



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

C435 Farringdon Main Station

CRL Lead reviewer: [Redacted]
CRL Reviewer:

Monitoring Close-Out Report: Automated Total Station ATS 53 and 3D Targets read by ATS 53.

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2a. Stakeholder Review Required? YES NO

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

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

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

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

2b. Review by Stakeholder (if required):

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

3. Acceptance by Crossrail:

13/10/2016

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A. INTRODUCTION

In line with the C122 – M&W Specification KX10 – Instrumentation & Monitoring C122-OVE-Z4-RSP-CR001-00007 [Sections KX10.2113 and KX10.2114 (final and close-out report)], 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 prisms read by ATS53. See Table 1 below with the details of the prisms read by ATS53

Sensor	Location	Easting (m)	Northing (m)	Elevation (mATD)
C435-RP05301	55 CHARTERHOUSE ST	82010.6407	36484.663	119.1604
C435-RP05302	55 CHARTERHOUSE ST	82010.6395	36484.6738	122.2797
C435-RP05303	55 CHARTERHOUSE ST	82008.8817	36481.3514	119.1206
C435-RP05304	55 CHARTERHOUSE ST	82008.8754	36481.41	122.2801
C435-RP05305	55 CHARTERHOUSE ST	82009.8679	36479.342	122.6841
C435-RP05306	55 CHARTERHOUSE ST	82011.179	36476.7369	122.6822
C430-RP18001 – Lower Parapet Level	36-43 COWCROSS ST	81927.5172	36550.5808	119.9883
C430-RP18002- Roof Level	36-43 COWCROSS ST	81926.9625	36551.6335	119.8992
C430-RP18003 – Lower Parapet Level	36-43 COWCROSS ST	81930.6902	36550.2756	116.9053
C430-RP18004- Roof Level	36-43 COWCROSS ST	81929.8093	36553.2957	121.0954
C430-RP18005- Roof Level	36-43 COWCROSS ST	81932.6583	36554.7495	121.1013
C430-RP18006- Roof Level	36-43 COWCROSS ST	81935.806	36556.3564	121.1008
C430-RP18007 – Lower Parapet Level	36-43 COWCROSS ST	81937.3575	36553.6319	116.8953
C430-RP18008 – Lower Parapet Level	36-43 COWCROSS ST	81940.3714	36555.1137	116.8916
C430-RP18009- Roof Level	36-43 COWCROSS ST	81943.0059	36559.0039	121.097
C430-RP18010- Roof Level	36-43 COWCROSS ST	81945.7117	36560.3509	121.106

Sensor	Location	Easting (m)	Northing (m)	Elevation (mATD)
C430-RP18011-Roof Level	36-43 COWCROSS ST	81947.9884	36561.4778	121.1076
C430-RP18012-Roof Level	36-43 COWCROSS ST	81948.3296	36562.6736	121.1185
C430-RP18013 – Lower Parapet Level	36-43 COWCROSS ST	81949.9681	36559.9299	116.8724
C430-RP18014	36-43 COWCROSS ST	81952.831	36561.3669	116.5682
C430-RP18015-Roof Level	36-43 COWCROSS ST	81952.0017	36564.4836	121.1094
C430-RP18016	36-43 COWCROSS ST	81955.2404	36566.1016	121.1314
C430-RP18017	36-43 COWCROSS ST	81956.9066	36563.4091	116.5688
C430-RP18018-Roof Level	36-43 COWCROSS ST	81958.8806	36567.9035	121.1239
C430-RP18019-Roof Level	36-43 COWCROSS ST	81958.4077	36569.7224	121.123
C430-RP18020-Roof Level	36-43 COWCROSS ST	81956.7005	36573.1211	121.1188
C430-RP18021-Roof Level	36-43 COWCROSS ST	81954.7892	36576.9753	121.1193
C430-RP18031 – Lower Parapet Level	36-43 COWCROSS ST	81924.6248	36547.6309	117.1717
C430-RP18032 – Lower Parapet Level	36-43 COWCROSS ST	81927.6595	36550.4459	116.9162
C430-RP18033 – Lower Parapet Level	36-43 COWCROSS ST	81927.6595	36550.4459	116.9162
C430-RP18034 – Lower Parapet Level	36-43 COWCROSS ST	81927.0018	36551.6626	116.8849
C430-RP18035-Roof Level	36-43 COWCROSS ST	81960.064	36565.071	120.2329
C430-RP18036-Roof Level	36-43 COWCROSS ST	81927.0337	36548.8927	120.0279
C430-RP18037 – Lower Parapet Level	36-43 COWCROSS ST	81960.0808	36565.0842	116.8658
C430-RP18038 – Lower Parapet Level	36-43 COWCROSS ST	81934.6598	36552.3068	116.8271
C430-RP18039-Roof Level	36-43 COWCROSS ST	81938.9505	36557.9152	121.096
C430-RP18040-Roof Level	36-43 COWCROSS ST	81923.0201	36561.8135	120.0703
C430-RP18041-Roof Level	36-43 COWCROSS ST	81924.9891	36562.8094	120.0617
C430-RP18042-Roof Level	36-43 COWCROSS ST	81928.089	36564.3748	120.0551
C430-RP18043-Roof Level	36-43 COWCROSS ST	81931.4211	36566.0165	120.0515
C430-RP18044-Roof Level	36-43 COWCROSS ST	81934.46	36567.5269	120.0478

Sensor	Location	Easting (m)	Northing (m)	Elevation (mATD)
C430-RP18045-Roof Level	36-43 COWCROSS ST	81937.3384	36568.971	120.0538
C430-RP18046-Roof Level	36-43 COWCROSS ST	81941.1438	36570.8736	120.056
C430-RP18048-Roof Level	36-43 COWCROSS ST	81947.1784	36573.8902	120.0699
C430-RP18049-Roof Level	36-43 COWCROSS ST	81949.5979	36575.0801	120.0779
C430-RP18050-Roof Level	36-43 COWCROSS ST	81952.7683	36576.6943	120.0807

Table 1: Details of the prisms read by ATS53

These prisms are read by ATS 53, which is installed on 61-63 Cowcross St, and are shown in the following documents:

Drawings:

- C435-BFK-C2-DWG-M123-50045. 3D Targets installed for Farringdon Station. Attached in Appendix A

Installation Reports:

- C435-BFK-C2-RGN-M123-50025 Installation Report: Automated Total Station Installation at 63-61 Cowcross St (ATS 53)
- C435-BFK-C2-RGN-M123-51009 Installation Report of 3D Targets read by ATSS 51, 52, 53 and 54.
- C430-LOS-C-RGN-M123-50019 Installation Report – Assets Protection Outside Site Boundaries – WTH

B.2 Location of the Instruments

Prisms associated with ATS53 are located on the plan below highlighted in yellow.

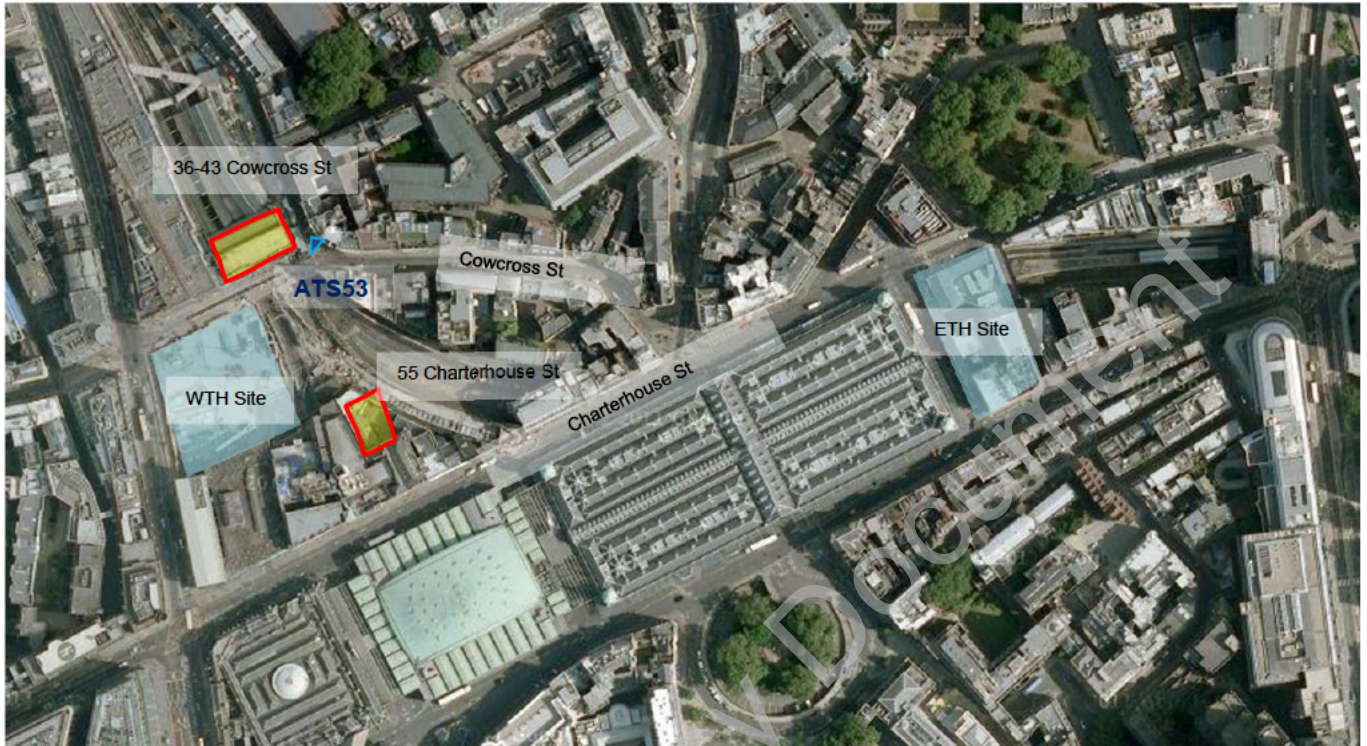


Figure 1 – Map showing the Location of prisms read by ATS 53.

C. MOVEMENTS

C.1 Movements Resulting from Construction Activities

C.1.1 Relevant Crossrail (BFK) Works

Crossrail construction activities that may have affected the above instruments are outlined in the Table 2 below and highlighted in the drawing presented in Appendix A:

ACTIVITY	START DATE	END DATE
STW2-PL1	01/05/2013	21/06/2013
Butcher's Ramp Shaft TAM Installation	07/06/2013	16/09/2013
STW2 Excavation	20-06-201	28-06-2013
CP1	06/07/2013	22/07/2013
Butcher's Ramp Shaft Pre-Treatment works	29/07/2013	16/08/2013
CH1 pilot tunnel	20/08/2013	21/10/2013
WB TBM passage	10/09/2013	25/09/2013
WTH – SHW3 excavation	28/10/2013	21/08/2014
CH1 Enlargement	01/12/2013	23/03/2014
EB TBM passage	14/12/2013	09/01/2014
PTW enlargement	19/02/2014	29/04/2014
WTH – SHW2 Level -8 excavation	11/04/2014	09/05/2014

ACTIVITY	START DATE	END DATE
CP2	28/04/2014	23/09/2014
PTE enlargement	04/05/2014	08/06/2014
CP3	20/05/2014	27/08/2014
PL1	01/09/2014	05-09-2014
VA1	23/11/2014	17/01/2015
ES1	14/03/2015	20/05/2015
PL2 connection	29/04/2015	24/05/2015

Table 2 – Construction Activities in proximity ATS53 and related prisms

C.1.2 Resulting Movements

- 55 Charterhouse St:

Monitoring data for these prisms is presented in Appendix B.

- WB TBM passage caused around 6mm settlement from 24-09-2013 to 26-09-2013.
- PL1 and CP1 excavation caused 3mm settlement in the area from 18-06-2013 to 22-07-2013.
- CH1 Enlargement caused 3mm of settlement in this building between 14-01-2014 and 05-03-2014.
- PTW enlargement caused maximum 12 mm of settlement from 19-02-2014 to 29-04-2014.
- PTE enlargement caused 4mm maximum of settlement from 04-05-2014 to 08-06-2014
- ES1 excavation caused 2mm of settlement from 14-03-2015 to 12-04-2015
- CP3 caused 3-4mm of settlement between 18-06-2014 and 27-08-2014.
- Butcher's Ramp shaft Pre-Treatment caused 3-4mm of heave in August 2013
- Compensation Grouting carried out during November-December 2013 caused 3mm of heave.
- Compensation Grouting carried out during June 2014 caused 3mm maximum of heave.
- Compensation Grouting carried out during December 2014 caused 4mm of heave.
- Maximum longitudinal (along the façade of the building) displacement -20mm
- Maximum transversal (perpendicular to the façade of the building) displacement -10mm
- Maximum settlement at the end of the works 28mm

- 36-43 Cowcross St-roof:

Monitoring data for these prisms is presented in Appendix B.

- No significant movement was captured by the prisms during the EB TBM.
- PL1 and CP1 excavation caused around 4mm of settlement in the area from 18-06-2013 to 22-07-2013
- PTE enlargement works do not caused significant movement.
- The prisms installed on the roof showed bad reading because there was a refurbishment works in the station.
- Maximum longitudinal (along the façade of the building) displacement +16mm
- Maximum transversal (perpendicular to the façade of the building) displacement -12mm
- Maximum settlement at the end of the works 15mm

- 36-43 Cowcross St-lower parapet level

Monitoring data for these prisms is presented in Appendix B.

- EB TBM passage caused around 1-2mm settlement in some prisms in the area from 14-12-2013 to 16-04-2013.
- PL1 and CP1 excavation caused around 4mm settlement in the area from 18-06-2013 to 22-07-2013
- STW1 construction caused 3mm maximum of settlement between 29-03-2014 and 24-04-2014.
- Maximum longitudinal (along the façade of the building) displacement -6mm
- Maximum transversal (perpendicular to the façade of the building) displacement +8mm
- Maximum settlement at the end of the works 7mm

C.2 Triggers/Default Alerts 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.

- Default alert value is defined as 10mm in any direction.
- Green trigger value is defined as 24mm of settlement.
- Amber trigger value is defined as 30mm of settlement
- Red trigger value is defined as 38mm of settlement.

No trigger values were breached.

The Table 3 below shows the breached default alerts.

MONITORING GROUP (Location)	POINT ID	TYPE	DIRECTION	DATE OF LAST READING	LAST READING VALUE (mm)	TRIGGER LEVEL	
						WORST HISTORICAL STATUS	CURRENT STATUS
55 CHARTERHOUSE STREET	C435-RP05301	AUTOMATIC RP	Settlement	25/11/2015 07:00	-19.1	Default Alert	Default Alert
	C435-RP05302	AUTOMATIC RP	Settlement	25/11/2015 07:00	-17.4	Default Alert	Default Alert
	C435-RP05303	AUTOMATIC RP	Settlement	25/11/2015 07:00	-21.9	Default Alert	Default Alert
	C435-RP05304	AUTOMATIC RP	Settlement	25/11/2015 07:00	-22.4	Default Alert	Default Alert
	C435-RP05305	AUTOMATIC RP	Settlement	25/11/2015 07:00	-20.3	Default Alert	Default Alert
	C435-RP05306	AUTOMATIC RP	Settlement	25/11/2015 07:00	-17.9	Default Alert	Default Alert
36-43 COWCROSS STREET	C430-RP18001	AUTOMATIC RP	Settlement	25/11/2015 07:00	-1.4	Clear	Clear
	C430-RP18002	AUTOMATIC RP	Settlement	25/11/2015 07:00	-1.4	Clear	Clear
	C430-RP18003	AUTOMATIC RP	Settlement	25/11/2015 07:00	-2.3	Clear	Clear
	C430-RP18004	AUTOMATIC RP	Settlement	25/11/2015 07:00	-1.2	Clear	Clear
	C430-RP18005	AUTOMATIC RP	Settlement	25/11/2015 07:00	-5	Clear	Clear
	C430-RP18006	AUTOMATIC RP	Settlement	25/11/2015 07:00	-2.8	Clear	Clear
	C430-RP18007	AUTOMATIC RP	Settlement	25/11/2015 07:00	-5.5	Clear	Clear
	C430-RP18008	AUTOMATIC RP	Settlement	25/11/2015 07:00	-2.7	Clear	Clear
	C430-RP18009	AUTOMATIC RP	Settlement	25/11/2015 07:00	-3.3	Clear	Clear
	C430-RP18010	AUTOMATIC RP	Settlement	25/11/2015 05:00	-11.8	Default Alert	Default Alert
	C430-RP18011	AUTOMATIC RP	Settlement	25/11/2015 07:00	-3.1	Clear	Clear
	C430-RP18012	AUTOMATIC RP	Settlement	25/11/2015 07:00	-1	Clear	Clear
	C430-RP18013	AUTOMATIC RP	Settlement	23/11/2015 21:00	-0.2	Clear	Clear
	C430-RP18014	AUTOMATIC RP	Settlement	-	-	-	-
	C430-RP18015	AUTOMATIC RP	Settlement	25/11/2015 07:00	-0.9	Clear	Clear
	C430-RP18016	AUTOMATIC RP	Settlement	-	-	-	-
	C430-RP18017	AUTOMATIC RP	Settlement	-	-	-	-
	C430-RP18018	AUTOMATIC RP	Settlement	25/11/2015 07:00	3.4	Clear	Clear
	C430-RP18019	AUTOMATIC RP	Settlement	25/11/2015 07:00	-9.5	Default Alert	Clear
	C430-RP18020	AUTOMATIC RP	Settlement	25/11/2015 08:00	-7.5	Clear	Clear
	C430-RP18021	AUTOMATIC RP	Settlement	23/09/2013 12:00	-4.5	Clear	Clear
	C430-RP18031	AUTOMATIC RP	Settlement	25/11/2015 07:00	-0.4	Clear	Clear
	C430-RP18032	AUTOMATIC RP	Settlement	25/11/2015 07:00	-2.3	Clear	Clear
	C430-RP18033	AUTOMATIC RP	Settlement	25/11/2015 07:00	-2.4	Clear	Clear
	C430-RP18034	AUTOMATIC RP	Settlement	25/11/2015 07:00	-1.9	Clear	Clear
	C430-RP18035	AUTOMATIC RP	Settlement	-	-	-	-
	C430-RP18036	AUTOMATIC RP	Settlement	25/11/2015 07:00	-2	Clear	Clear
	C430-RP18037	AUTOMATIC RP	Settlement	25/11/2015 07:00	-1.2	Clear	Clear
	C430-RP18038	AUTOMATIC RP	Settlement	25/11/2015 07:00	-1	Clear	Clear
	C430-RP18039	AUTOMATIC RP	Settlement	25/11/2015 07:00	-3	Clear	Clear
	C430-RP18040	AUTOMATIC RP	Settlement	07/12/2013 08:00	-2.4	Clear	Clear
	C430-RP18041	AUTOMATIC RP	Settlement	06/01/2014 06:00	-3.7	Clear	Clear
	C430-RP18042	AUTOMATIC RP	Settlement	04/06/2013 18:00	-0.5	Clear	Clear
	C430-RP18043	AUTOMATIC RP	Settlement	02/03/2014 16:00	-3.2	Clear	Clear
	C430-RP18044	AUTOMATIC RP	Settlement	05/03/2014 04:00	-9.8	Clear	Clear
	C430-RP18045	AUTOMATIC RP	Settlement	21/10/2014 06:00	-4.5	Clear	Clear
C430-RP18046	AUTOMATIC RP	Settlement	05/08/2014 20:00	-7.6	Clear	Clear	
C430-RP18048	AUTOMATIC RP	Settlement	03/03/2014 10:00	-3.5	Clear	Clear	
C430-RP18049	AUTOMATIC RP	Settlement	24/01/2014 10:00	-2.7	Clear	Clear	
C430-RP18050	AUTOMATIC RP	Settlement	23/09/2013 14:00	-2.2	Clear	Clear	

Table 3 – Default Alerts breached by the prisms read by ATS53.

C.3 Significant issues with the Instrumentation

Prisms C430-RP18014, 18016, 18017 and 18035 installed on the 36-43 Cowcross St were never read by C435 because of the lack of line of sight from any ATS.

Movement was recorded in July 2014 by instrument installed on the 36-43 Cowcross St building as result of external refurbishment works carried out by others (refurbishment in the station) and not because of any Crossrail activity in the area.

C.4 Residual Risks

The rate of settlement for all instrumentation within this report has been analysed and in all cases the rate is less than 2mm/year.

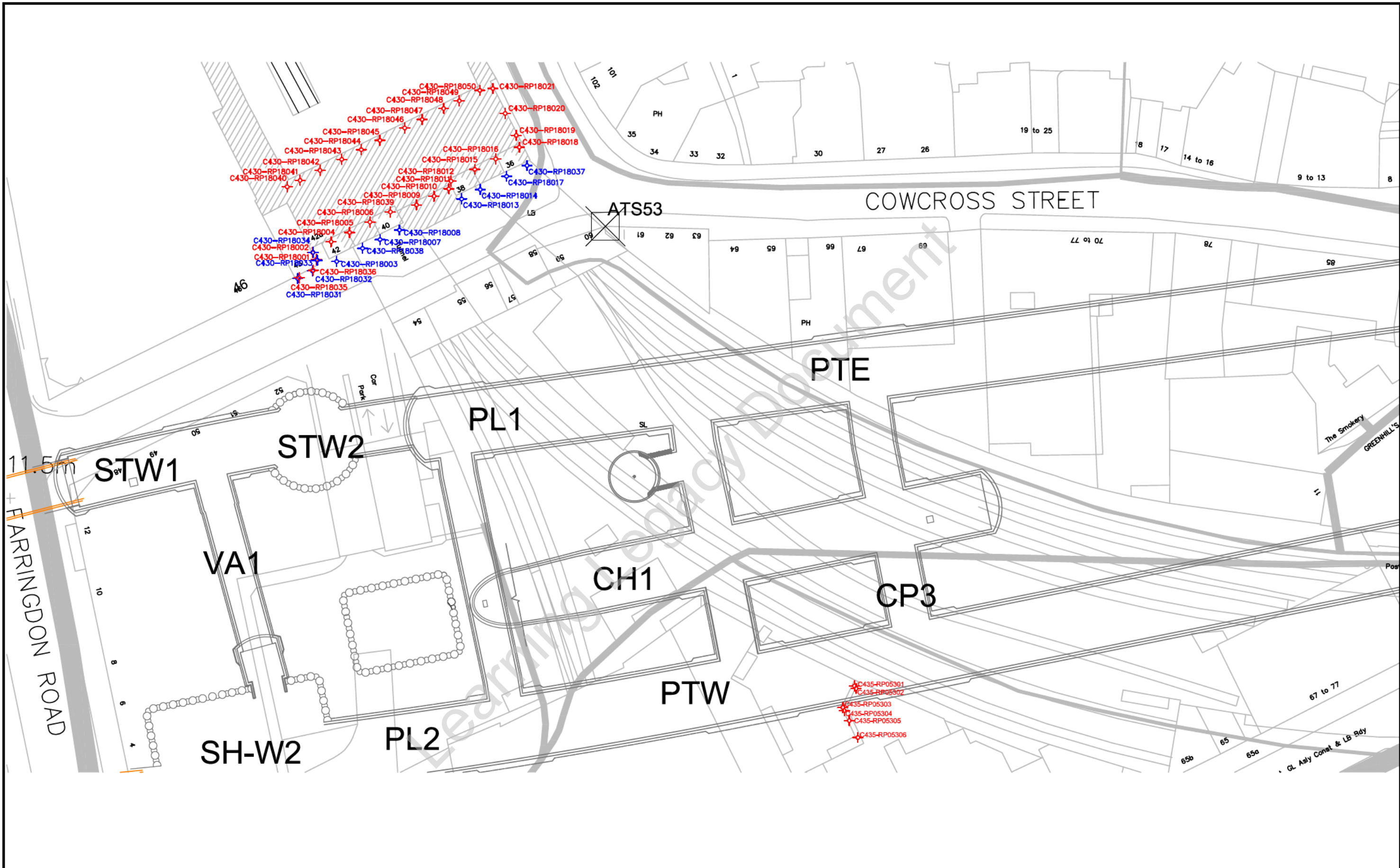
D. CONCLUSIONS

No triggers breached, monitoring stable. No residual risks remain. Long term monitoring to be completed by Crossrail.

Learning Legacy Document

APPENDIX A: DRAWINGS

Learning Legacy Document



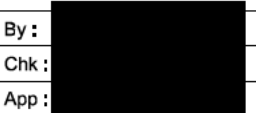
Rev.	Date	Description	By	Chkd	App	Auth

Notes:





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Contract : BORED TUNNELS (ALIGNMENT AND TRACK)
 Originator : OVE ARUP & PARTNERS LIMITED
 Location : CROSSRAIL GENERAL
 Title : 3D TARGETS INSTALLED FOR FARRINGDON STATION
 Drg No : C435-BFK-C2-DWG-M123-50045
 Rev : Sult : Auth : 

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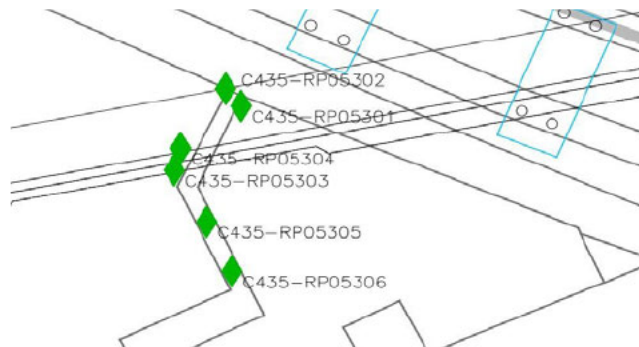
APPENDIX B: GRAPHS

Learning Legacy Document

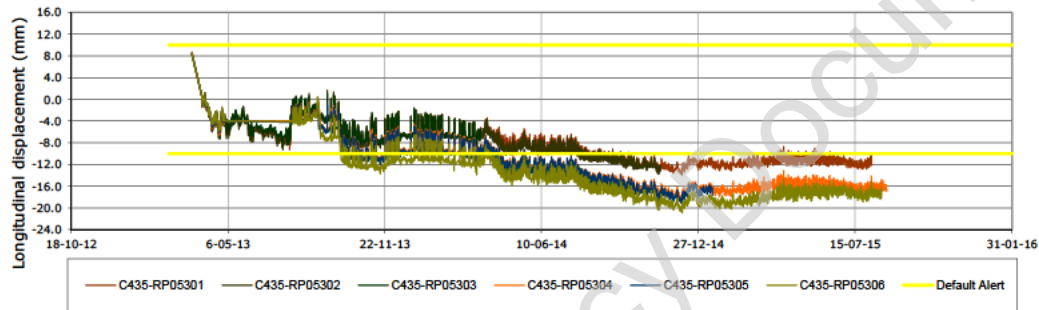


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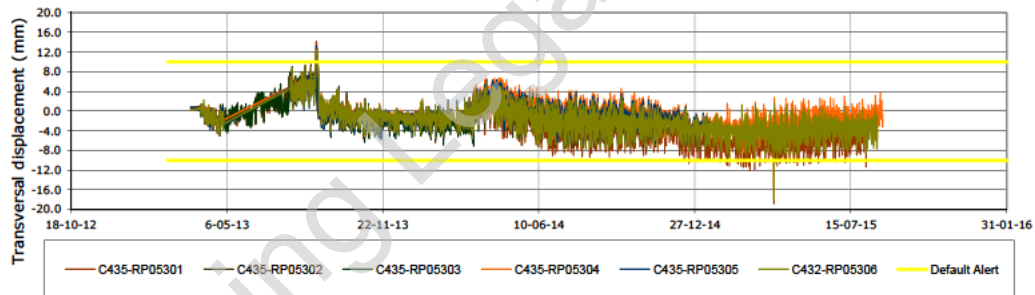
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 AREA Farringdon Station
 DEVICE 3D Target



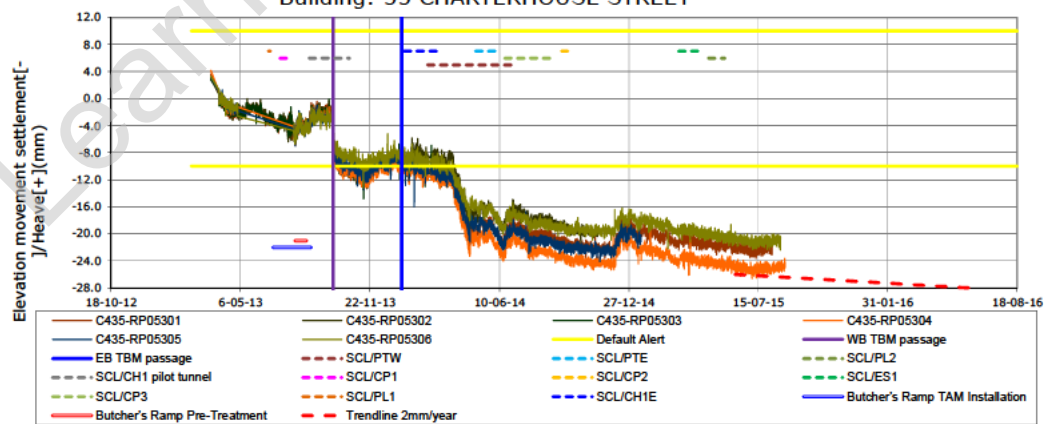
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Building: 55 CHARTERHOUSE STREET

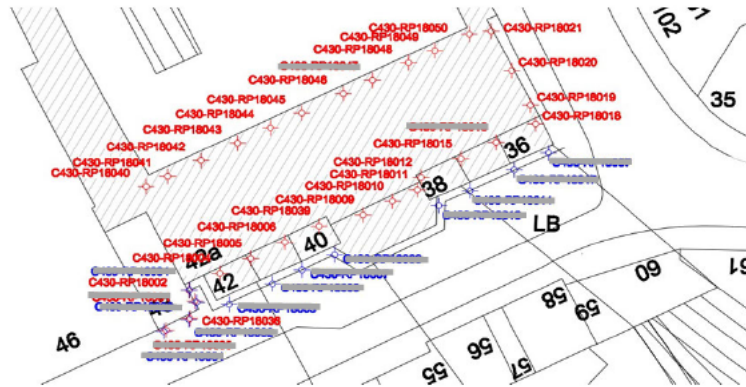


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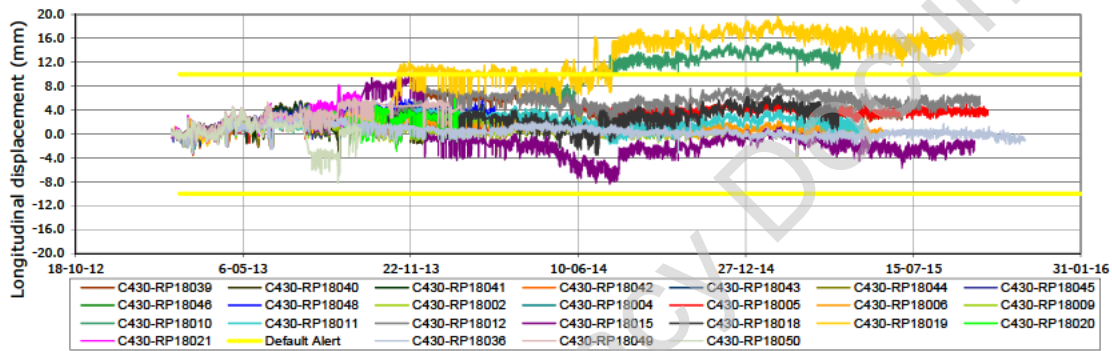


REMARKS

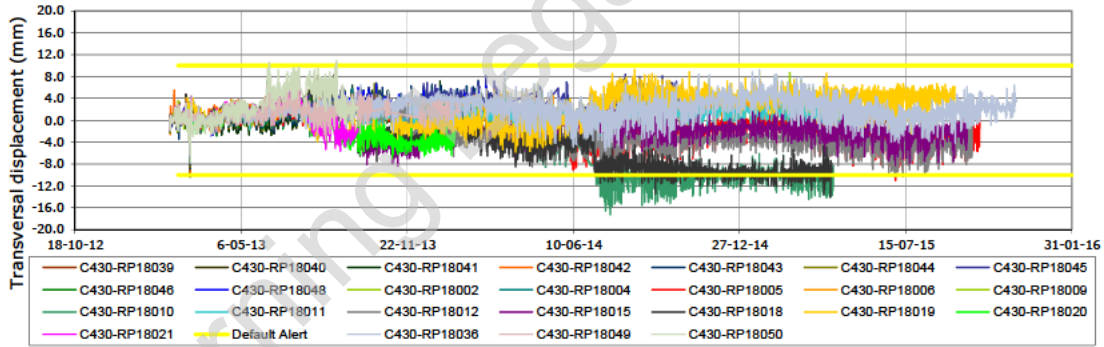
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 AREA Farringdon Station
 DEVICE 3D Target



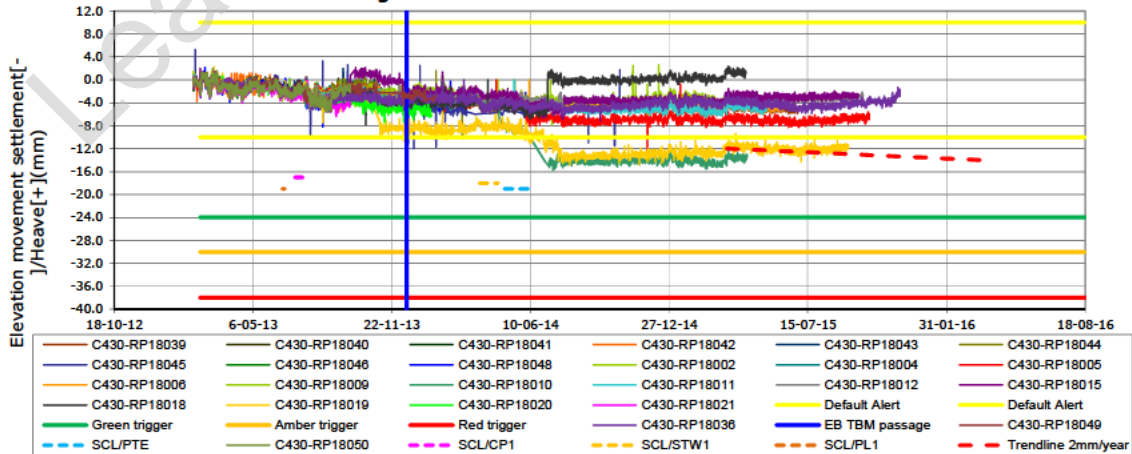
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Building: 36-43 COWCROSS STREET ROOF



Building: 36-43 COWCROSS STREET ROOF

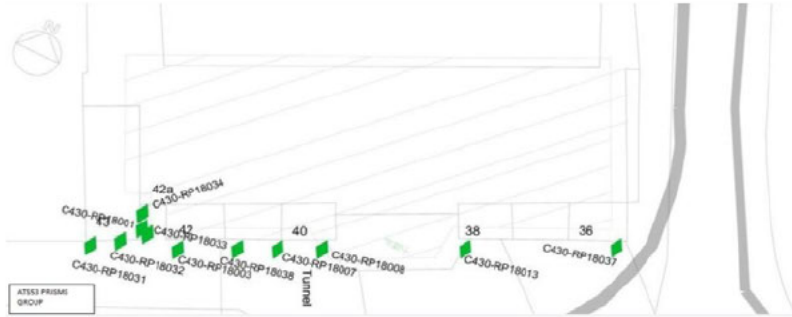


REMARKS The jumps in the readings in some prisms was caused by the refurbishment works carried out in Farringdon Station.

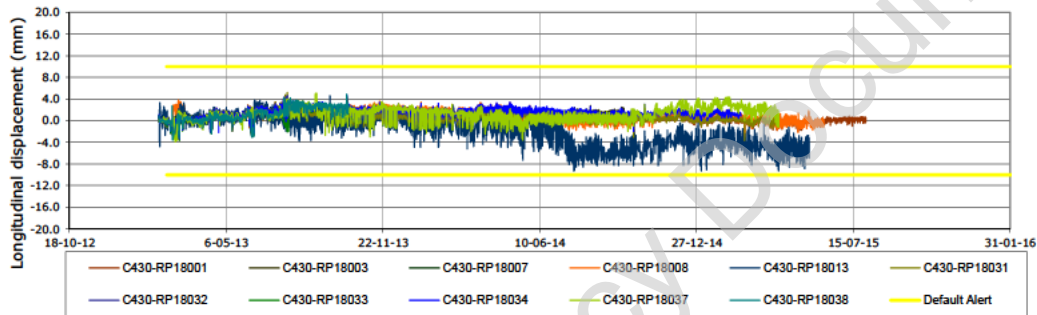


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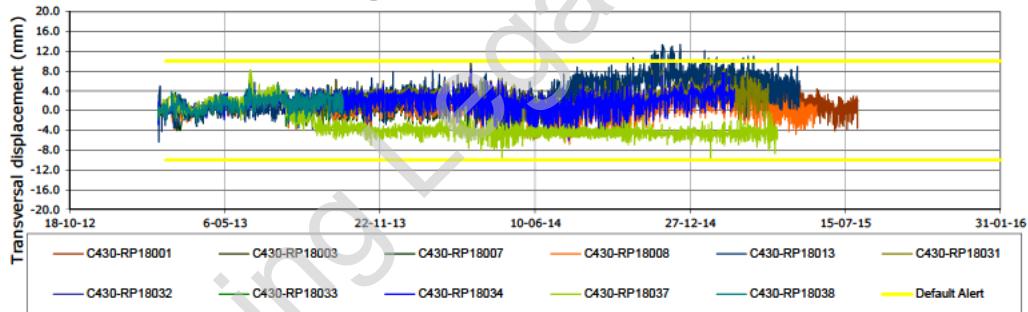
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 AREA Farringdon Station
 DEVICE 3D Target



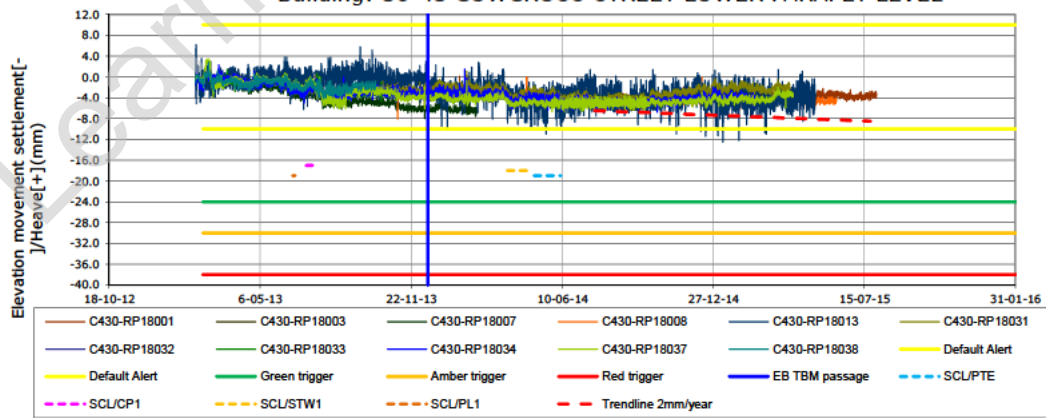
Building: 36-43 COWCROSS STREET LOWER PARAPET LEVEL



Building: 36-43 COWCROSS STREET LOWER PARAPET LEVEL



Building: 36-43 COWCROSS STREET LOWER PARAPET LEVEL



REMARKS

[Empty box for remarks]

APPENDIX C: GLOSSARY

- ATS Automatic Total Station.
- CH Concourse Hall.
- CP Cross Passages.
- EB Eastbound.
- ES Escalator Shaft.
- PL Platform Link
- PTE Platform Tunnel East.
- PTW Platform Tunnel West.
- RTE Running Tunnel East.
- STW Stub Tunnel West.
- TaM Tube a Manchette.
- TBM Tunnel Boring Machine.
- VA Ventilation Adit.
- WB Westbound.
- WTH Western Ticket Hall.
- WTH-SHW2 West Ticket Hall-Shaft West 2

Learning Legacy Document