



Work Area: SMM
Work Type: I&M
Originator Company: GEOCISA UK

C435
Farringdon Main Station

CRL Lead reviewer: [REDACTED]
CRL Reviewer: [REDACTED]

Monitoring Close-Out Report:
External Monitoring

CRL Document Number: C435-BFK-C2-RGN-M123-51617

Supplier Document Number: N/A

Contract MDL reference C13.012

1. Contractor Document Submittal History:

Revision:	Date:	Prepared by:	Checked by:	Approved by:	Reason for Issue:
1.0	24-09-2015	[REDACTED]	[REDACTED]	[REDACTED]	For acceptance
2.0	27-01-2015	[REDACTED]	[REDACTED]	[REDACTED]	For acceptance

2a. Stakeholder Review Required? YES NO

Stakeholder submission required: LU RfL Purpose of submission: For no objection
 NR LO For information
 DLR Other: _____

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

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

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

2b. Review by Stakeholder (if required):

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

3. Acceptance by Crossrail:

compliance with their contractual obligations and does not constitute
ds or materials developed or selected by the designer/supplier.

[REDACTED]
16/02/2016

Contents

A.	INTRODUCTION	3
B.	INSTRUMENTS	3
B.1	DESCRIPTION OF THE INSTRUMENTS	3
B.2	LOCATION OF THE INSTRUMENTS	4
C.	MOVEMENTS	5
C.1	MOVEMENTS RESULTING FROM CONSTRUCTION ACTIVITIES	5
C.1.1	Relevant Crossrail (BFK) Works	5
C.1.2	Resulting Movements	5
C.2	TRIGGER BREACHES	6
C.3	SIGNIFICANT ISSUES WITH THE INSTRUMENTATION	8
C.4	RESIDUAL RISKS	8
D.	CONCLUSIONS	8

APPENDIX A: DRAWINGS / PHOTOMONTAGES

APPENDIX B: GRAPHS.

A. INTRODUCTION

In line with the C122 – M&W Specification KX10 – Instrumentation & Monitoring C122-OVE-Z4-RSP-CR001-00007, this close out report aims to address the following points in relation to the instrumentation defined in Section B.

- Identify movements observed by the relevant instruments;
- Relate these movements to construction activities, where applicable.
- Identify trigger breaches that may have occurred.
- Demonstrate that the rate of change of the data is either in line with the required rate or such that residual risks are minimal.
- Identify any such residual risks should there be considered to be any.
- Based on the above points, this close out reports will provide justification for the decommissioning of the instruments.

B. INSTRUMENTS

B.1 Description of the Instruments

This Close-Out Report relates the Cowcross Street, Albion Courtyard and Greenhill's Rents Area, consisting of Tiltmeters, Water settlement cells and Electrolevel beams located externally on these buildings. See table 1 below with details.

LOCATION	SENSOR TYPE	SENSOR CODE
79-85 Cowcross Street	Tiltmeter	C435-TB01201 A/B
	Waterlevel Settlement Cell	C435-SH01401
	Waterlevel Settlement Cell	C435-SH01402
	Waterlevel Settlement Cell	C435-SH01403
	Waterlevel Settlement Cell	C435-SH01404
Albion Courtyard, Greenhill's Rents	Tiltmeter	C435-TB01101 A/B
	Tiltmeter	C435-TB01102 A/B
	Tiltmeter	C435-TB01103 A/B
	Tiltmeter	C435-TB01104 A/B
70-77 Cowcross Street	Electrolevel	C435-EL000511
	Electrolevel	C435-EL000512
	Electrolevel	C435-EL000513
	Electrolevel	C435-EL000514
	Electrolevel	C435-EL000515
	Electrolevel	C435-EL000516
	Electrolevel	C435-EL000517
	Electrolevel	C435-EL000518
	Electrolevel	C435-EL000519
	Electrolevel	C435-EL0005110
	Electrolevel	C435-EL0005111
	Electrolevel	C435-EL0005112
	Electrolevel	C435-EL0005113
	Electrolevel	C435-EL0005114
	Electrolevel	C435-EL0005115

78 Cowcross Street	Tiltmeter	C435-TB01301 A/B
	Tiltmeter	C435-TB01302 A/B
	Electrolevel	C435-EL00411
	Electrolevel	C435-EL00412
	Electrolevel	C435-EL00413
	Electrolevel	C435-EL00414

Table 1: Details External Monitoring instrumentation

At the moment, this area monitored by these prisms should be in a Long Term basis, but per C435-PMI-00549 Long Term has being ceased in this area, being the last measure carried out for these devices on 18/09/2015.

These devices are shown in the following documents:

Drawings:

- C122-OVE-C2-DDA-CR001_Z-31532

Photomontages:

- C122-OVE-C2-DDJ-CR001_Z-30805
- C122-OVE-C2-DDJ-CR001_Z-39700
- C122-OVE-C2-DDJ-CR001_Z-30801
- C122-OVE-C2-DDJ-CR001_Z-39678

Installation Reports:

- C435-BFK-C2-RGN-M123-51002

B.2 Location of the Instruments

As you can see from the Figure 1 below, the instruments described in Section B.1 are located in Cowcross Street and Greenhill's Rents area. A drawing showing the location of these devices can be found in the Appendix A.



Figure 1 – Map showing the location of monitored buildings.

C. MOVEMENTS

C.1 Movements Resulting from Construction Activities

C.1.1 Relevant Crossrail (BFK) Works

The construction activities associated with these instruments are related to Crossrail tunnelling works. In all cases, these comprise of the passage of a TBMs (C300) and a platform tunnel enlargement.

ACTIVITY	START DATE	END DATE
Butcher's Ramp Shaft TAM Installation	25/06/2013	23/08/2013
Moorgate Spur Shaft No. 3 TAM Installation	19/07/2013	03/09/2013
Butcher's Ramp Shaft Pre-Treatment works	29/07/2013	16/08/2013
Moorgate Spur Shaft No. 3 Pre-Treatment works	10/08/2013	15/09/2013
WB TBM passage	25/09/2013	04/10/2013
EB TBM passage	09/01/2014	17/01/2014
SCL-PTW enlargement	05/04/2014	29/08/2014
SCL-CP3a	24/05/2014	28/08/2014
SCL-PTE enlargement	24/05/2014	09/09/2014
SCL-CP4	17/09/2014	16/10/2014

C.1.2 Resulting Movements

- 79-85 Cowcross Street
 data for Waterlevel Settlement Cells and Tiltmeters installed externally on this building is shown in Appendix B. No special movement during WB-TBM passage and approximately 1mm of movement recorded during the EB-TBM one. PTE enlargement caused a maximum of 5mm of movement, being insignificant the movement caused by PTW enlargement and CP4 cross passage excavation. All of the Water Settlement Cells were installed inside the zone of influence being not fixed to any absolute reference value.
- Albion Courtyard, Greenhill's Rents Street
 data for Tiltmeters installed externally on this building is shown in Appendix B. No special movement recorded during WB or EB C300 TBM passage or the CP4 cross passage excavation, being the maximum movement recorded for these devices of 3mm/m during the PTE or PTW enlargement period CP4 cross passage excavation. Around 2mm settlement due to the Moorgate Spur No.3 Shaft TAM installation, being not recorded any significant movement during Pre-Treatment works.
- 70-77 Cowcross Street
 data for Electrolevels installed externally on this building is shown in Appendix B. WB-TBM passage caused no significant movement and the EB-TBM around 1.5mm settlement. During SCL-PTW, PTE enlargement and CP3a cross passage excavation works the maximum settlement recorded by these devices was around 9mm combined with the heave produced by compensation grouting works carried out at the same time from Butcher's Ramp Shaft. Around 2mm settlement recorded by northern devices due to the Butcher's Ramp Shaft TAM installation, recording around 4mm heave by southern sensors during the Pre-Treatment works.
- 78 Cowcross Street
 data for Tiltmeters and Electrolevels installed externally on this building is shown in Appendix B. WB-TBM passage caused a maximum of 2mm settlement and no significant movement recorded during EB-TBM one. During SCL-PTW and PTE enlargement works the maximum settlement recorded by these devices was around 3mm. It is important to highlight the significant affection of

the temperature recorded on these electrolevel beams over these years, clearly showed on the behaviour and trend of historical movement of these devices.

C.2 Trigger Breaches

The Instrumentation and Monitoring Plan: Farringdon Station Ground Movement and Asset Protection C122-OVE-C2-RGN-M123-50013 outlines the triggers associated with the works.

In this case, the right trigger values depend of the building location where the devices are installed.

In areas of compensation grouting such as Albion Courtyard and 70-77 Cowcross Street buildings, the trigger values for asset protection have been set on parameters related to distortion: i.e change in gradient (slope) and deflection ratio, between survey points at ground level (studs in ground surface and BRE sockets at the base of buildings) to be applied to ground and near ground level instrumentation throughout all construction stages. So, as distortion movement is to be controlled by studs and BRE sockets measure, the current trigger and alert values set on these automatic devices installed on the facade of these buildings are as follow:

- DEFAULT ALERT (in any direction): 10mm

In case of 79-85 Cowcross Street and 78 Cowcross Street, the trigger values are shown below taking into account these buildings are located outside the compensation grouting area:

- DEFAULT ALERT (in any direction): 10mm
- GREEN: 24mm settlement
- AMBER: 30mm settlement
- RED: 38mm settlement

Close-Out Report – External Monitoring

C435-BFK-C2-RGN-M123-51617

MONITORING GROUP (Location)	POINT ID	TYPE	DIRECTION	DATE OF LAST READING	LAST READING VALUE (mm)	TRIGGER LEVEL	
						WORST HISTORICAL STATUS	CURRENT STATUS
79-85 Cowcross Street	C435-TB01201A	Tiltmeter	A	18/09/2015 15:19	-0.33	Clear	Clear
	C435-TB01201B	Tiltmeter	B	18/09/2015 15:19	0.24	Clear	Clear
	C435-SH01401	Waterlevel Settlement Cell	Settlement	18/09/2015 15:19	3.41	Clear	Clear
	C435-SH01402	Waterlevel Settlement Cell	Settlement	18/09/2015 15:19	1.82	Clear	Clear
	C435-SH01403	Waterlevel Settlement Cell	Settlement	18/09/2015 15:19	0.98	Clear	Clear
Albion Courtyard, Greenhill's Rents	C435-SH01404	Waterlevel Settlement Cell	Settlement	18/09/2015 15:19	0.60	Clear	Clear
	C435-TB01101A	Tiltmeter	A	18/09/2015 15:19	-1.18	Clear	Clear
	C435-TB01101B	Tiltmeter	B	18/09/2015 15:19	-0.66	Clear	Clear
	C435-TB01102A	Tiltmeter	A	18/09/2015 15:19	-4.35	Clear	Clear
	C435-TB01102B	Tiltmeter	B	18/09/2015 15:19	-0.22	Clear	Clear
70-77 Cowcross Street	C435-TB01103A	Tiltmeter	A	18/09/2015 15:19	-0.74	Clear	Clear
	C435-TB01103B	Tiltmeter	B	18/09/2015 15:19	1.52	Clear	Clear
	C435-TB01104A	Tiltmeter	A	18/09/2015 15:19	7.72	Clear	Clear
	C435-TB01104B	Tiltmeter	B	18/09/2015 15:19	-0.75	Clear	Clear
	C435-EL000511	Electrolevel	Settlement	18/09/2015 15:52	-3.10	Clear	Clear
	C435-EL000512	Electrolevel	Settlement	18/09/2015 15:52	-6.42	Clear	Clear
	C435-EL000513	Electrolevel	Settlement	18/09/2015 15:52	-7.69	Clear	Clear
	C435-EL000514	Electrolevel	Settlement	18/09/2015 15:52	-9.76	Clear	Clear
C435-EL000515	Electrolevel	Settlement	18/09/2015 15:52	-10.33	Default alert	Default alert	
C435-EL000516	Electrolevel	Settlement	18/09/2015 15:52	-6.04	Clear	Clear	
C435-EL000517	Electrolevel	Settlement	18/09/2015 15:52	-9.13	Clear	Clear	
C435-EL000518	Electrolevel	Settlement	18/09/2015 15:52	-4.08	Clear	Clear	
C435-EL000519	Electrolevel	Settlement	18/09/2015 15:52	-5.27	Clear	Clear	
C435-EL0005110	Electrolevel	Settlement	18/09/2015 15:52	-9.25	Clear	Clear	
C435-EL0005111	Electrolevel	Settlement	18/09/2015 15:52	-10.11	Default alert	Default alert	
C435-EL0005112	Electrolevel	Settlement	18/09/2015 15:52	-11.21	Default alert	Default alert	
C435-EL0005113	Electrolevel	Settlement	18/09/2015 15:52	-12.13	Default alert	Default alert	
C435-EL0005114	Electrolevel	Settlement	18/09/2015 15:52	-10.44	Default alert	Default alert	
C435-EL0005115	Electrolevel	Settlement	18/09/2015 15:52	-9.86	Clear	Clear	
78 Cowcross Street	C435-TB01301A	Tiltmeter	A	18/09/2015 15:19	-0.04	Clear	Clear
	C435-TB01301B	Tiltmeter	B	18/09/2015 15:19	-0.89	Clear	Clear
	C435-TB01302A	Tiltmeter	A	18/09/2015 15:19	-0.59	Clear	Clear
	C435-TB01302B	Tiltmeter	B	18/09/2015 15:19	-0.93	Clear	Clear
	C435-EL00411	Electrolevel	Settlement	18/09/2015 15:19	-5.73	Clear	Clear
	C435-EL00412	Electrolevel	Settlement	18/09/2015 15:19	-6.03	Clear	Clear
	C435-EL00413	Electrolevel	Settlement	18/09/2015 15:19	-2.00	Clear	Clear
	C435-EL00414	Electrolevel	Settlement	18/09/2015 15:19	-3.90	Clear	Clear

C.3 Significant Issues with the Instrumentation

- Tiltmeter C435-TB01104A installed externally on the Albion Courtyard building was damaged showing an anomalous behaviour from 25/08/2013. After several investigations and analysis, the drift was amended and the device fixed properly on 17/05/2014 coming the readings back to normal after the maintenance works an applying an offset taking into account the movement recorded during this time by surrounding devices.
- Electrolevels C435-EL00411 and C435-EL00412 show an inaccurate behaviour and trend of settlement recorded from origin to 17/11/2013, when the devices were fixed and readings amended applying an offset on 17/11/2015 taking into account the behaviour recorded by surrounding devices in this period of time.
- Electrolevels from C435-EL00516 to C435-EL005115 installed externally on 70-77 Cowcross Street show an inaccurate behaviour and trend of heave recorded from origin to 28/09/2013, amended applying an offset on 28/09/2013 after maintenance works carried out taking into account the behaviour recorded by surrounding devices in this period of time.
- Electrolevels from C435-EL00511 to C435-EL005115 installed externally on 70-77 Cowcross Street show an inaccurate behaviour and trend of settlement recorded from 04/11/2014 to 22/01/2015, amended applying an offset on 22/01/2015 taking into account the behaviour recorded by surrounding devices in this period of time.

C.4 Residual Risks

The rates of residual settlement for these Electrolevels and Water settlement cells have been determined and in all cases these rates are less than 2mm/year.

D. CONCLUSIONS

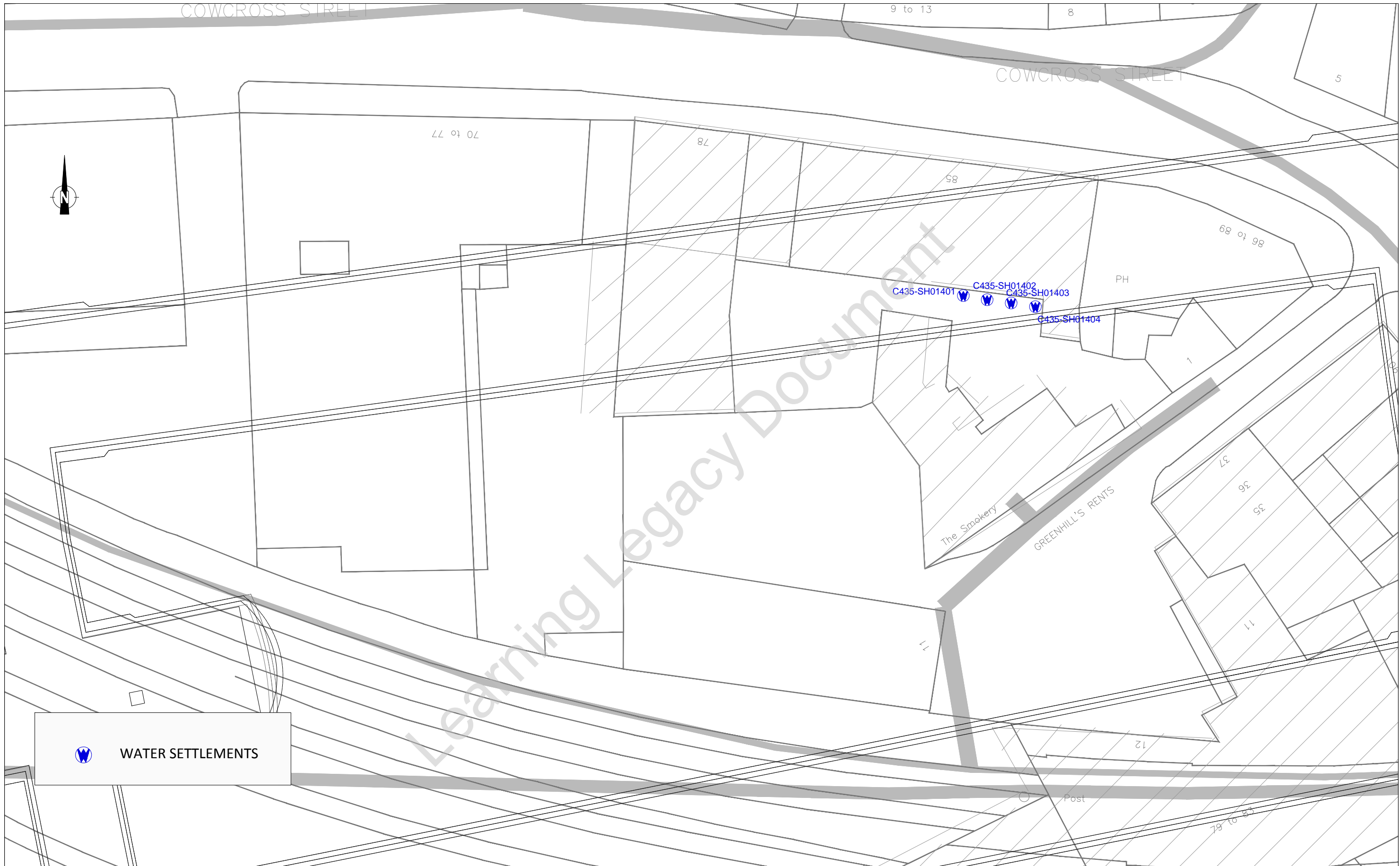
Following the WB and EB TBMs passage, as well as the SCL enlargement of PTW and PTE and the cross passages CP3a and CP4 and Compensation Grouting works carried out from the Butcher's Ramp and Moorgate Spur No.3 shafts, a maximum measured settlement of 12.2mm has been recorded in the 70-77 Cowcross Street building by these Electrolevels and Water settlement cells.


On the other hand, the maximum tilt movement recorded in A and B directions has been -4.35mm/m and +1.52mm/m in the Albion Courtyard building by these Tiltmeters.

After the works, all devices do not show any significant movement, therefore these devices are considered stabilized.

Learning Legacy Document

Appendix A: Drawings / Photomontages



 WATER SETTLEMENTS





Learning Legacy Document

Rev.	Date	Description	By	Chkd	App	Auth
01	23-08-2013					

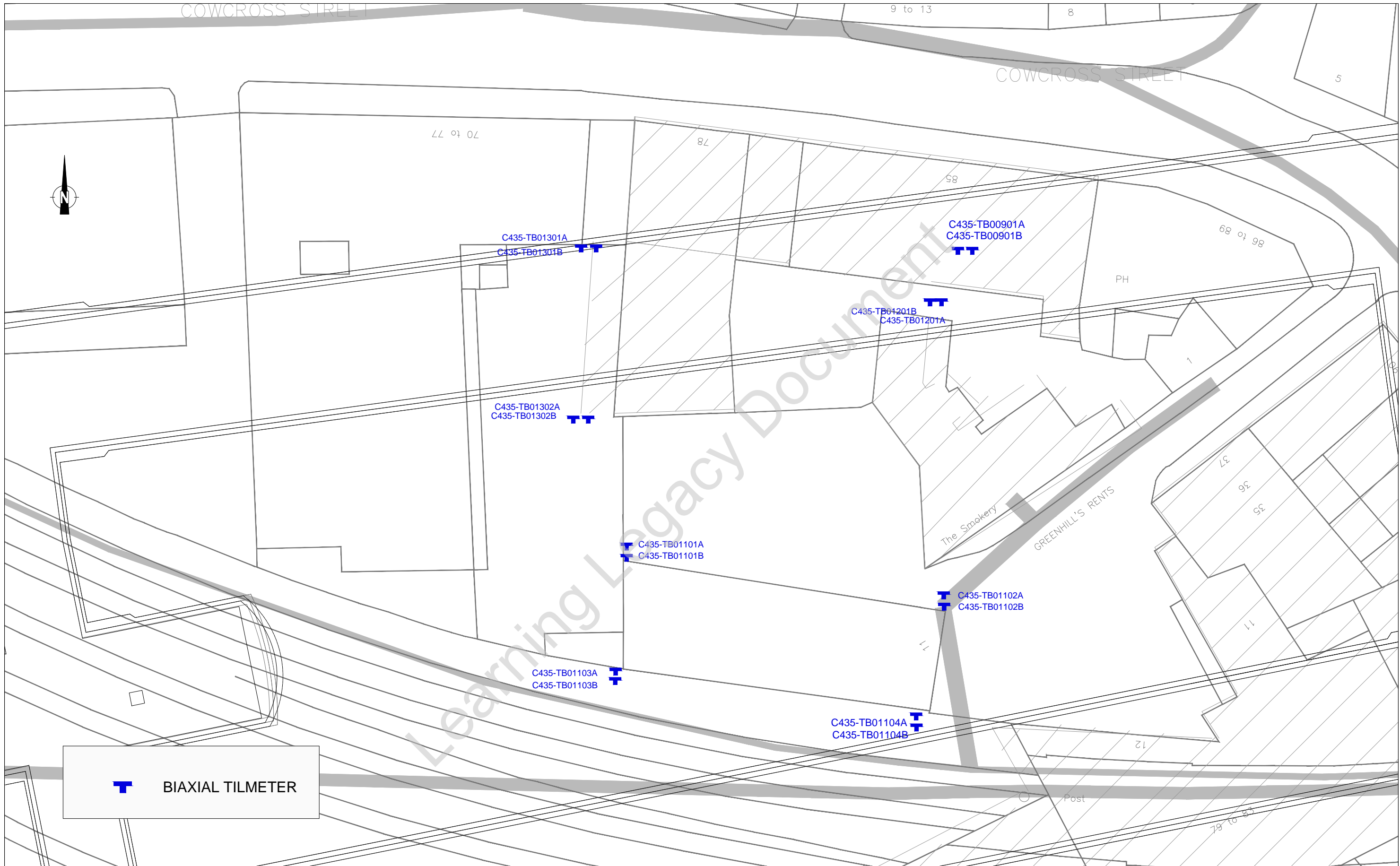
Notes:




GEOCISA UK
 C/ Los Llanos de Jerez 10-12
 28823- MADRID
 www.geocisa.com

Contract :	C435 I&M FARRINGTON STATION
Originator :	GEOCISA
Location :	CROSSRAIL GENERAL
Title :	Water Settlement Cells- 70-85 Cowcross St
Drg No :	C435-BFK-C2-RGN-M-123-50998-IR-SH-70/85CCR
Rev :	
Suit :	
By :	
Chk :	
App :	
Auth :	

\$Ploy\$



T BIAXIAL TILTMETER

Notes:

Rev.	Date	Description	By	Chkd	App	Auth
01	23-08-2013					



GEOCISA UK

C/ Los Llanos de Jerez 10-12
28823- MADRID
www.geocisa.com



Scale : @ A3

Contract : C435 I&M FARRINGTON STATION

Originator : GEOCISA

Location : CROSSRAIL GENERAL

Title :

Biaxial Tiltmeters - 70-85 Cowcross St

Drg No : C435-BFK-C2-RGN-M-123-50998-IR-TB-70/85CCR

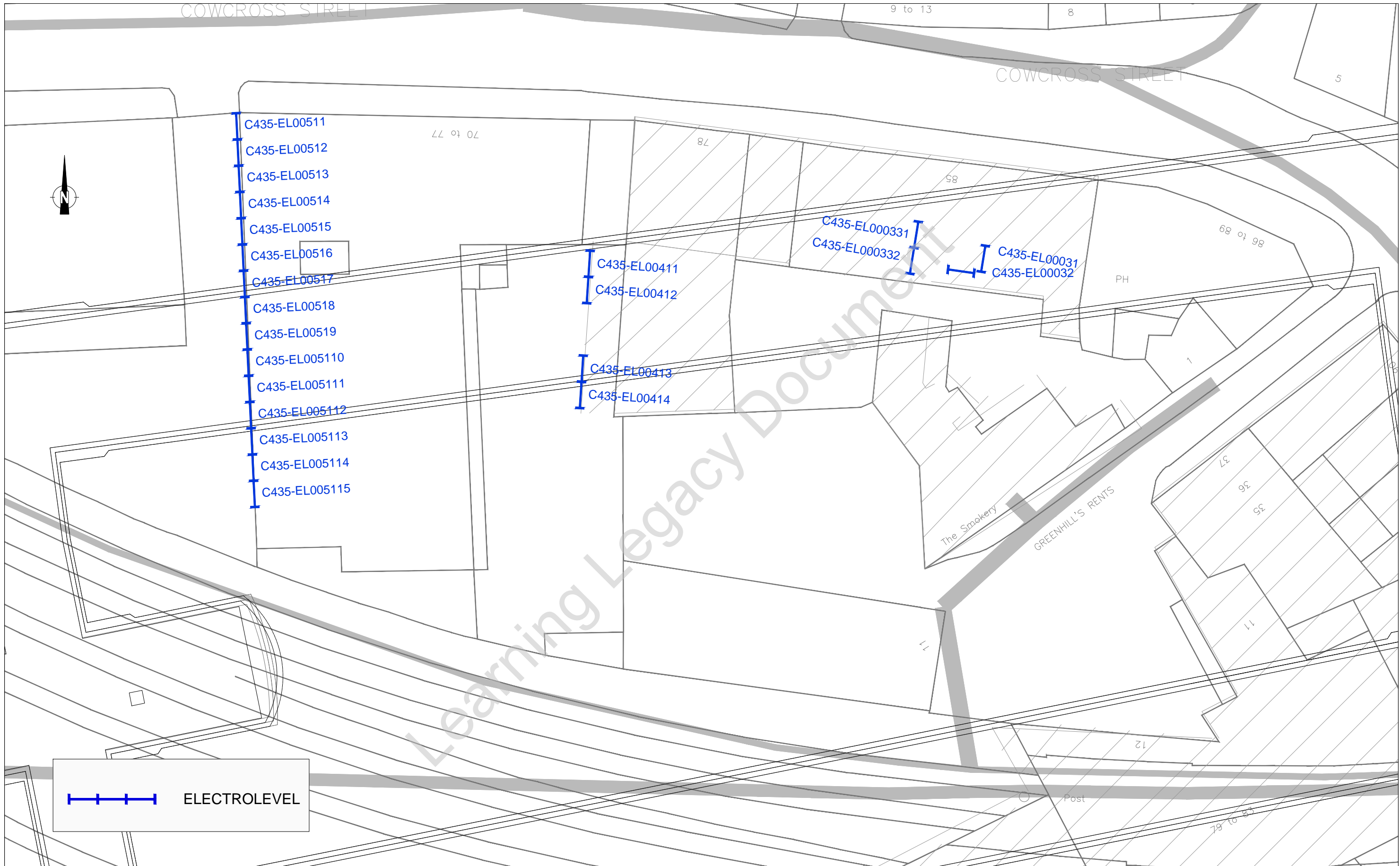
By : [Redacted]


Chk : [Redacted]

App : [Redacted]

Auth : **GEOCISA**

\$Pby\$




ELECTROLEVEL

Notes:

Rev.	Date	Description	By	Chkd	App	Auth
01	23-08-2013					



GEOCISA UK

C/ Los Llanos de Jerez 10-12
28823- MADRID
www.geocisa.com



Scale : @ A3

Contract : C435 I&M FARRINGTON STATION

Originator : GEOCISA

Location : CROSSRAIL GENERAL

Title :

Electrolevel Beams-70-77 Cowcross St

Drg No : C435-BFK-C2-RGN-M-123-50998-IR-EL-70/77CCR

Rev :

Suit :

By :

Chk :

App :

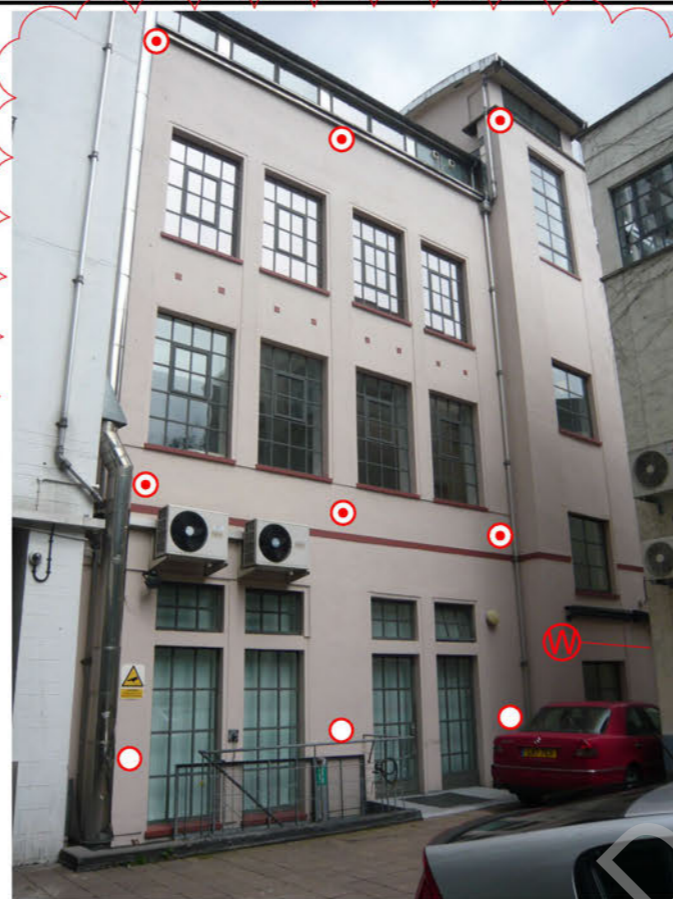
Auth :



\$Poy\$



BRE studs at base of building columns.



 Vibrating Wire Crackmeter



Vibrating Wire Crackmeter:
Vibrating Wire Crackmeters measure the expansion and contraction across existing cracks and joints. They are read from a transmitter box located on the façade.

 Tiltmeter Beam



Electrolevel Beam:
Electrolevel beam consists of a tilt sensor attached to a rigid metal beam. The beam is mounted on walls using anchors. Monitoring is real-time and data transmitted via cable or wirelessly to a data logger.


External Monitoring Instrumentation

Monitoring type	Number of Instruments	Fixings per instrument	Fixing details	Making good strategy
BRE Levelling Studs	10	1	Studs are screwed into slightly recessed 13mm diameter BRE sockets, fixed into drill holes and stabilised with grout or resin.	Protruding studs will be removed, and recessed fixing area made good with materials to match the existing façade finish.
Geodetic Prisms	18	1	Brackets screwed into slightly recessed shell anchor fixings approximately 10mm in diameter, inserted into drill holes and expanded to stabilise.	Prism brackets will be removed, and recessed fixing area made good with materials to match the existing façade finish.
Vibrating Wire Crackmeters	TBC on site	TBC on site	Attached by screws with movable ball joints into slightly recessed shell anchor fixings approximately 10mm in diameter, inserted into drill holes and expanded to stabilise. These are attached by a lead to a transmitter box with screw fixings.	Crackmeter and transmitter box will be removed, and recessed fixing areas made good with materials to match the existing façade finish.
Tiltmeter beam	1	2	Beams screwed into slightly recessed shell anchor fixings approximately 10mm in diameter, inserted into drill holes and expanded to stabilise.	Beams will be removed, and recessed fixing area made good with materials to match the existing façade finish.
Water Settlement	4	2	15mm mounting plate, 90mm diameter, screwed to structure surface.	Instrument and screws will be removed and the finishes reinstated to match the surrounding finish in texture and colour.

Internal Monitoring Instrumentation

Requirement for internal monitoring to be confirmed.


Legend

 Geodetic Prism



Geodetic Prism:

Geodetic prisms are supported on brackets. They are read remotely using Automatic Total Stations fixed to structures nearby.

 BRE Levelling Stud



BRE Levelling Stud:

Levelling stud screws into BRE socket within wall. Manually read levelling staff placed onto stud.

 Water Settlement Cells



Settlement cells measure vertical ground movement relative to a reference point. They are read from a transmitter box.

Notes:

- 1) Drawing issued as designer's recommendations for use by contractor.
- 2) Monitoring positions shown are approximate. Adjustments may be necessary by contractor depending on "as found" conditions at time of installation.
- 3) Invar scales to be located at suitable survey tripod height to allow direct reading.
- 4) Prisms and BRE sockets on same horizontal alignment to be installed at same level where possible.

Safety, Health and Environmental Information

1. Works on this drawing should be undertaken only by an experienced and competent contractor using an approved, safe method of working.
2. Before installing instrumentation, contractor to carry out site inspection to assess proposed positions and location-specific risks to be avoided or controlled.
3. Hazards and risks noted below are additional to those normally associated with instrumentation and monitoring works:
 - (a) Working at height - e.g. installing geodetic prisms at high level on buildings;
 - (b) Near railways - risk of train drivers mistaking retro reflective prisms for signals. Prisms to be sited to avoid this risk.

Rev.	Date	Description	By	Chkd	App	Auth
P01	06/07/2011	Issued as per note 1	MK	HJ	RM	
P02	22/07/2011	Reissued as per note 1	MK	JA	RM	
C01	11/11/2011	Issued as Fit for construction	MK	JA	RM	IT

Notes:



Crossrail Limited
25 Canada Square
Canary Wharf
London
E14 5LQ
www.crossrail.co.uk

Scale: NTS @ A3

Contract: Bored Tunnels (Alignment and Track)

Originator: Ove Arup & Partners Limited

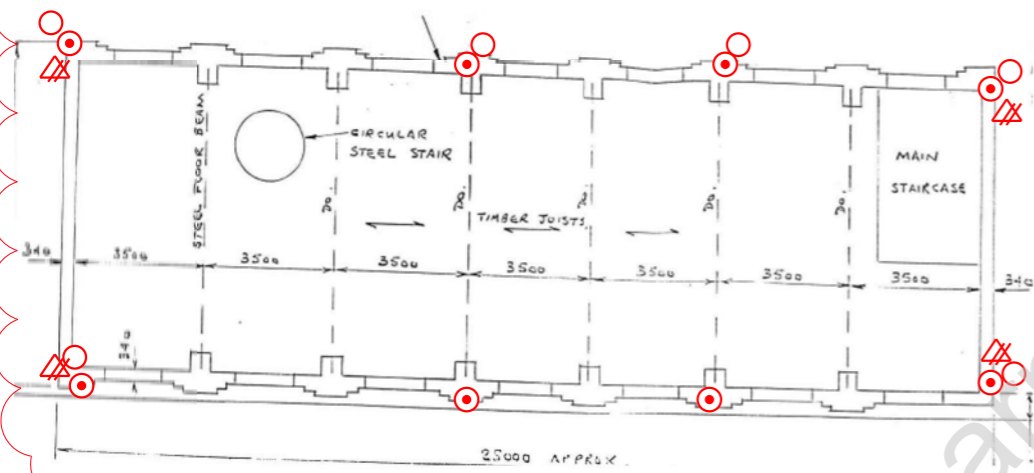
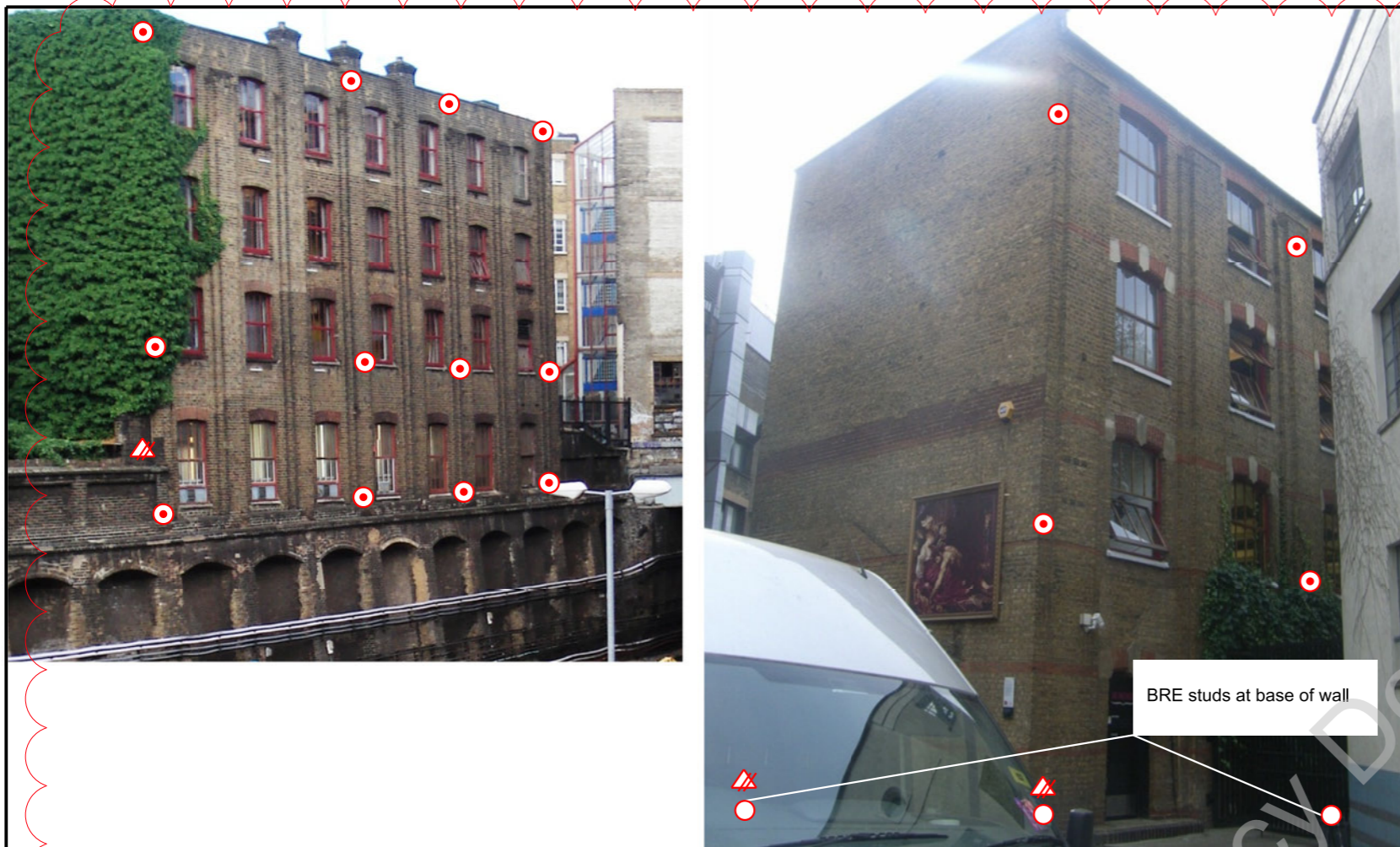
Location: Crossrail General

Title: Proposed Building Instrumentation
Farringdon Station
MDC3-00011 79-85 Cowcross Street

Drg No: C122-OVE-C2-DDJ-CR001_Z-30805

Rev: C01 Suit: A

By: [Redacted]
Chk: [Redacted]
App: [Redacted]
Auth: [Redacted]



- Notes:**
- 1) Drawing issued as designer's recommendations for use by contractor.
 - 2) Monitoring positions shown are approximate. Adjustments may be necessary by contractor depending on "as found" conditions at time of installation.
 - 3) Invar scales to be located at suitable survey tripod height to allow direct reading.
 - 4) Prisms and BRE sockets on same horizontal alignment to be installed at same level where possible.

External Monitoring Instrumentation

Monitoring type	Number of Instruments	Fixings per instrument	Fixing details	Making good strategy
BRE Levelling Studs	6	1	Studs are screwed into slightly recessed 13mm diameter BRE sockets, fixed into drill holes and stabilised with grout or resin.	Protruding studs will be removed, and recessed fixing area made good with materials to match the existing façade finish.
Geodetic Prisms	24	1	Brackets screwed into slightly recessed shell anchor fixings approximately 10mm in diameter, inserted into drill holes and expanded to stabilise.	Prism brackets will be removed, and recessed fixing area made good with materials to match the existing façade finish.
Vibrating Wire Crackmeters	TBC on site	TBC on site	Attached by screws with movable ball joints into slightly recessed shell anchor fixings approximately 10mm in diameter, inserted into drill holes and expanded to stabilise. These are attached by a lead to a transmitter box with screw fixings.	Crackmeter and transmitter box will be removed, and recessed fixing areas made good with materials to match the existing façade finish.
Tiltmeter beams	4	2	Beams screwed into slightly recessed shell anchor fixings approximately 10mm in diameter, inserted into drill holes and expanded to stabilise.	Beams will be removed, and recessed fixing area made good with materials to match the existing façade finish.

Internal Monitoring Instrumentation

Requirement for internal monitoring to be confirmed.

Legend

- Geodetic Prism
- BRE Levelling Stud



Geodetic Prism:

Geodetic prisms are supported on brackets. They are read remotely using Automatic Total Stations fixed to structures nearby.



BRE Levelling Stud:

Levelling stud screws into BRE socket within wall. Manually read levelling staff placed onto stud.

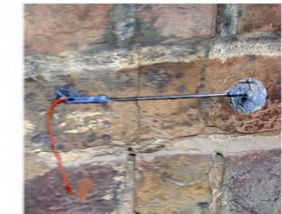
- ▧ Tiltmeter beam



Tiltmeter Beam:

Tiltmeter beam consists of a tilt sensor attached to a rigid metal beam. The beam is mounted on walls using anchors. Monitoring is real-time and data transmitted via cable or wirelessly to a data logger.

- ▧ Vibrating Wire Crackmeter



Vibrating Wire Crackmeter:

Vibrating Wire Crackmeters measure the expansion and contraction across existing cracks and joints. They are read from a transmitter box located on the façade.

Safety, Health and Environmental Information

1. Works on this drawing should be undertaken only by an experienced and competent contractor using an approved, safe method of working.
2. Before installing instrumentation, contractor to carry out site inspection to assess proposed positions and location-specific risks to be avoided or controlled.
3. Hazards and risks noted below are additional to those normally associated with instrumentation and monitoring works:
 - (a) Working at height - e.g. installing geodetic prisms at high level on buildings;
 - (b) Near railways - risk of train drivers mistaking retro reflective prisms for signals. Prisms to be sited to avoid this risk.

Rev.	Date	Description	By	Chkd	App	Auth
P01	30/06/2011	Issued as per note 1	MK	AS	RM	
P02	22/07/2011	---	MK			

Notes:

Crossrail Limited
 25 Canada Square
 Canary Wharf
 London
 E14 5LQ
 www.crossrail.co.uk

Contract : Bored Tunnels (Alignment and Track)	
Originator : Ove Arup & Partners Limited	
Location : Crossrail General	
Title : Proposed Building Instrumentation Farringdon Station C122_15973 Albion Courtyard, Greenhill's Rents	By : [Redacted]
Scale : NTS @ A3	Chk : [Redacted]
Drg No : C122-OVE-C2-DDJ-CR001_Z-39700	App : [Redacted]
Rev : P02	Suit : S4
Auth : ---	



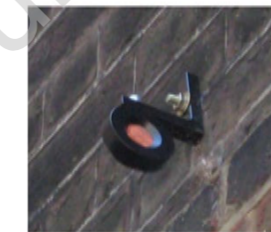
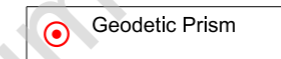
External Monitoring Instrumentation

Monitoring type	Number of Instruments	Fixings per instrument	Fixing details	Making good strategy
Geodetic Prisms	8	1	Brackets screwed into slightly recessed shell anchor fixings approximately 10mm in diameter, inserted into drill holes and expanded to stabilise.	Prism brackets will be removed, and recessed fixing area made good with materials to match the existing façade finish.
Vibrating Wire Crackmeters	TBC on site	TBC on site	Attached by screws with movable ball joints into slightly recessed shell anchor fixings approximately 10mm in diameter, inserted into drill holes and expanded to stabilise. These are attached by a lead to a transmitter box with screw fixings.	Crackmeter and transmitter box will be removed, and recessed fixing areas made good with materials to match the existing façade finish.
Electrolevel Beam	6	2	Beams screwed into slightly recessed shell anchor fixings approximately 10mm in diameter, inserted into drill holes and expanded to stabilise.	Beams will be removed, and recessed fixing area made good with materials to match the existing façade finish
Tiltmeter Beam	2	2	Beams screwed into slightly recessed shell anchor fixings approximately 10mm in diameter, inserted into drill holes and expanded to stabilise.	Beams will be removed, and recessed fixing area made good with materials to match the existing façade finish

Internal Monitoring Instrumentation

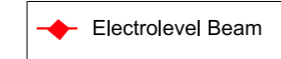
Requirement for internal monitoring to be confirmed.

Legend



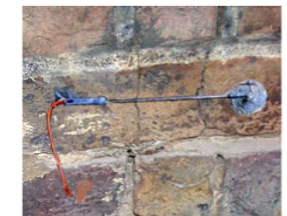
Geodetic Prism:

Geodetic prisms are supported on brackets. They are read remotely using Automatic Total Stations fixed to structures nearby.



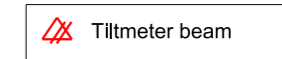
Electrolevel Beam:

Electrolevel beam consists of a tilt sensor attached to a rigid metal beam. The beam is mounted on walls using anchors. Monitoring is real-time and data transmitted via cable or wirelessly to a data logger.



Vibrating Wire Crackmeter:

Vibrating Wire Crackmeters measure the expansion and contraction across existing cracks and joints. They are read from a transmitter box located on the façade.



Tiltmeter Beam:

Tiltmeter beam consists of a tilt sensor attached to a rigid metal beam. The beam is mounted on walls using anchors. Monitoring is real-time and data transmitted via cable or wirelessly to a data logger.

- Notes:
- Drawing issued as designer's recommendations for use by contractor.
 - Monitoring positions shown are approximate. Adjustments may be necessary by contractor depending on "as found" conditions at time of installation.
 - Invar scales to be located at suitable survey tripod height to allow direct reading.
 - Prisms and BRE sockets on same horizontal alignment to be installed at same level where possible.

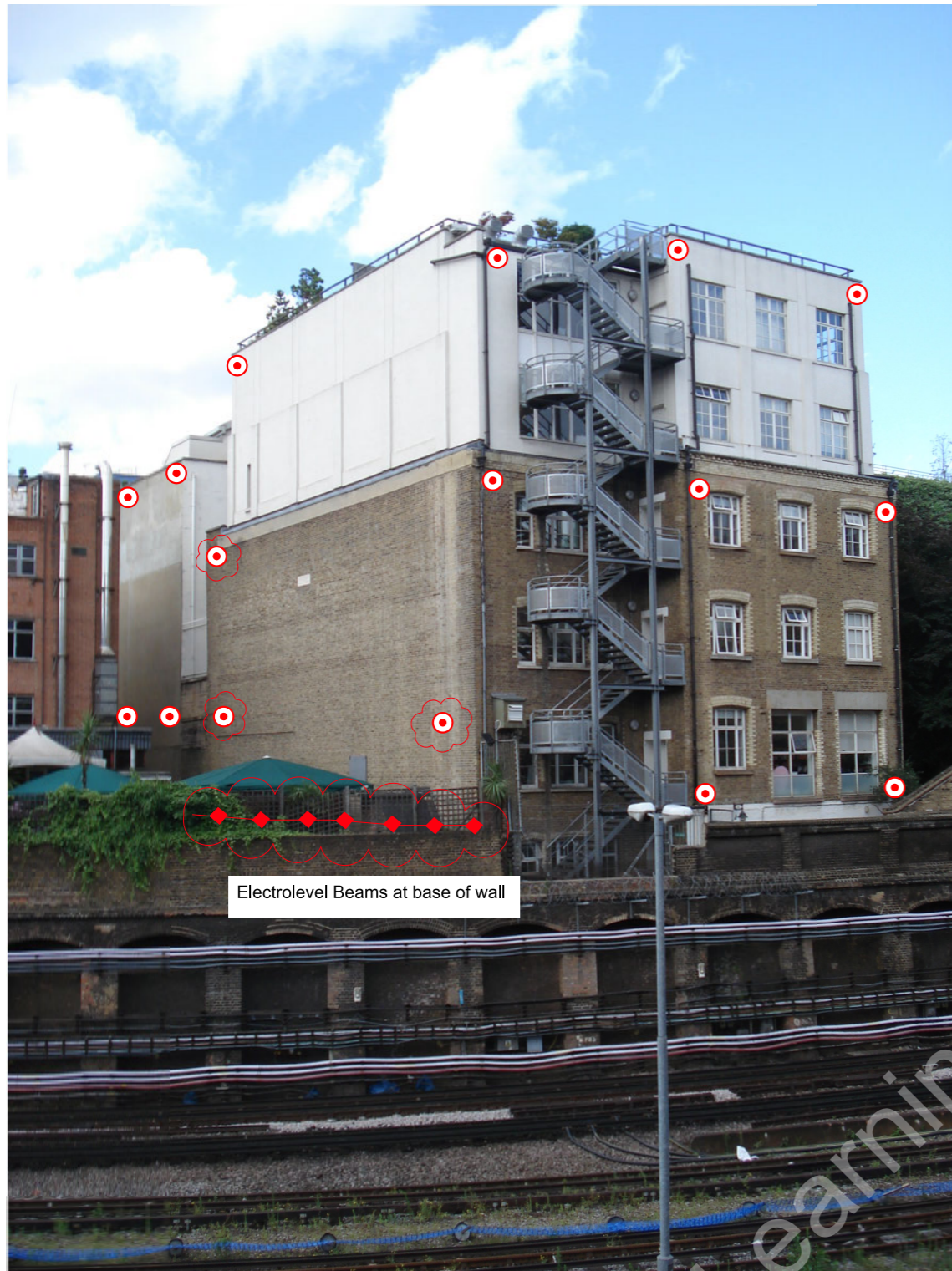
- Safety, Health and Environmental Information**
- Works on this drawing should be undertaken only by an experienced and competent contractor using an approved, safe method of working.
 - Before installing instrumentation, contractor to carry out site inspection to assess proposed positions and location-specific risks to be avoided or controlled.
 - Hazards and risks noted below are additional to those normally associated with instrumentation and monitoring works:
 - Working at height - e.g. installing geodetic prisms at high level on buildings;
 - Near railways - risk of train drivers mistaking retro reflective prisms for signals. Prisms to be sited to avoid this risk.

Rev.	Date	Description	By	Chkd	App	Auth
P01	06/07/2011	Issued as per note 1	MK	HJ	RM	
P02	21/07/2011	Reissued as per note 1	MK	JA	RM	
C01	11/11/2011	Issued as Fit for construction	MK			IT

Notes:

 **Crossrail Limited**
 25 Canada Square
 Canary Wharf
 London
 E14 5LQ
 © Crossrail
 www.crossrail.co.uk

Contract : Bored Tunnels (Alignment and Track)	
Originator : Ove Arup & Partners Limited	
Location : Crossrail General	
Title : Proposed Building Instrumentation Farringdon Station MDC3-0008 78 Cowcross Street 1 of 2	By : [Redacted]
	Chk : [Redacted]
	App : [Redacted]
Scale : NTS @ A3	Auth : [Redacted]
Drg No : C122-OVE-C2-DDJ-CR001_Z-30801	Rev : C01 Suit : A



Notes:

- 1) Drawing issued as designer's recommendations for use by contractor.
- 2) Monitoring positions shown are approximate. Adjustments may be necessary by contractor depending on "as found" conditions at time of installation.
- 3) Invar scales to be located at suitable survey tripod height to allow direct reading.
- 4) Prisms and BRE sockets on same horizontal alignment to be installed at same level where possible.

Rev.	Date	Description	By	Chkd	App	Auth
P01	29/06/2011	Issued as per note 1	MK	AS	RM	
P02	21/07/2011	Reissued as per note 1	MK	JA	RM	
		Issued as Fit for construction		JA	RM	IT

Notes:

External Monitoring Instrumentation

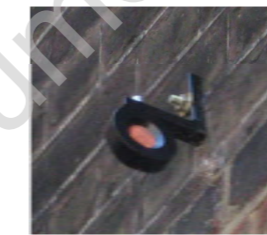
Monitoring type	Number of Instruments	Fixings per instrument	Fixing details	Making good strategy
Geodetic Prisms	16	1	Brackets screwed into slightly recessed shell anchor fixings approximately 10mm in diameter, inserted into drill holes and expanded to stabilise.	Prism brackets will be removed, and recessed fixing area made good with materials to match the existing façade finish.
Vibrating Wire Crackmeters	TBC on site	TBC on site	Attached by screws with movable ball joints into slightly recessed shell anchor fixings approximately 10mm in diameter, inserted into drill holes and expanded to stabilise. These are attached by a lead to a transmitter box with screw fixings.	Crackmeter and transmitter box will be removed, and recessed fixing areas made good with materials to match the existing façade finish.
Electrolevel Beam	15	2	Beams screwed into slightly recessed shell anchor fixings approximately 10mm in diameter, inserted into drill holes and expanded to stabilise.	Beams will be removed, and recessed fixing area made good with materials to match the existing façade finish

Internal Monitoring Instrumentation

Requirement for internal monitoring to be confirmed.

Legend

-  Geodetic Prism
-  Vibrating Wire Crackmeter




Geodetic Prism:

Geodetic prisms are supported on brackets. They are read remotely using Automatic Total Stations fixed to structures nearby.



Vibrating Wire Crackmeter:

Vibrating Wire Crackmeters measure the expansion and contraction across existing cracks and joints. They are read from a transmitter box located on the façade.

-  Electrolevel Beam



Electrolevel Beam:

Electrolevel beam consists of a tilt sensor attached to a rigid metal beam. The beam is mounted on walls using anchors. Monitoring is real-time and data transmitted via cable or wirelessly to a data logger.

Safety, Health and Environmental Information

1. Works on this drawing should be undertaken only by an experienced and competent contractor using an approved, safe method of working.
2. Before installing instrumentation, contractor to carry out site inspection to assess proposed positions and location-specific risks to be avoided or controlled.
3. Hazards and risks noted below are additional to those normally associated with instrumentation and monitoring works:
 - (a) Working at height - e.g. installing geodetic prisms at high level on buildings;
 - (b) Near railways - risk of train drivers mistaking retro reflective prisms for signals. Prisms to be sited to avoid this risk.

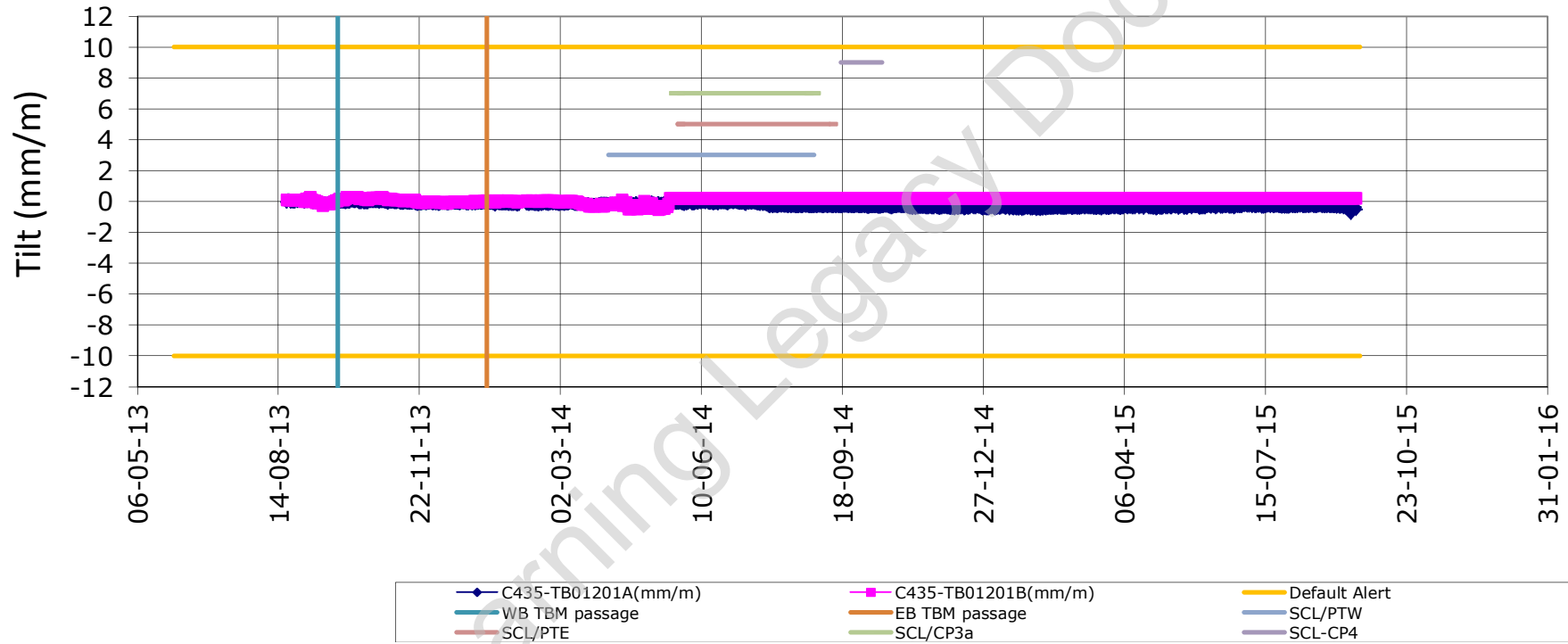
 **Crossrail Limited**
 25 Canada Square
 Canary Wharf
 London
 E14 5LQ
 www.crossrail.co.uk

Contract : Bored Tunnels (Alignment and Track)	
Originator : Ove Arup & Partners Limited	
Location : Crossrail General	
Title : Proposed Building Instrumentation Farringdon Station MDC3-0007 70-77 Cowcross Street 6 of 6	By : M [redacted]
	Chk : [redacted]
	App : R [redacted]
Scale : NTS @ A3	Auth : I [redacted]
Drg No : C122-OVE-C2-DDJ-CR001_Z-39678	Rev : [redacted] Suit : A

Learning Legacy Document

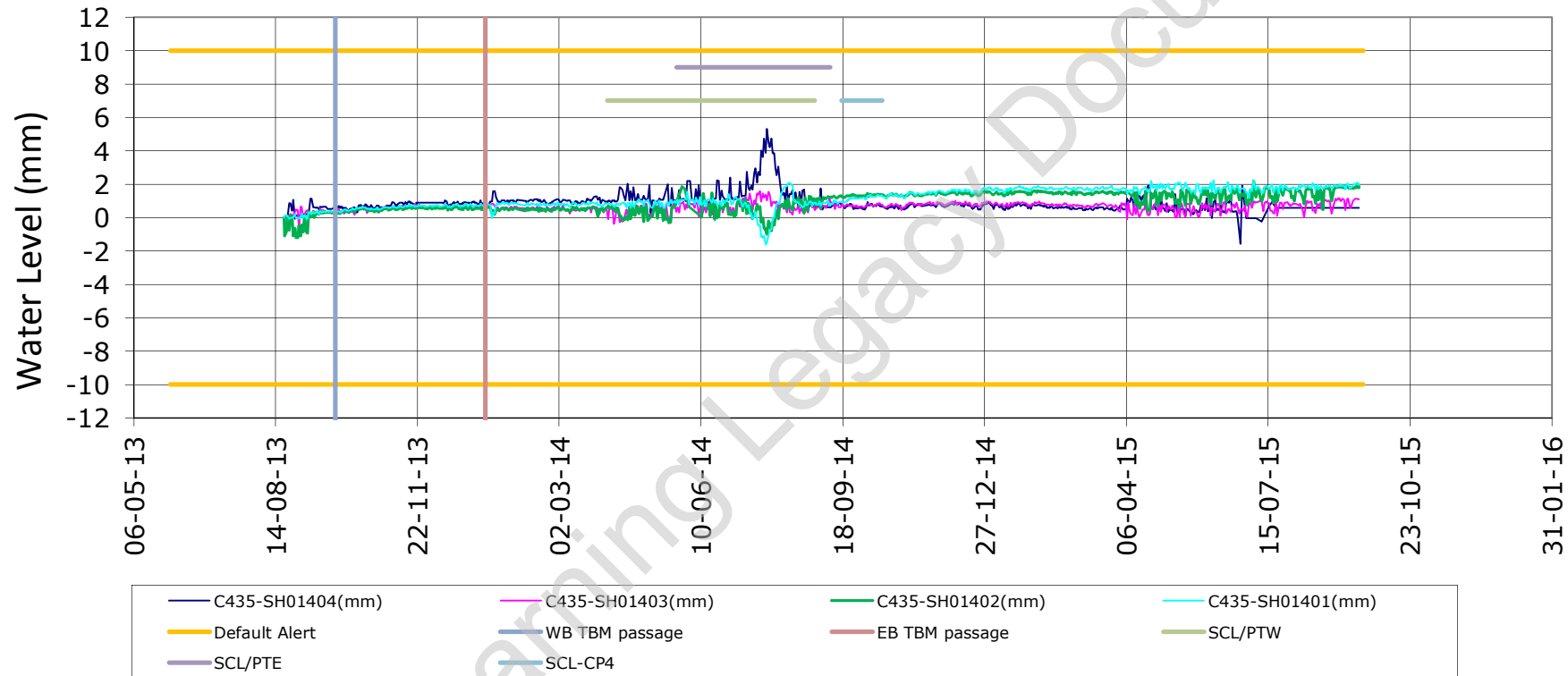
Appendix B: Graphs

85 Cowcross Street



REMARKS:

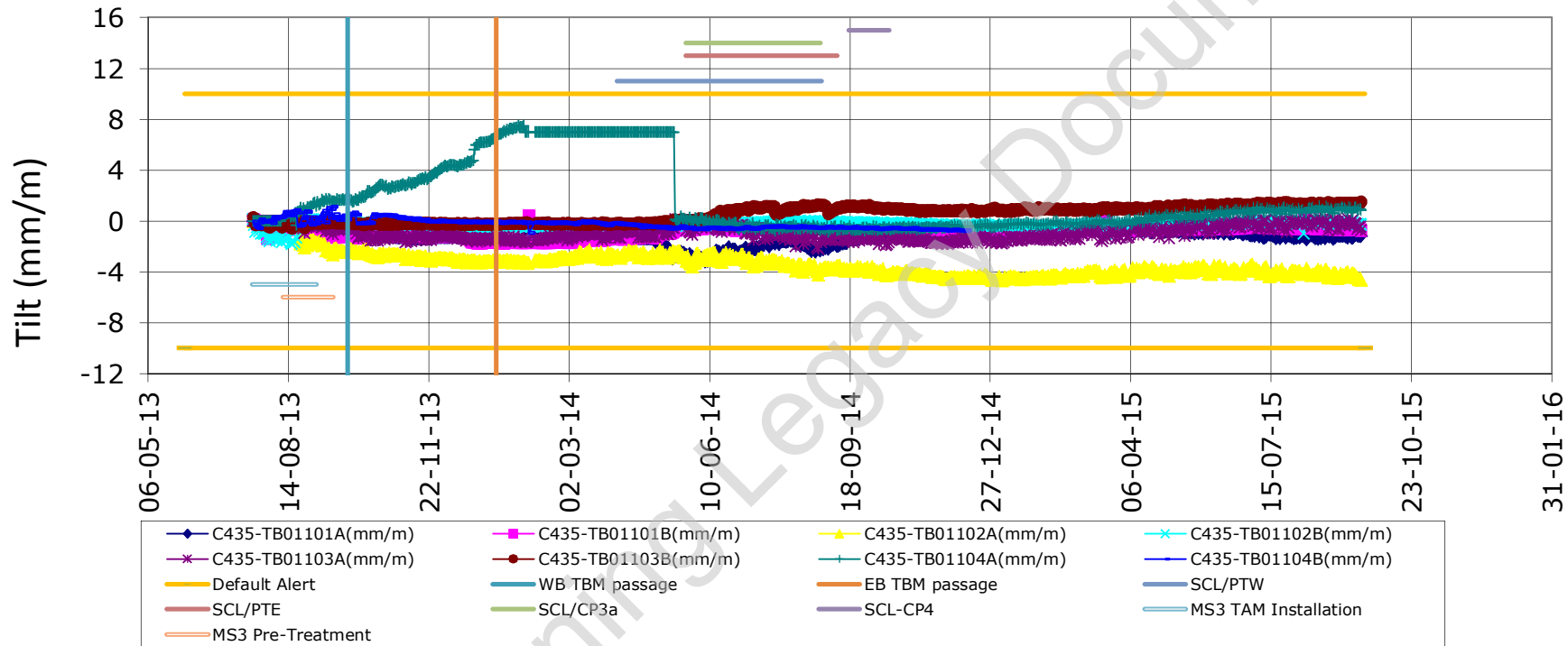
79-85 Cowcross Street



REMARKS:

All of the Water Settlement Cells were installed inside the zone of influence being not fixed to any reference absolute value, being that the reason why the movement shown during SCL works has not been the expected one.

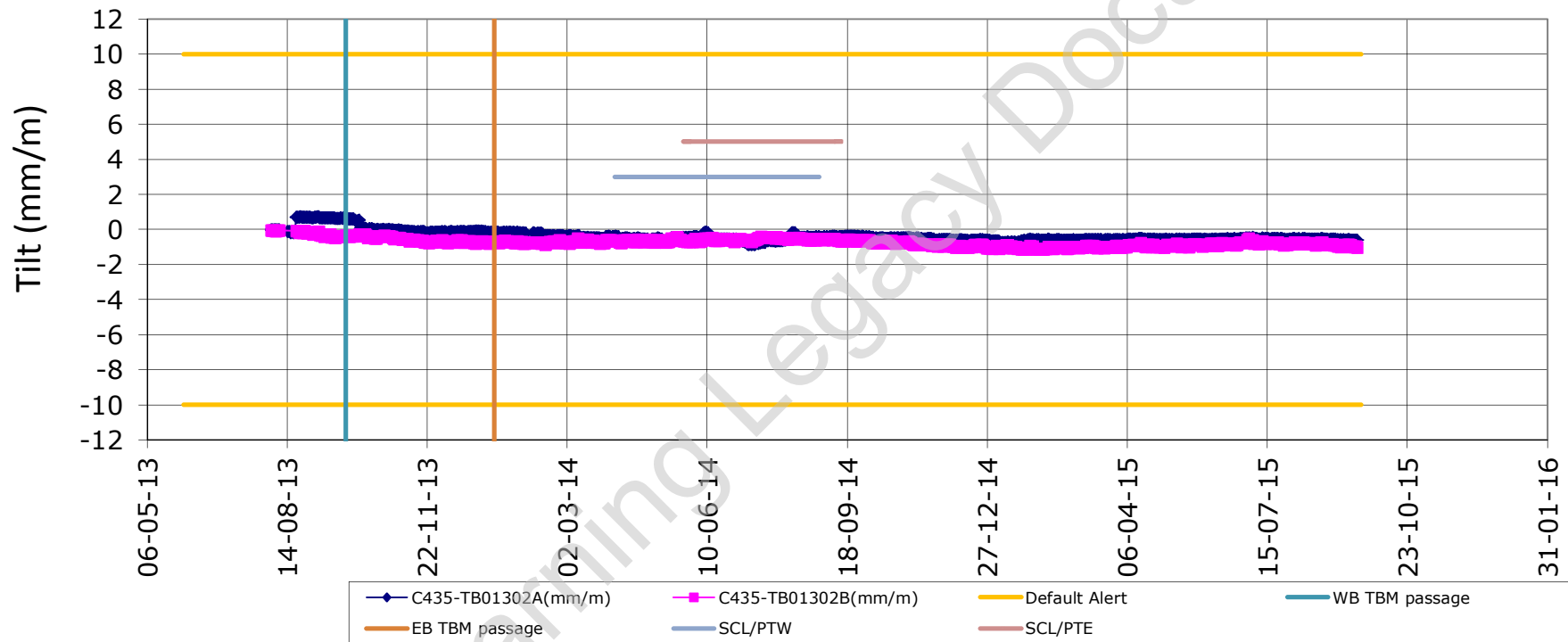
Albion Courtyard, Greenhill's Rents



REMARKS:

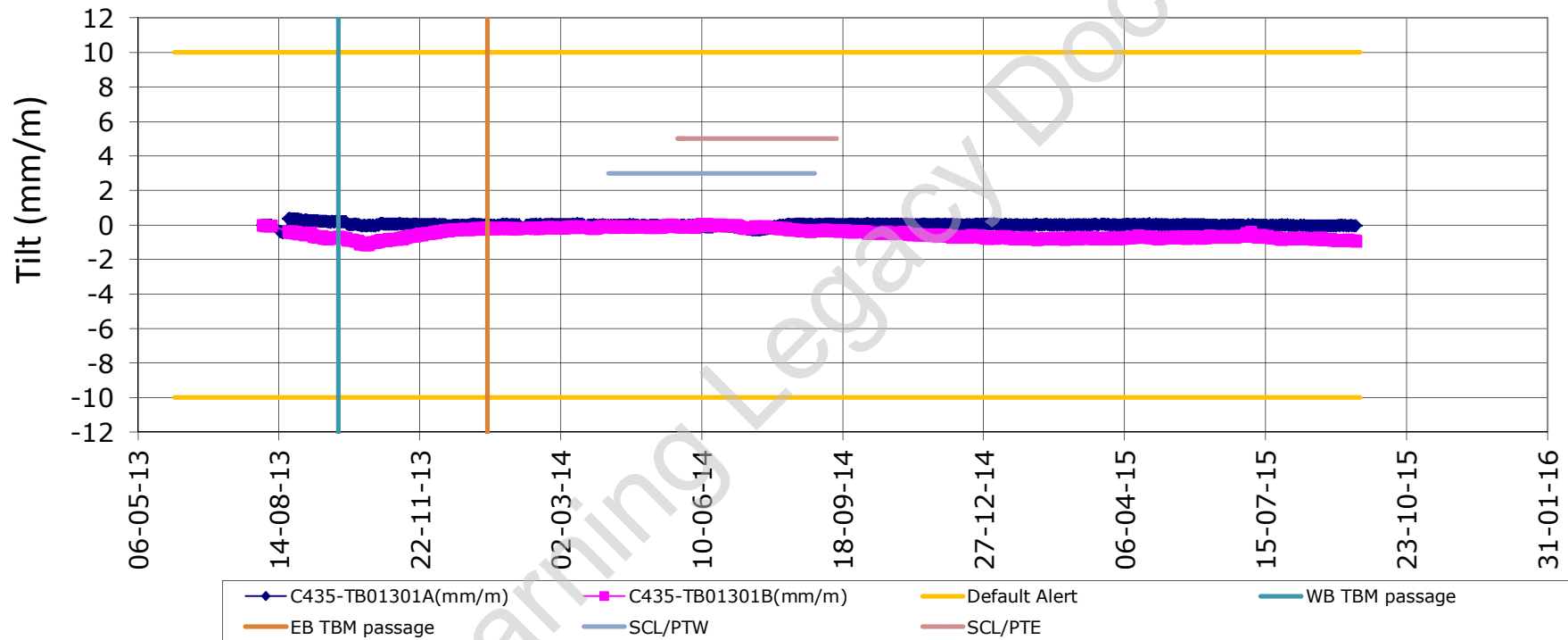
C435-TB01104A was damaged showing an anomalous behaviour from 25/08/2013. After several investigations and analysis, the drift was amended and the device fixed properly on 16/05/2014 coming the readings back to normal after applying an offset taking into account the movement recorded during these time by surrounding devices.

78 Cowcross Street



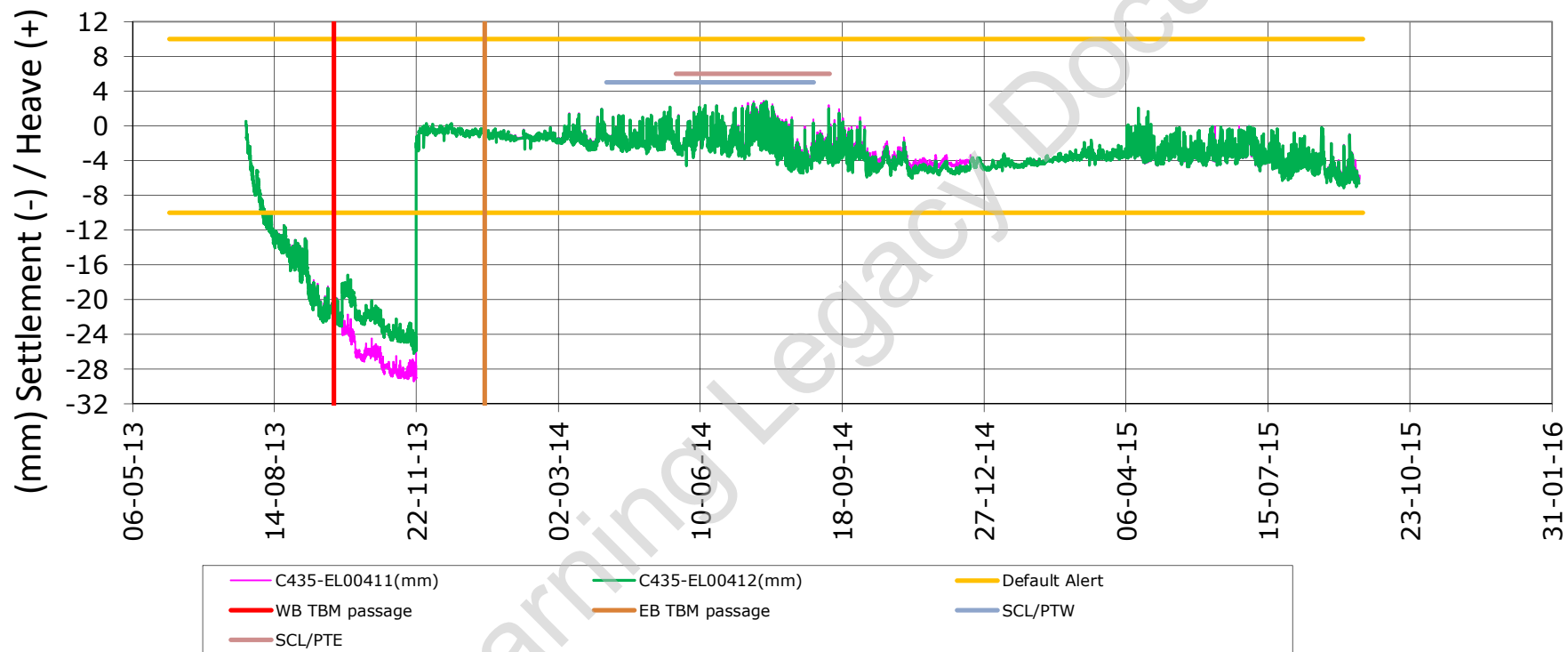
REMARKS:

78 Cowcross Street



REMARKS:

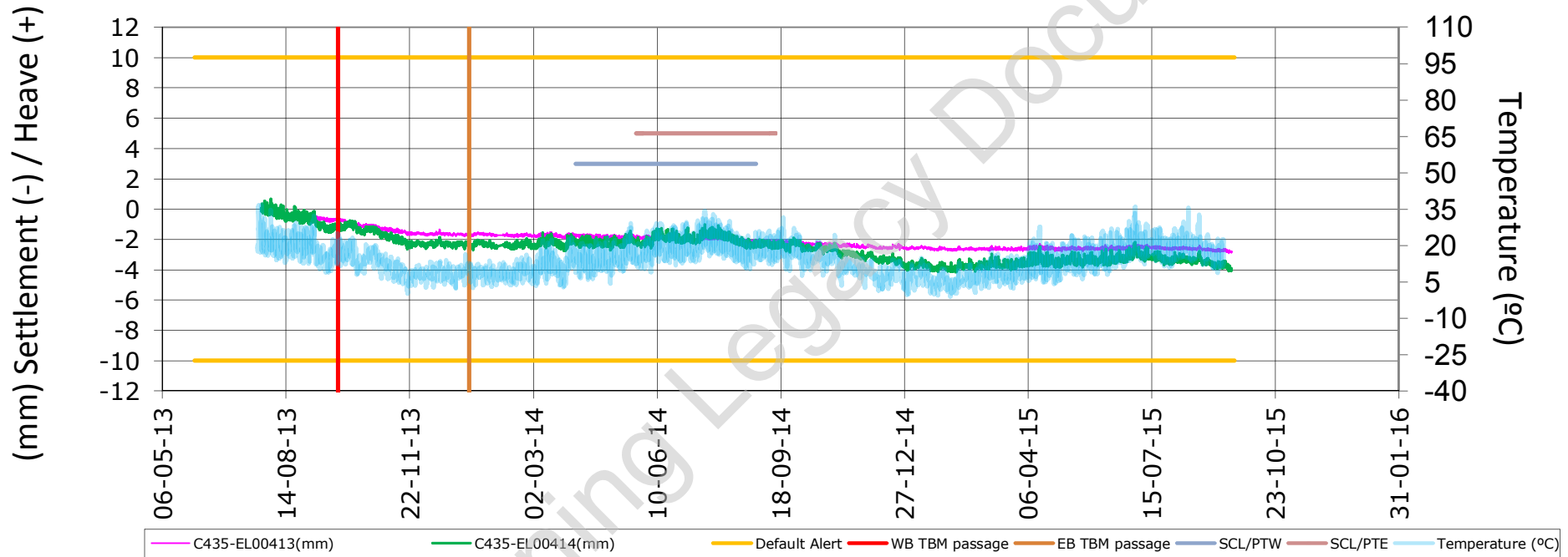
78 Cowcross Street



REMARKS:

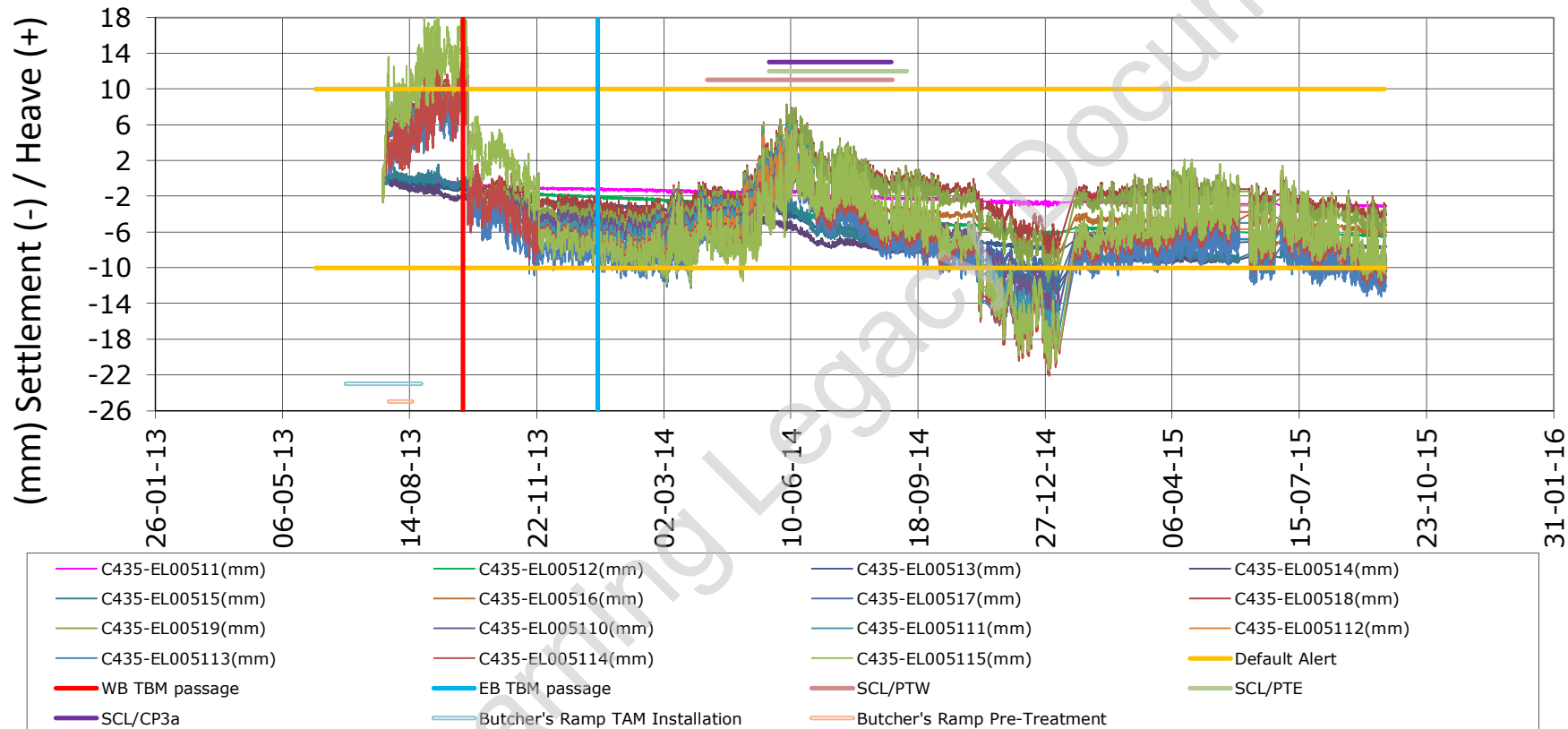
Inaccurate behaviour and trend of settlement recorded from origin to 17/11/2013, when the devices were fixed and readings amended applying an offset on 17/11/2013 taking into account the behaviour recorded by surrounding devices in this period of time.

78 Cowcross Street



REMARKS:

70-77 Cowcross Street



REMARKS:

Inaccurate behaviour and trend of heave recorded from origin to 28/09/2013 in devices from C435-EL00516 to C435-EL005115, amended applying an offset on 28/09/2013 after maintenance works carried out taking into account the behaviour recorded by surrounding devices in this period of time.

Inaccurate behaviour and trend of settlement recorded from 04/11/2014 to 22/01/2015 in all these devices, amended applying an offset on 22/01/2015 taking into account the behaviour recorded by surrounding devices in this period of time.