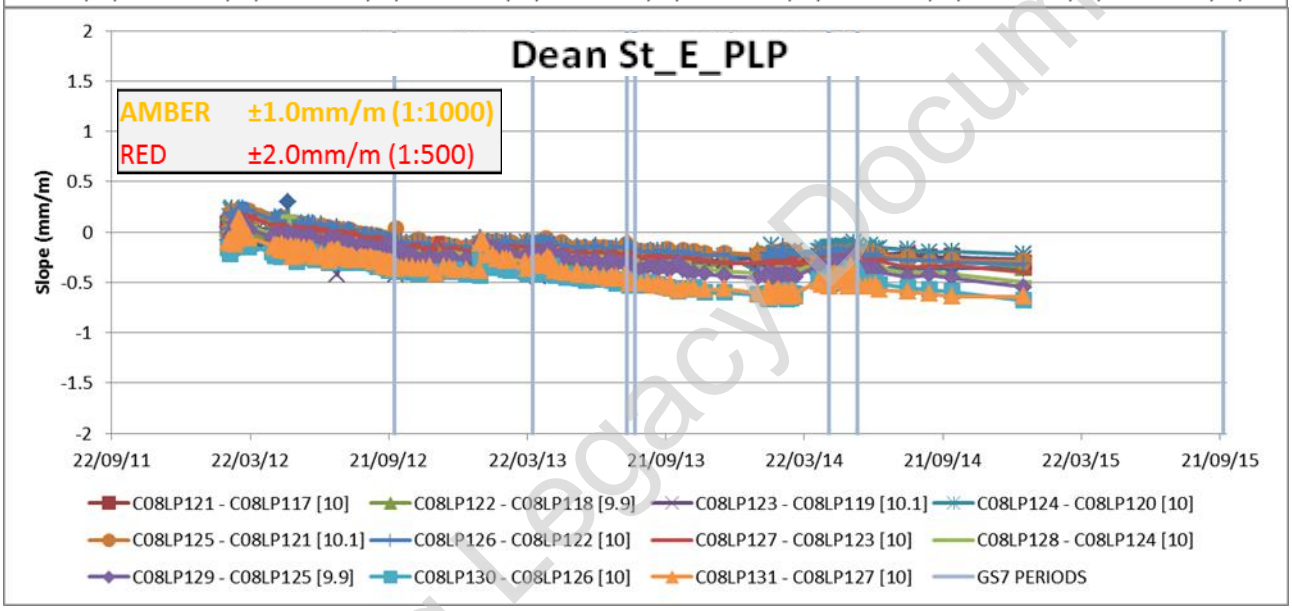
5.2. Dean Street East - north

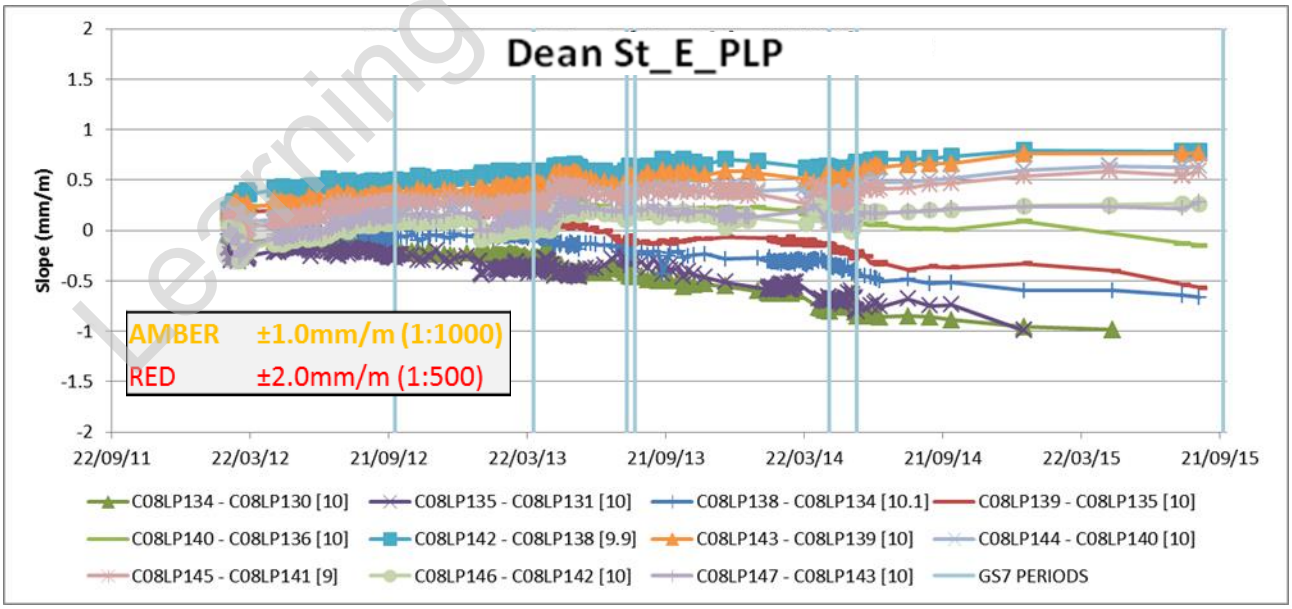


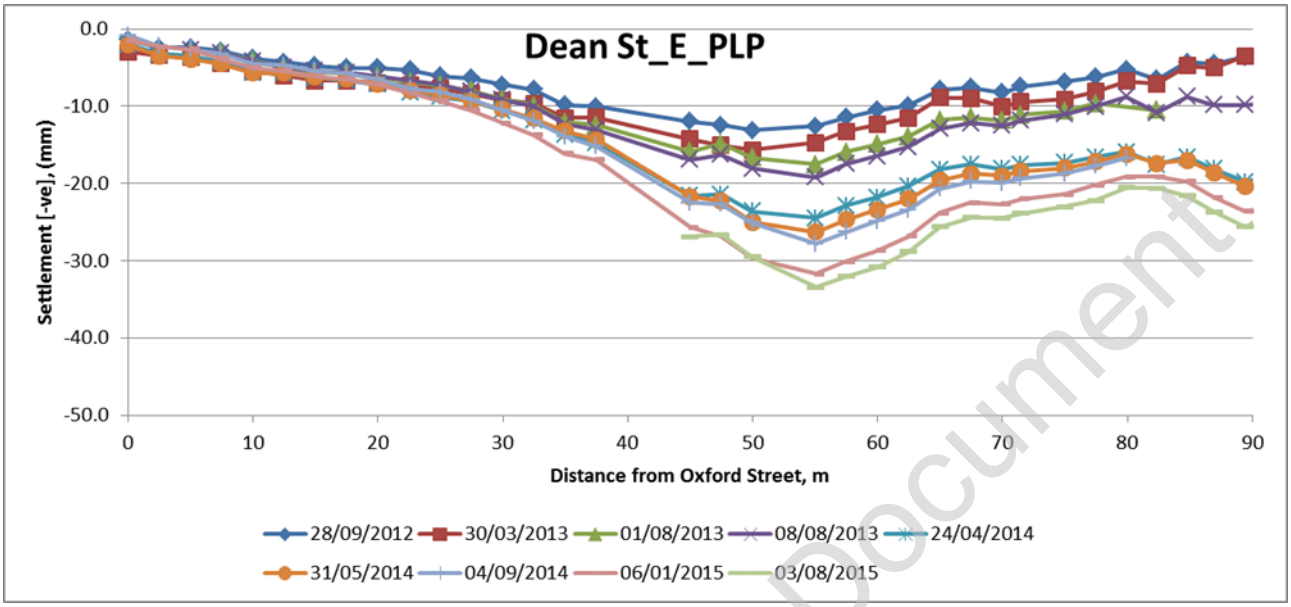










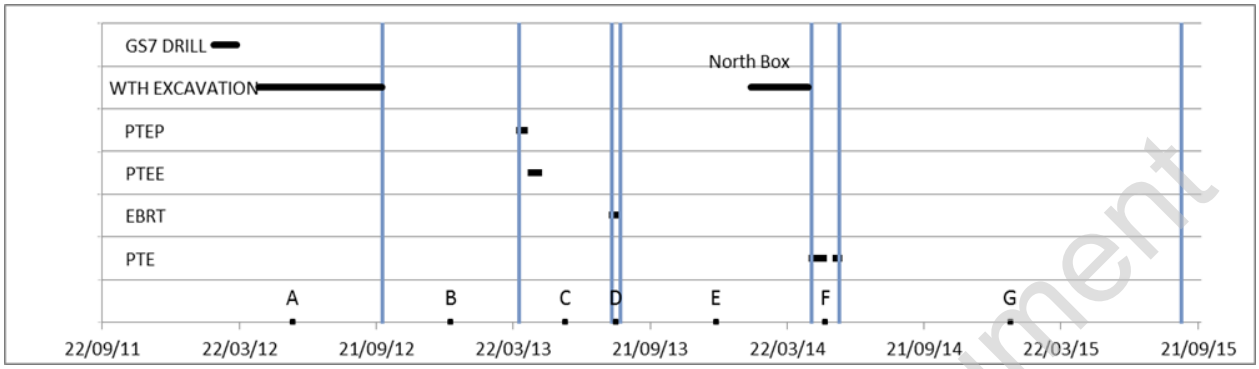


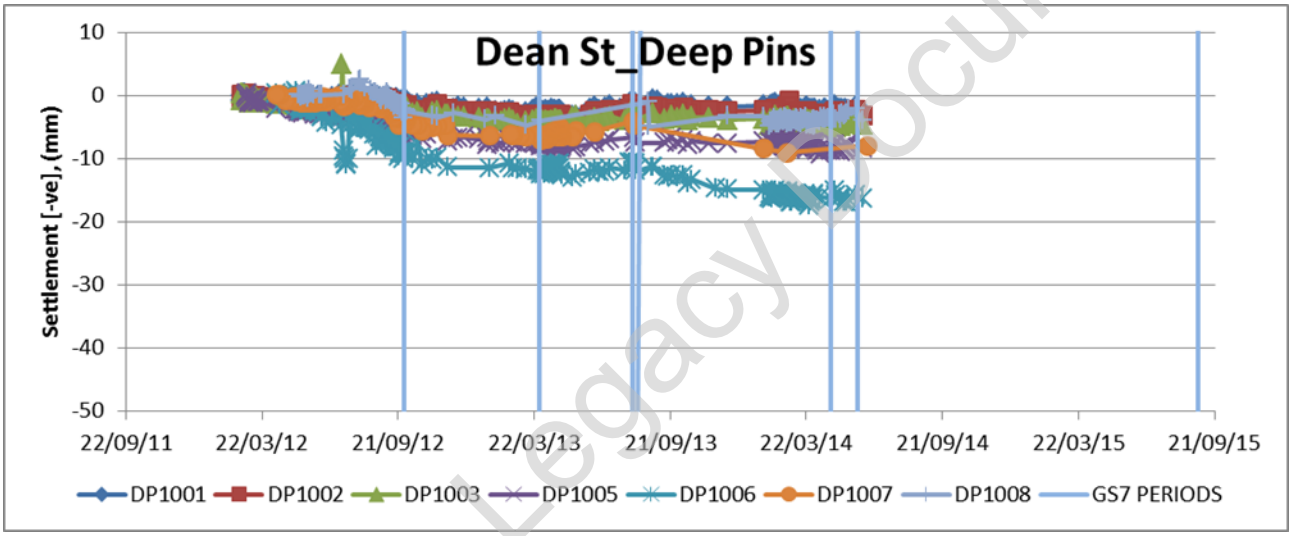
The following points are noted:

- The northerly part of the Dean Street east kerb line is outside the specified compensation grouting zone although a limited number of ports were installed. The kerb line is within the plan extent of the GS7 array between distances 28m and 77m.[1]
- In Period A, up to 5mm heave was generated during TaM drilling with water flush. Subsequent dissipation together with excavation of the WTH south box produced a settlement of up to 12mm at the end of the Period.
- Minor increases in settlement are evident associated with the PTEE and EBRT, but the majority of the increase in settlement during construction is time dependent and not associated with any particular construction activity. Maximum settlement reached 20mm at the end of Period D, 25mm at the end of Period E and 28mm at the end of Period F.
- The rate of post construction settlement shows a small tendency to a reducing rate to the end of Period G. It is noted that re-development of the building between 0 and 28m distance (1 Dean Street) commenced during the monitoring period and no further readings were possible on points C08LP116 - C08LP129 after January 2015.
- No Amber or Red slope triggers were exceeded during construction, although a number of locations have slopes close to the Amber limit as a result of post construction movements. It is noted that C422 was constructing the permanent internal structure and removing temporary props in the WTH during this period.
- The profile plot confirms that the consolidation settlement is relatively uniform over a wide area resulting in little change in slopes.

[1] PLPs C08LP132, C08LP133 and C08LP137 are not presented since they are located over building vaults and are not representative of the ground movements.

5.3. Dean Street – Shallow Datums





The following points are noted:

- DP1006 and DP 1007 are adjacent to the South box; DP1005 is adjacent to the North box with the remainder further to the north. Only DP1006, located close to the PTE, shows over 10mm settlement
- The key event for DP1006 is the WTH south box excavation in Period A which generated up to 9mm settlement. The EBRT in Period D appears to have initiated a further increase in settlement of ~6mm in Period E as post construction movements, giving a total settlement of 17mm.

6. DISCUSSION

The preceding presentation of settlement monitoring data shown that no Amber slope triggers have been exceeded. Since there are no Amber slope triggers, there can be no exceedances of the Deflection Ratio trigger. The data also show that, in some locations, settlement continues to increase, albeit generally at a slow and decreasing rate. Slopes appear to be stable within the accuracy of the measurements.

BFK's opinion is 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: this objective has been achieved.

7. CONCLUSION

It was concluded that no further grouting from TCR GS7 would be required based on an abridged version of this report submitted in August 2014 under C300-CCM-08749 and accepted by CRL under C300-PMC-09405: Grout Shaft 7 was subsequently decommissioned.

The key factor which lead to this conclusion was that, in the 3 months after the completion of tunnelling and compensation grouting, ongoing post construction settlements were kept under continual review at daily, weekly and monthly review meetings and no grout jacking was deemed necessary. Thus, it was concluded that the grout shaft could be decommissioned.

Manual monitoring within the GS7 area was terminated under C300-PMI-01858, and consequently this report comprises a Final and Close Out report.

Appendix A

Assumptions used to produce contour plots of grout intensity

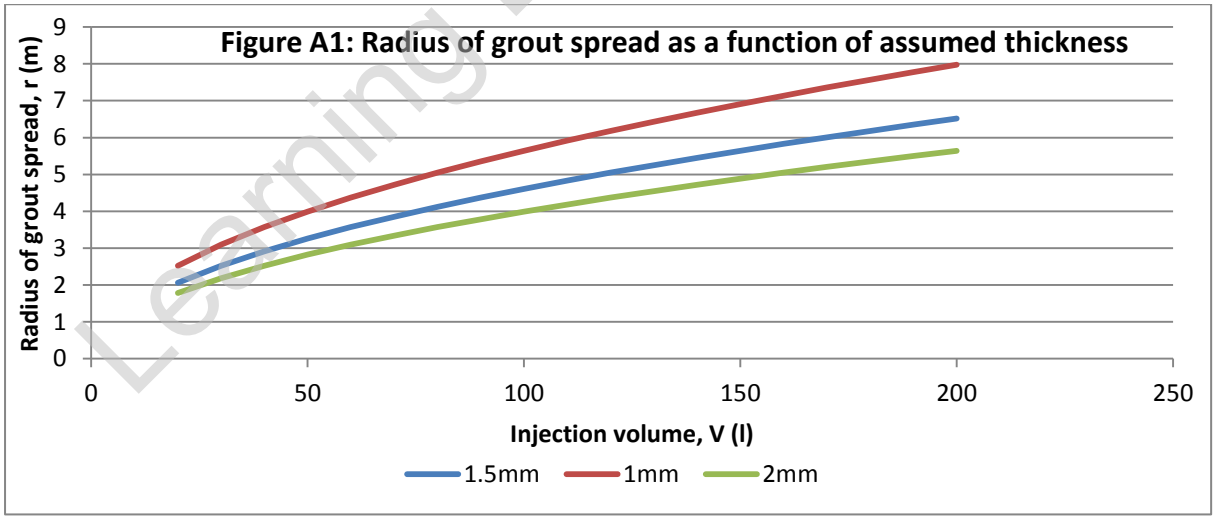
A method of producing a visualisation of the quantity and distribution of grout injected during compensation grouting is useful in interpreting performance. For each injection the volume and the location of the port used are known. The model used is intended to approximate the distribution of grout within 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 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:

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



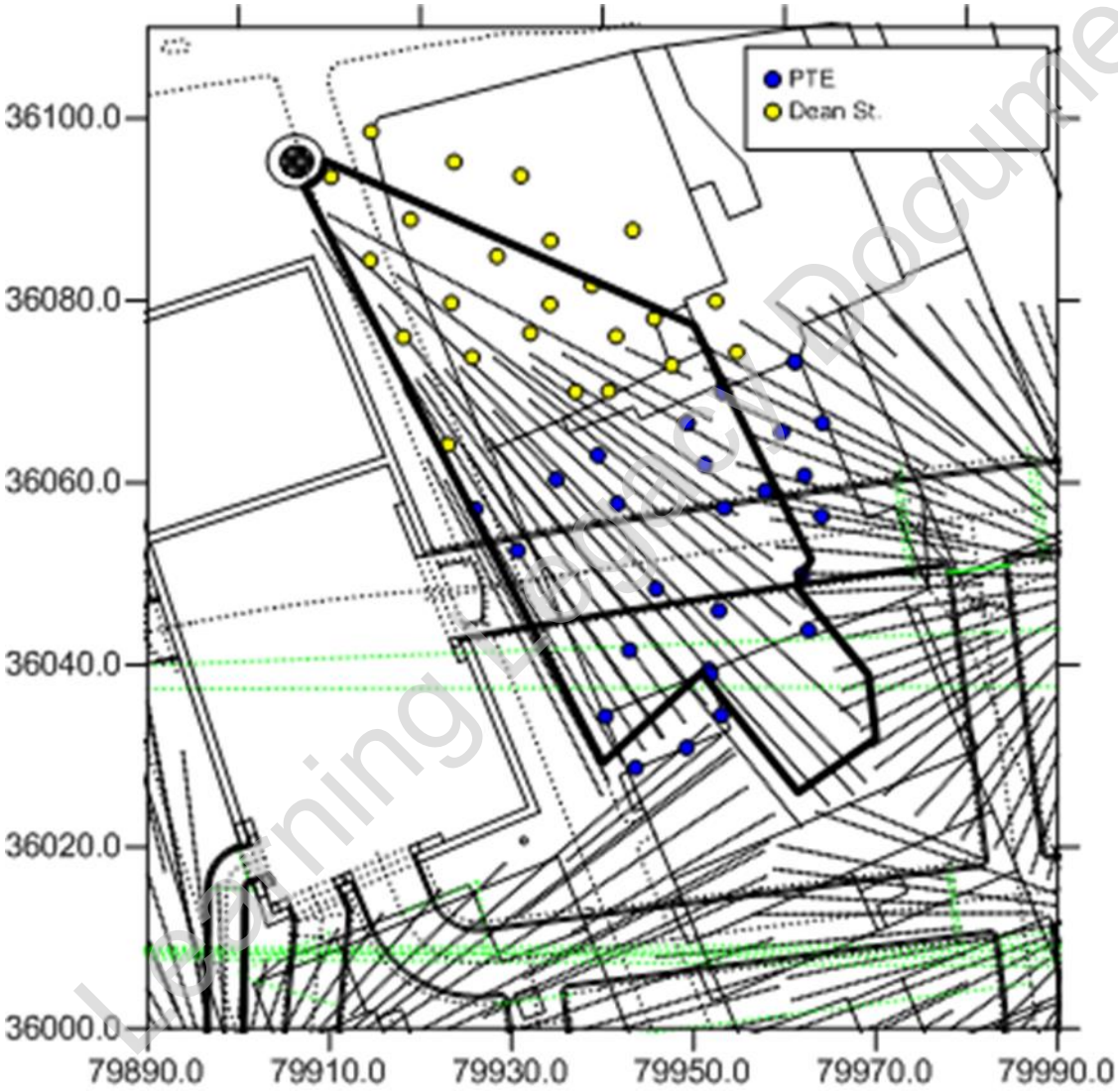
Observation of grout in the ground suggests that a thickness of 1 – 2mm is predominantly achieved. All of the plots included in this report are based on an assumed thickness of 1.5mm. Figure A1 shows the variation in radius for thicknesses of 1.0, 1.5 and 2.0mm.

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.

Appendix B

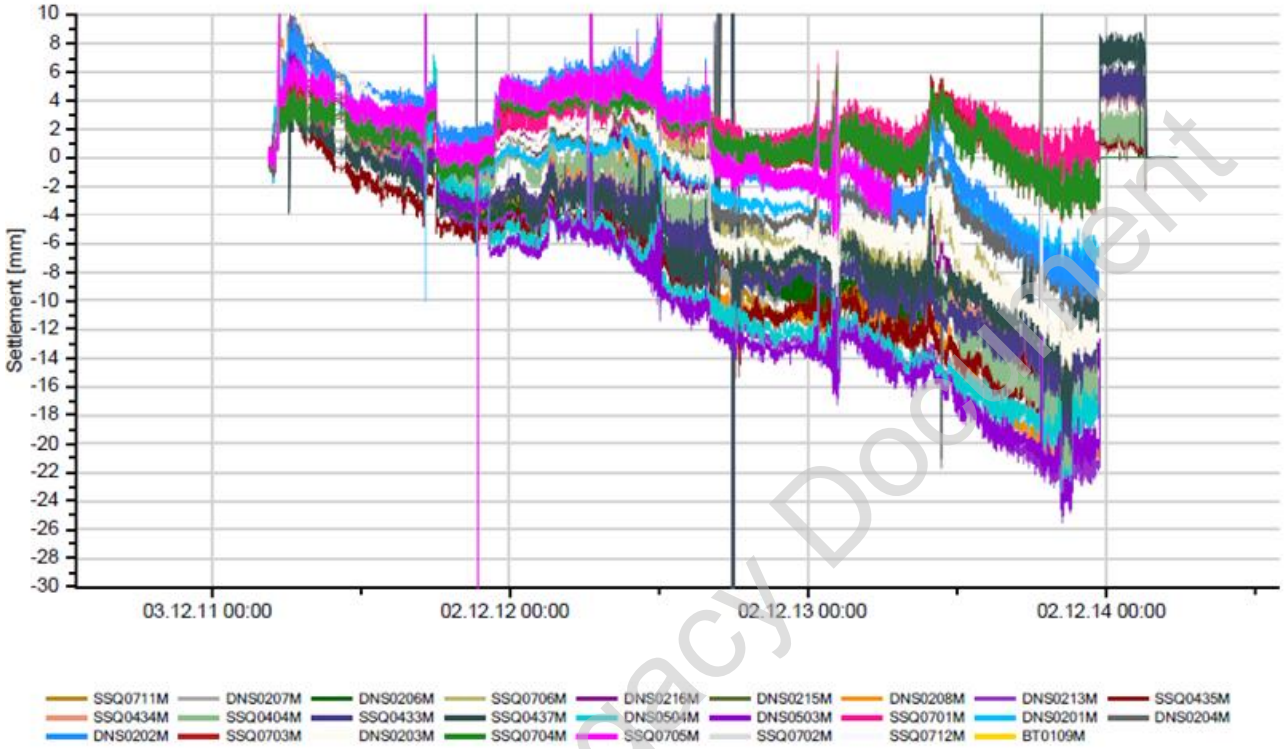
Data from HLCs and Tiltmeters in 4-6 Soho Square

Location of HLCs in time plots

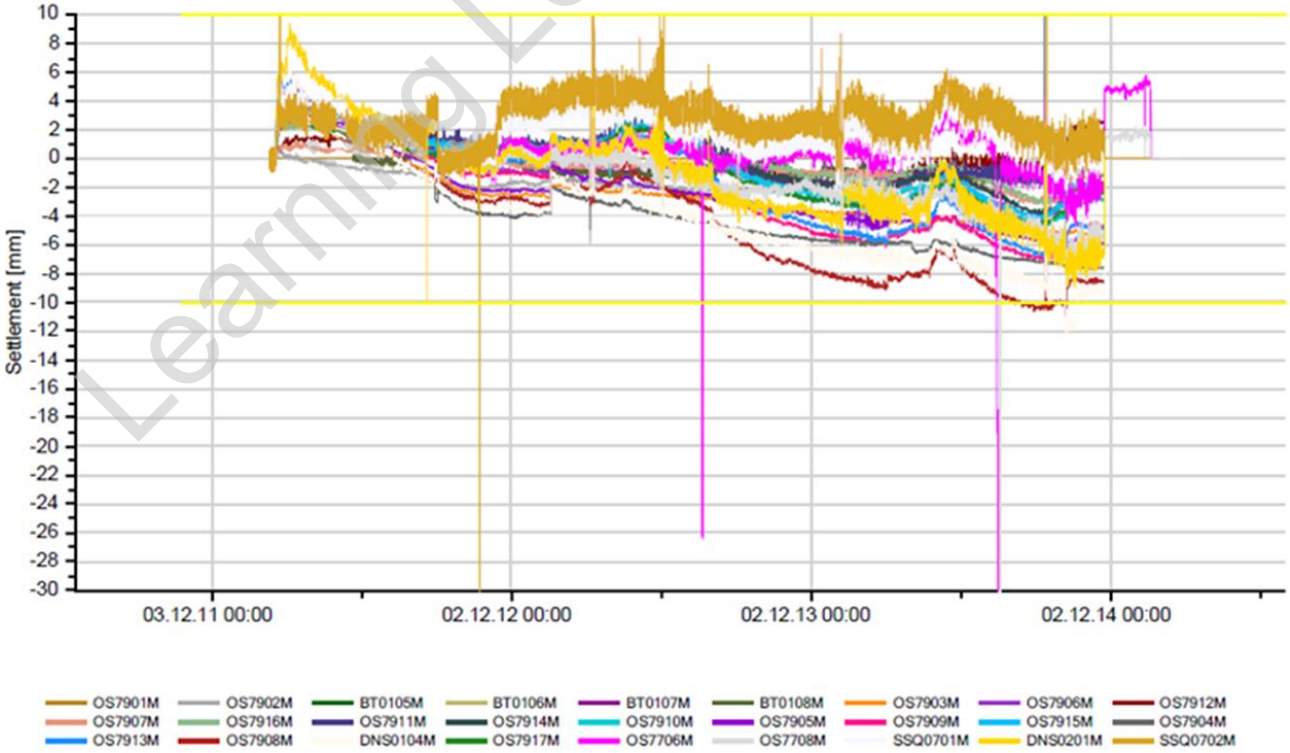


HLC were primarily used for control of compensation grouting giving data at 15 minute intervals. The system was left operational after the completion of the tunnelling to provide information on post –construction movements. Scatter observed in HLC data during December 2014 and February 2015 was due to the cessation of maintenance since this monitoring data following the completion of excavation works in May 2014 and the de-commissioning of the grout shaft from August 2014.

PTE



Dean St.



General Location Plan of tiltmeters in 4-6 Soho Square

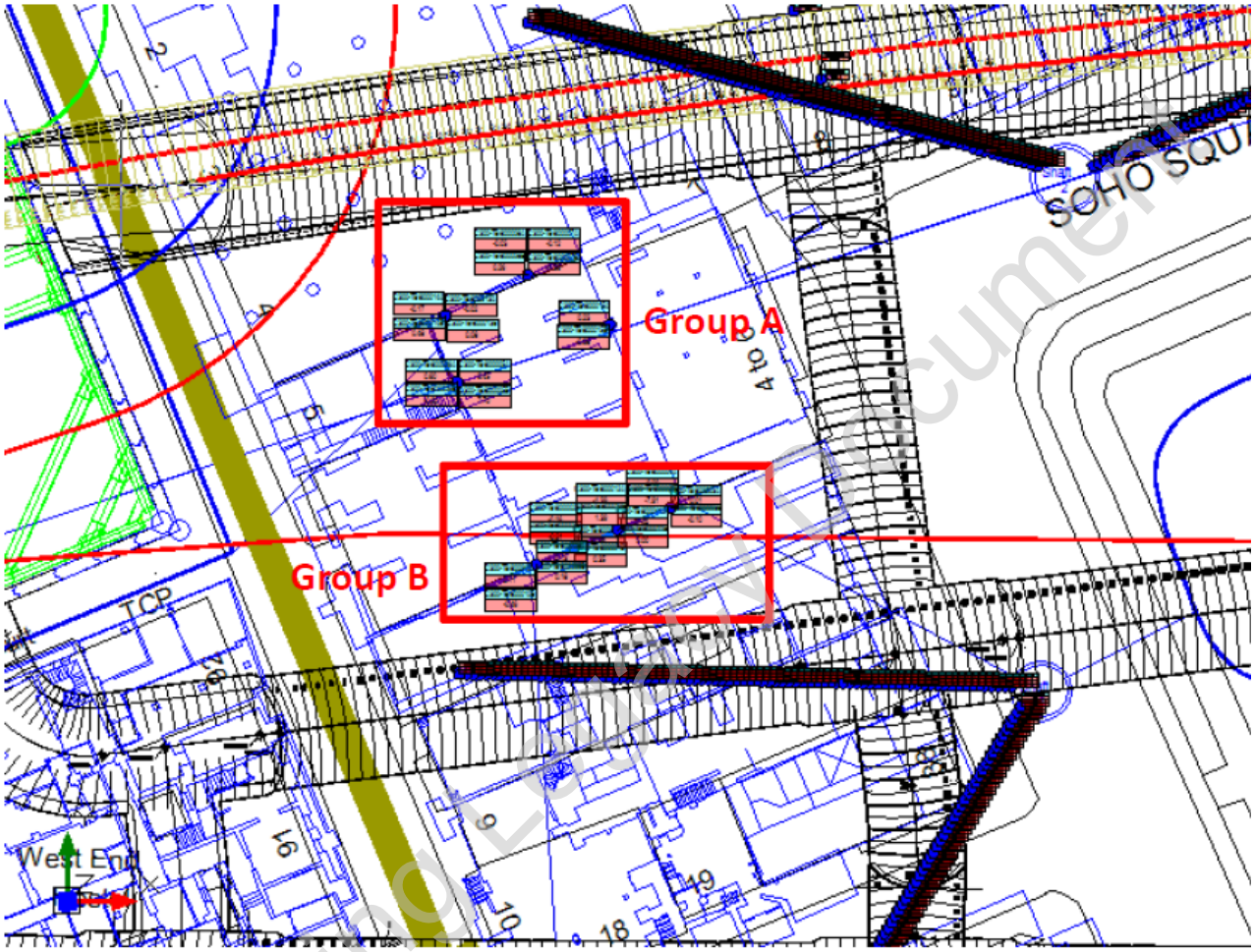
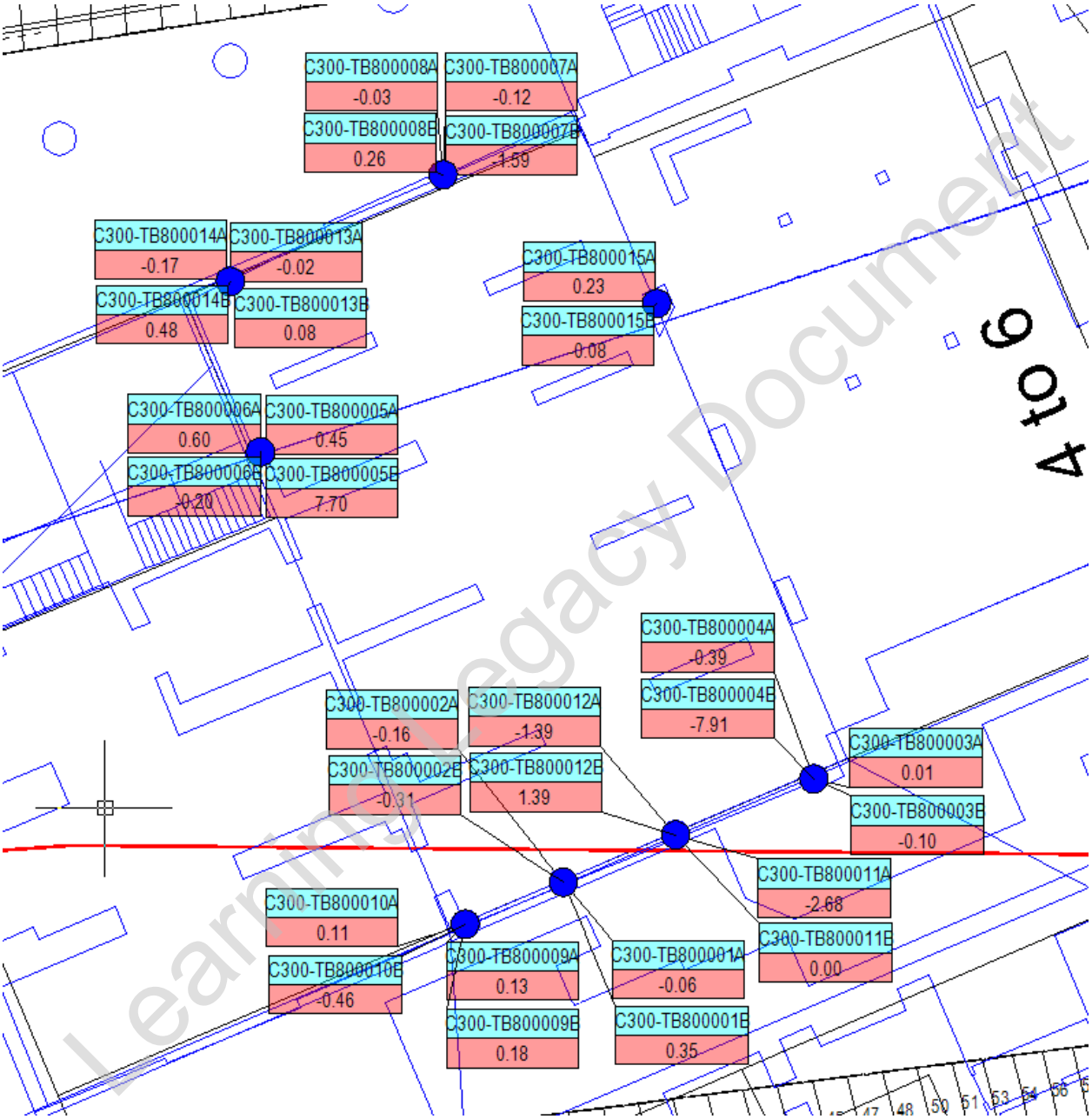
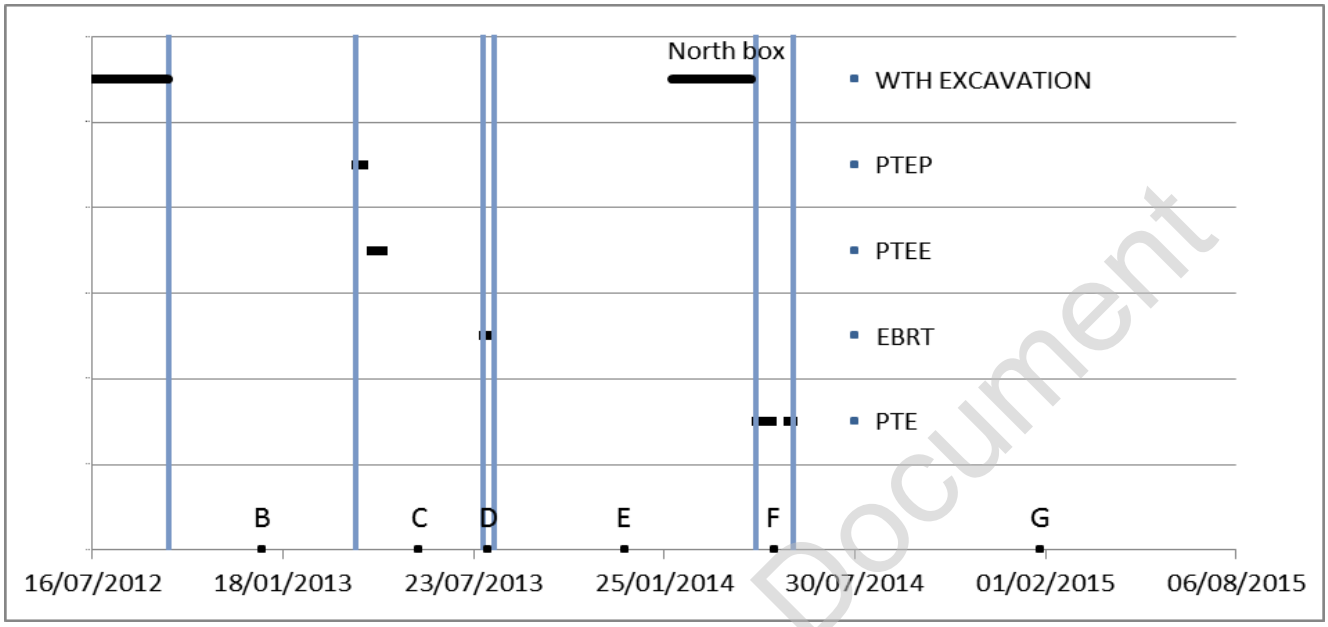


Table of Sensor Orientations

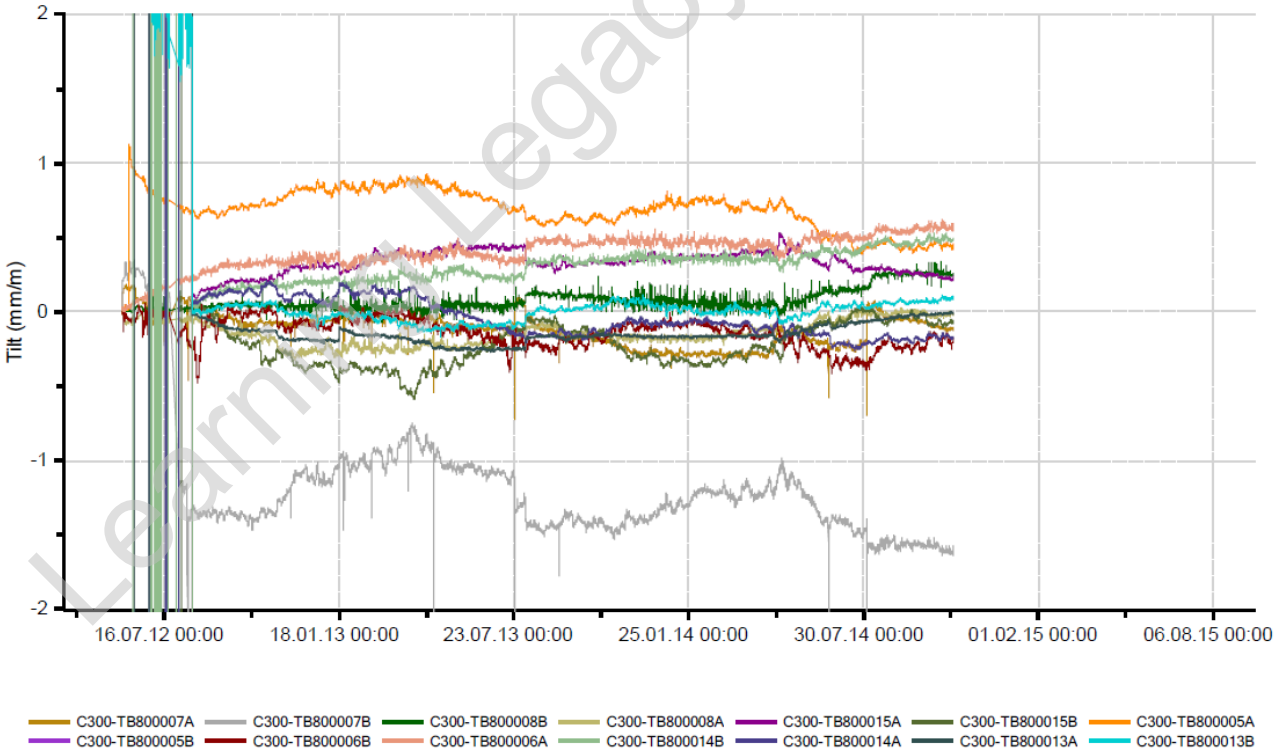
Sensor	A+	B+
C300-TB800001	South	West
C300-TB800002	South	West
C300-TB800003	North	East
C300-TB800004	East	South
C300-TB800005	East	South
C300-TB800006	South	West
C300-TB800007	East	South
C300-TB800008	North	East
C300-TB800009	South	West
C300-TB800010	East	South
C300-TB800011	North	East
C300-TB800012	West	North
C300-TB800013	South	West
C300-TB800014	West	North
C300-TB800015	West	North

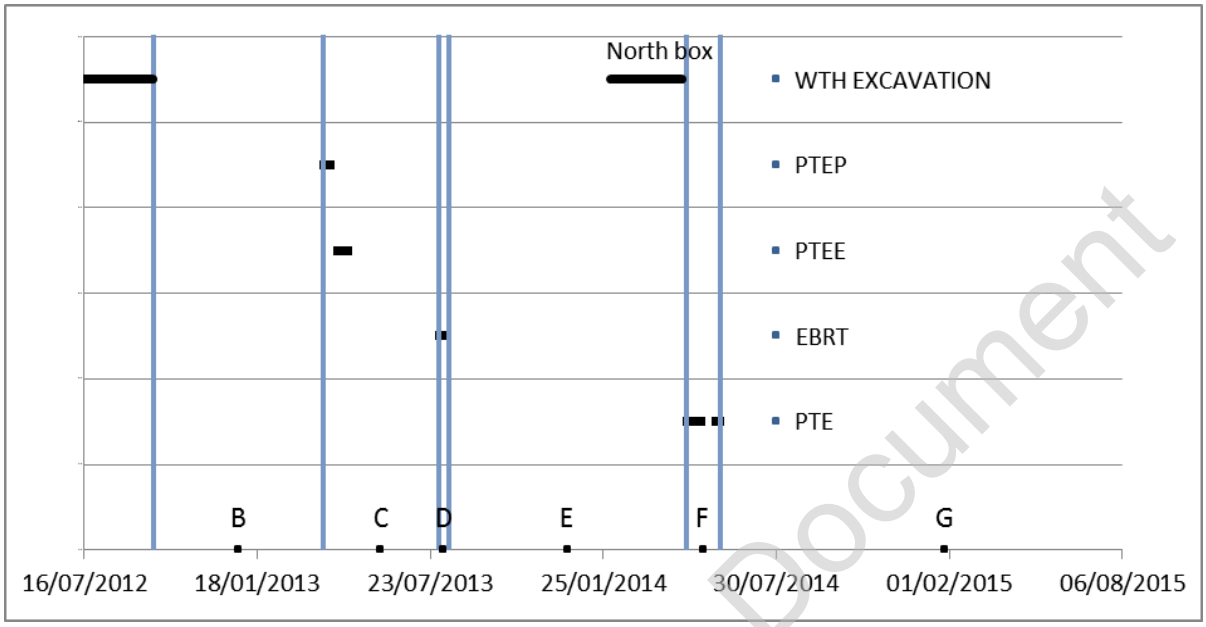
Location Plan of tiltmeters in 4-6 Soho Square



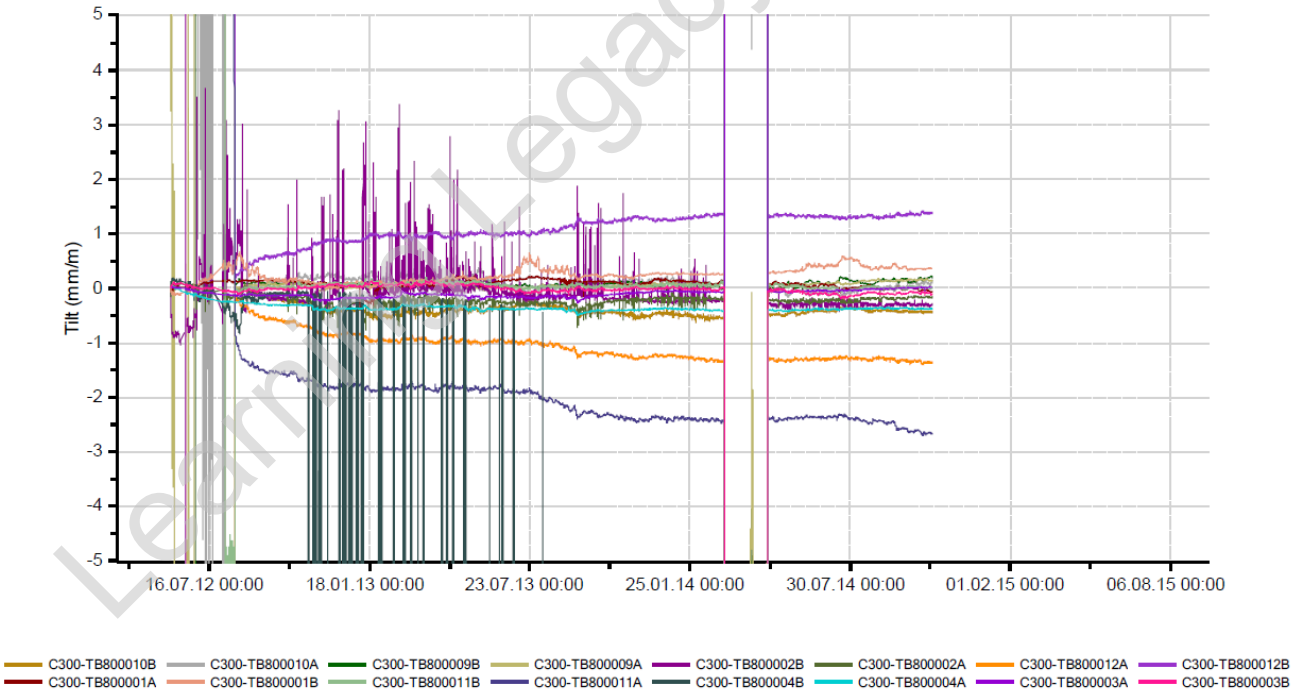


GROUP A





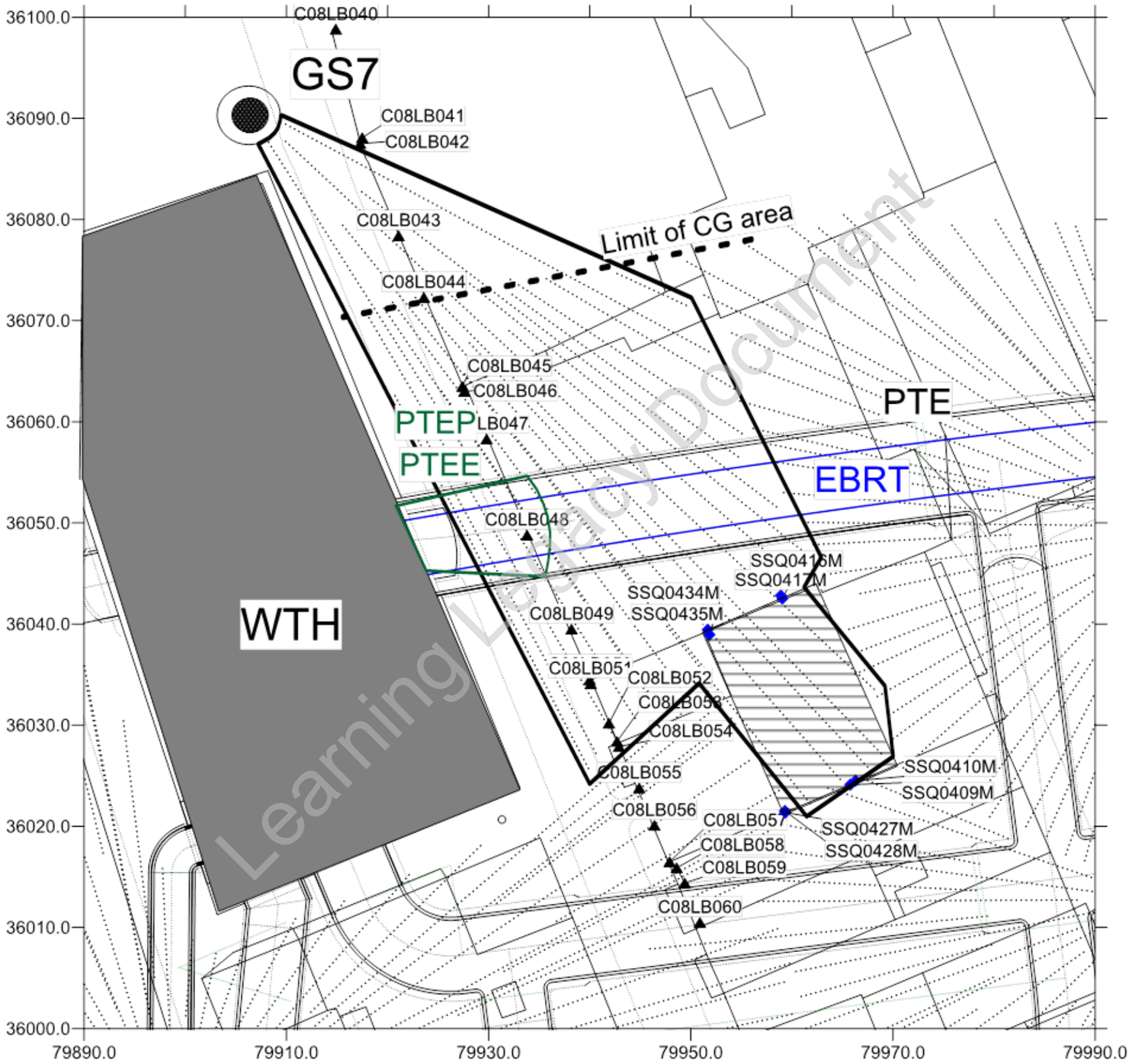
GROUP B



The observed changes in tilt are generally small and do not correlate with BFK construction activities. It is considered that the works within the building itself are most probably responsible.

Appendix C

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


GS7
WTH
PTEP
PTEE
PTE
EBRT
Limit of CG area
C08LB040
C08LB041
C08LB042
C08LB043
C08LB044
C08LB045
C08LB046
C08LB047
C08LB048
C08LB049
C08LB051
C08LB052
C08LB053
C08LB054
C08LB055
C08LB056
C08LB057
C08LB058
C08LB059
C08LB060
SSQ0434M
SSQ0435M
SSQ0410M
SSQ0409M
SSQ0427M
SSQ0428M
36100.0
36090.0
36080.0
36070.0
36060.0
36050.0
36040.0
36030.0
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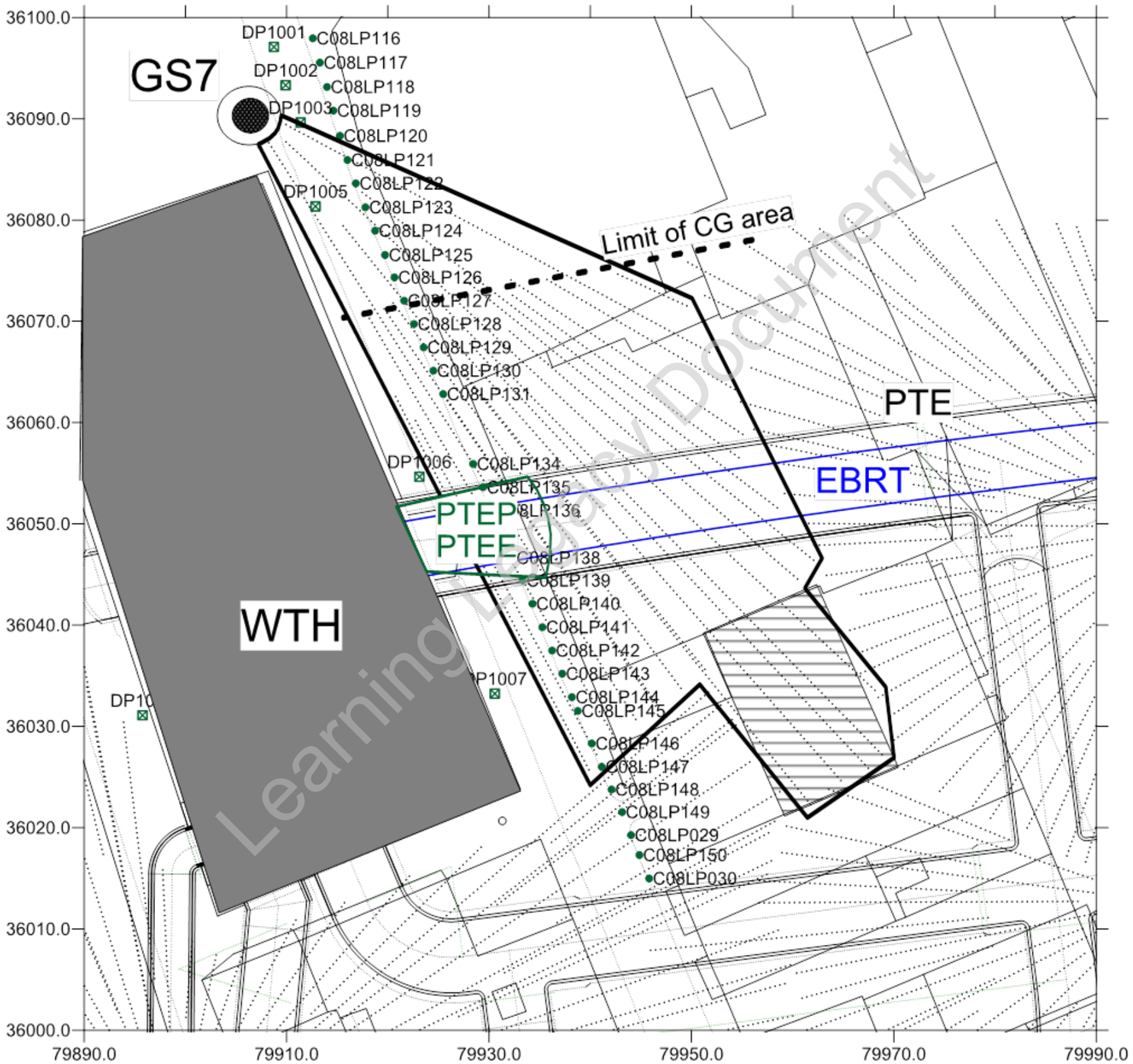
79970.0
79990.0


GS7
WTH
PTEP
PTEE
PTE
EBRT
Limit of CG area
DP1001
DP1002
DP1003
DP1005
DP1006
DP1007
C08LP116
C08LP117
C08LP118
C08LP119
C08LP120
C08LP121
C08LP122
C08LP123
C08LP124
C08LP125
C08LP126
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