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Work Type: I&M
Originator Company: BFK

C435 Farringdon Main Station

CRL Lead reviewer: [Redacted]
CRL Reviewer: [Redacted]

Monitoring Close Out Report – Inground Monitoring Section A

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Supplier Document Number: N/A

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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"/>
					<input type="checkbox"/>
					<input type="checkbox"/>

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

3. Acceptance by Crossrail:

[Redacted]
25/08/2015

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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 2.

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 In-ground Monitoring Section A, consisting of 3No Inclinometers and 2No Extensometers and 1No Piezometer located in the Farringdon Road. See table 1 below with details.

Instrument	Depth (m)	Northing's (m)	Easting's (m)	Elevation (m)	Description
C435-IM00015	38	81865.22	36513.87	111.71	Manual inclinometer
C435-IM00016	37.5	81879.69	36508.80	111.31	Manual inclinometer
C435-IM00017	37.5	81884.81	36476.64	111.09	Manual inclinometer
C435-IM00018	37	81888.76	36457.12	111.16	Inclinometer in-place
C435-XR01000	20	81866.95	36509.97	111.31	Manual extensometer
C435-XR02000	14	81898.61	36492.20	105.53	Manual extensometer
C435-XR03000	12.5	81901.40	36468.31	105.50	Manual extensometer
C435-PV13001	27.5	81909.08	36512.86	105.67	Piezometer

Table 1: Details In-Ground monitoring devices Section A.

The piezometer C435-PV13001 was grouted just after the drilling because it was completely dry.

The inclinometers, extensometers and piezometer installed on the Section A are shown in the following documents:

Drawings:

- C122-OVE-C2-DDA-CR001_Z-31531
- C122-OVE-C2-DDA-CR001_Z-31534

Installation Reports:

- C435-BFK-C2-RGN-M123-50990
- C435-BFK-C2-RGN-M123-51004
- C435-BFK-C2-RGN-M123-50930
- C435-BFK-C2-RGN-M123-50929
- C435-BFK-C2-RGN-M123-50987
- C435-BFK-C2-RGN-M123-50044
- C435-BFK-C2-RGN-M123-50931
- C435-BFK-C2-RGN-M123-51004
- C435-BFK-C2-RGN-M123-50038

B.2 Location of the Instruments

The instruments described in Section B are located in Farrington Road and WTH site. In the Appendix A is included the drawing with the location of instruments. See Figure 1 below with location Section A.

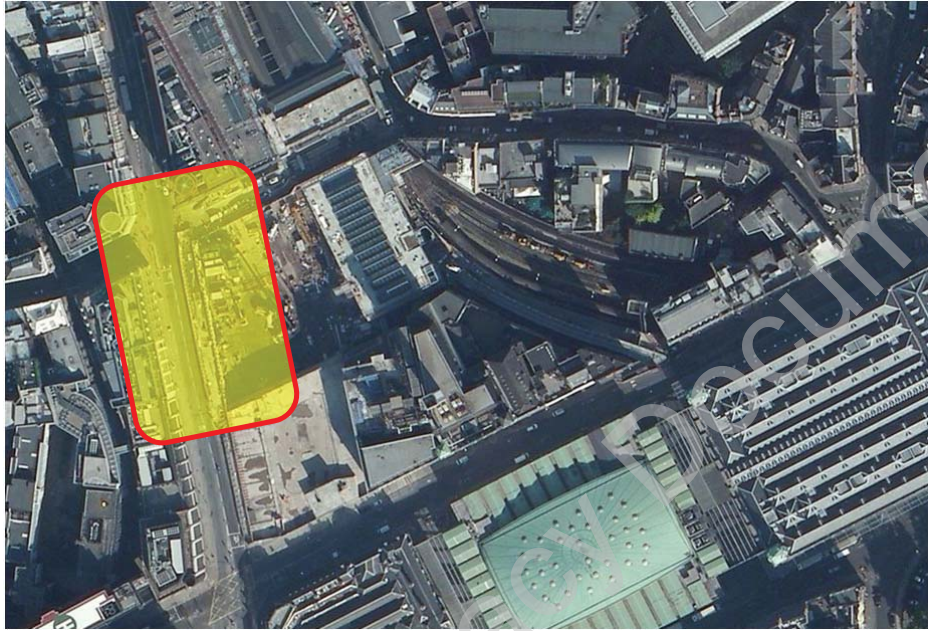


Figure 1 – Map showing the Location of Section A.

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 tunneling works. In all cases, these comprise of the passage of a TBMs (C300) and a platform tunnel enlargement.

Activity	Start Date	End Date
WB TBM passage	09/09/2013	17/09/2013
EB TBM passage	14/12/2013	23/12/2013
STW3 enlargement	05/01/2014	12/01/2014
STW1 enlargement	26/03/2014	24/04/2014
SHW2 excavation works (to level -8 & sump)	11/04/2014	09/05/2014

C.1.2 Resulting Movements

The monitoring data for the extensometer at street level located directly above the crown of the EB TBM (C435-XR01000) is shown in Appendix B. The passage of the EB TBM is shown to have caused a maximum settlement of 7mm, recorded on the extensometer rod at 17m below

street level (around 1m above the crown of the tunnel). During the enlargement of STW1 no significant settlement was observed on the extensometer

The monitoring data for the extensometer within the WTH site located directly above the crown of the WB TBM tunnel (C435-XR03000) is presented in Appendix B. The passage of the WB TBM is shown to have caused a maximum settlement of 7mm, recorded on the extensometer rod at 12m below surface level (around 3.5m above the crown of the tunnel). The settlement is shown to increase with depth from the surface, as expected, with only around 2mm recorded at 2m depth. During the enlargement of STW3 additional settlement of approximately 3mm was recorded on the extensometer rod at 12m depth.

The monitoring data for the extensometer within the WTH site located close WB TBM tunnel (C435-XR02000) is shown in Appendix B. The passage of the WB TBM is shown to have caused a maximum settlement of 9mm, recorded on the extensometer rod at 12m below surface level (around 3.5m above the crown of the tunnel). The settlement is shown to increase with depth from the surface, as expected, with only around 6mm recorded at 2m depth. During the enlargement of STW3 additional settlement of approximately 3mm was recorded on the extensometer rod at 12m depth.

The monitoring data for the inclinometers located directly north and south of the EB TBM tunnel (C435-IM00015 and C435-IM00016) are presented in Appendix B. The results obtained from these instruments do not show any conclusive movements from construction.

Inclinometer C435-IM00015 show 1-2mm due the TBM passage. During the STW1, this inclinometer show another 2mm in A direction and 1.5mm maximum in B- direction. The total/maximum horizontal movement in inclinometer C435-IM00015 is 3.6mm in A+ direction and 1.83mm in B- direction.

Inclinometer C435-IM00016 shows a kink at the top in the graphs. The reason for this kink is a combination of issues. One of the issues is the top of the inclinometer is within made ground, this is made up of compacted type 1 which was used to backfill the Farringdon Road Water main replacement excavations, because this fill was place at the time the inclinometer was installed it is possible that the fill, reservation tube and inclinometer casing have move.

The monitor data for the inclinometer located directly north of the WB TBM tunnel (C435-IM00017) is presented in Appendix B. The passage of the WB TBM tunnel is shown to have caused a maximum horizontal displacement of 9mm in the same level than tunnel, as expected. There is a reading taken on 15-10-13 that show maximum -15mm in B direction is a bad reading. During the enlargement of STW3 this inclinometer shows 4mm horizontal displacement, less than expected.

The monitor data for the automatic inclinometer located directly south of the WB TBM tunnel (C435-IE00018) is presented in Appendix B. The results obtained from this inclinometer do not show any conclusive movements from construction.

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. No triggers have been defined for the instruments included in this report.

C.3 Significant Issues with the Instrumentation

The piezometer C435-PV13001 was grouted just after the drilling because it was completely dry, therefore there are not any data for this device.

C.4 Residual Risks

The rates of residual settlement for the Extensometers and horizontal movement for the inclinometers have been determined and in all cases these rates are less than 2mm/year.

D. CONCLUSIONS

Following the WB and EB TBMs passage, of the SCL enlargement of STW1 and STW3 and the excavation of shaft SH-W2, the maximum measured settlement in the Extensometers and horizontal displacement in the inclinometers remain less than the expected.

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

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APPENDIX A: DRAWINGS

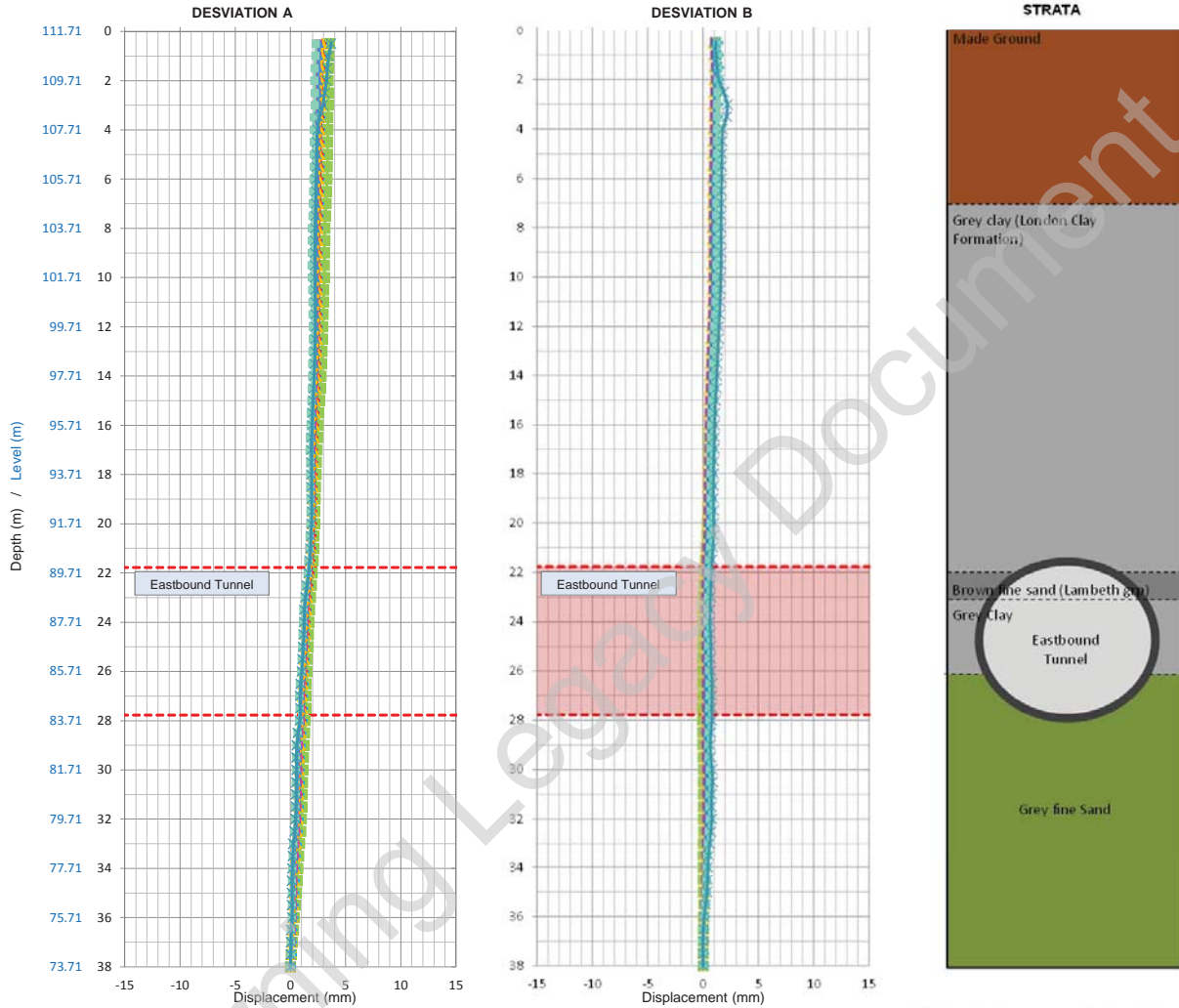
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APPENDIX B: GRAPHS

Learning Legacy Document

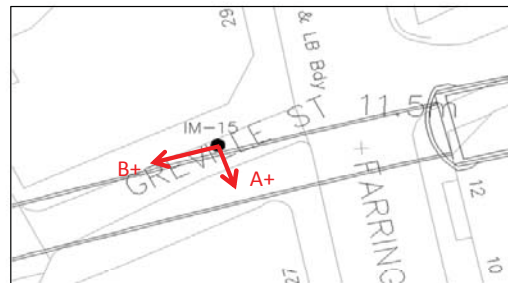
REPORT: MANUAL INCLINOMETER
LOCATION: FARRINGDON ROAD
DEVICE: Inclinometer C435-IM00015 - READINGS BEFORE AND AFTER EASTBOUND TBM PASSAGE

Eastbound TBM passage: 15/12/2013



MEASURING DATES

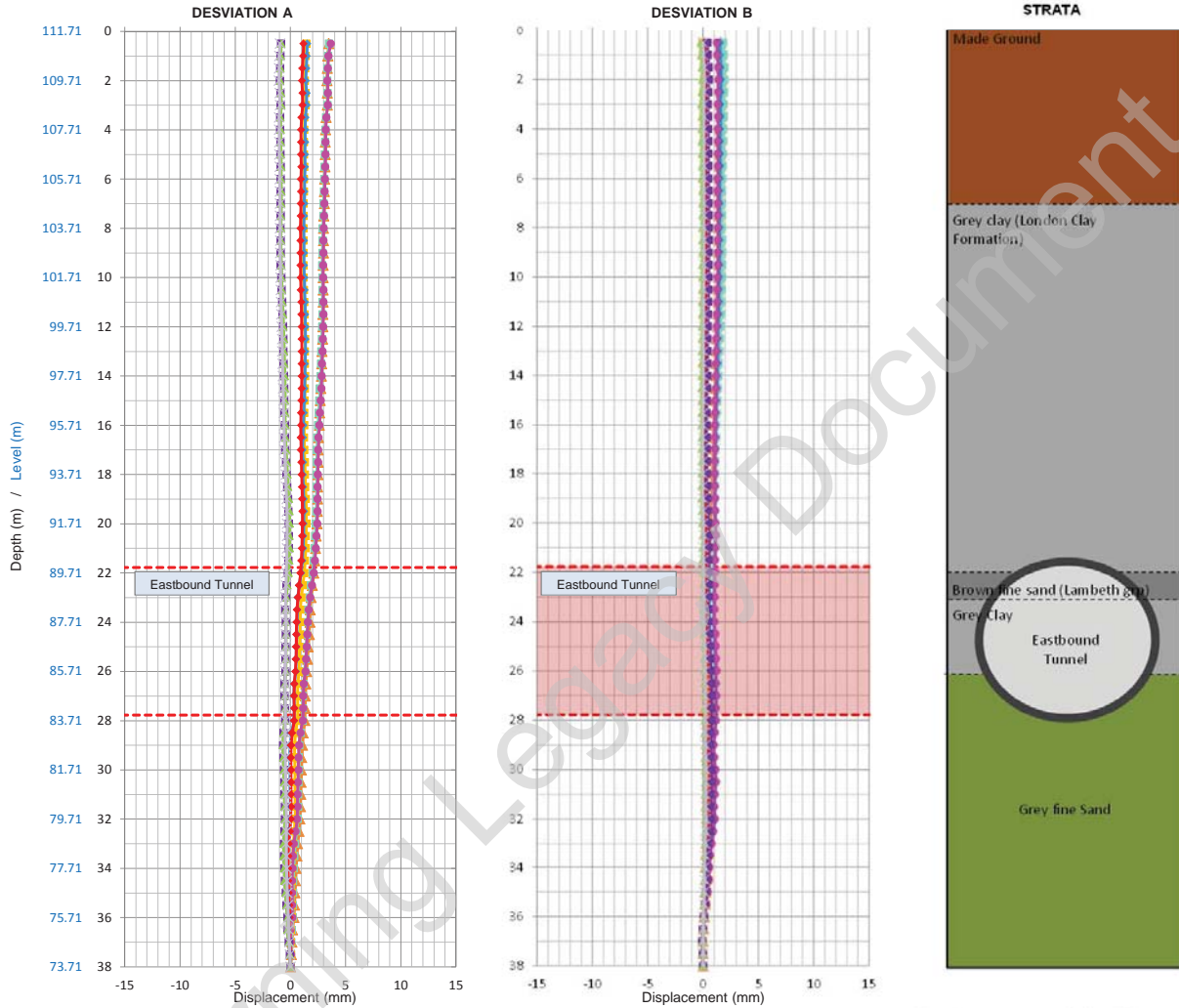
13-11-13 12-12-13 15-12-13 16-12-13 17-12-13 18-12-13 06-01-14 16-01-14



REMARKS:
 Readings before and after Eastbound TBM passage did not show any significant displacement, maybe 1-2mm.
 EB TBM passage on 15-12-2013

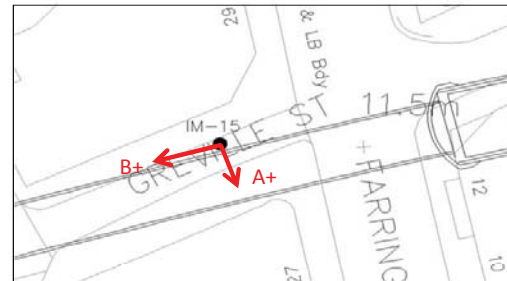
REPORT: MANUAL INCLINOMETER
LOCATION: FARRINGDON ROAD
DEVICE: Inclinometer C435-IM00015 - READINGS BEFORE AND AFTER STW1 ENLARGEMENT

STW1 Enlargement: 24/04/2014



MEASURING DATES

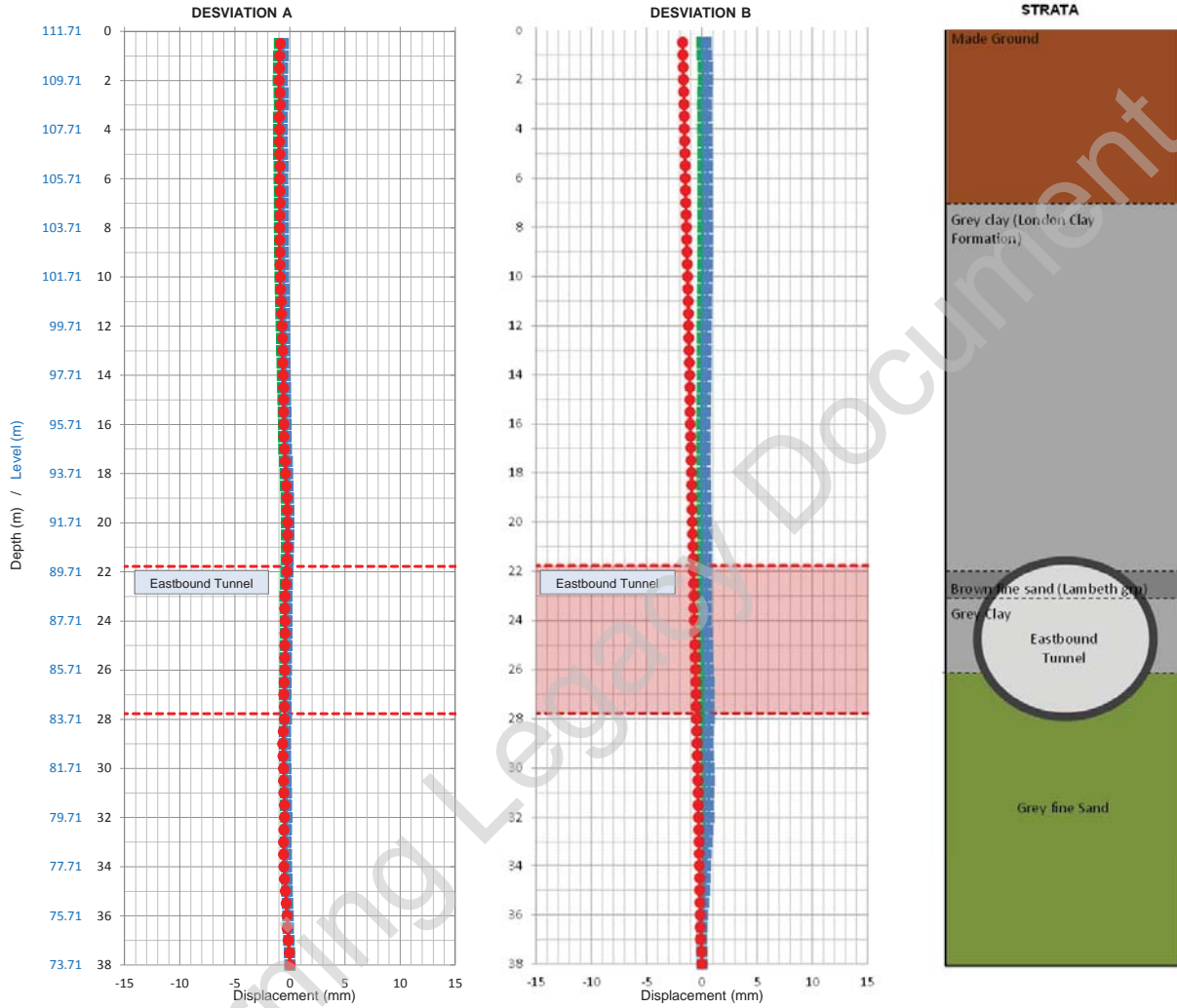
- 12-03-14
- 26-03-14
- 10-04-14
- 15-04-14
- 20-04-14
- 24-04-14
- 28-04-14
- 05-05-14
- 14-05-14



REMARKS:

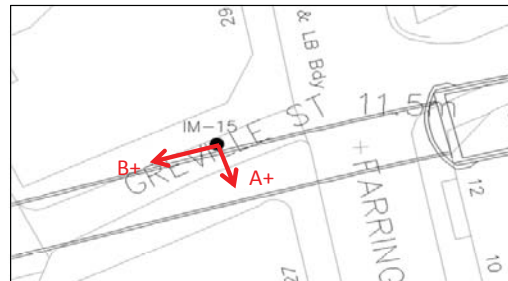
There is -2mm displacement on top during STW1 Enlargement works. There is 2mm maximum in B direction. STW1 start on 26-03-2014, and finish on 24-04-2014

REPORT: MANUAL INCLINOMETER
LOCATION: FARRINGDON ROAD
DEVICE: Inclinator C435-IM00015 - READINGS AFTER WORKS



MEASURING DATES

— 14-05-14
 — 21-05-14
 — 28-05-14

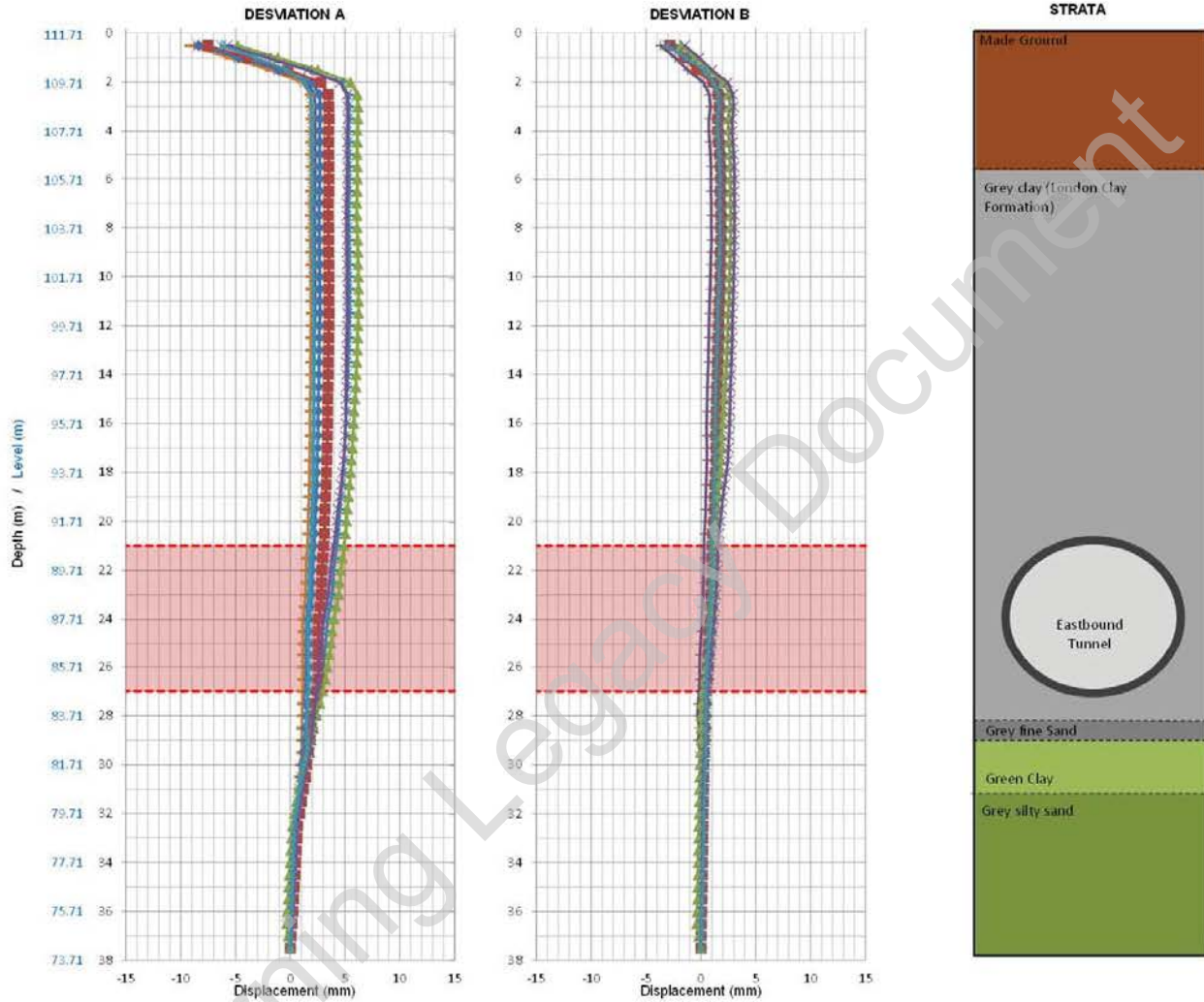


REMARKS:

Readings after works do not show appreciable horizontal displacements.

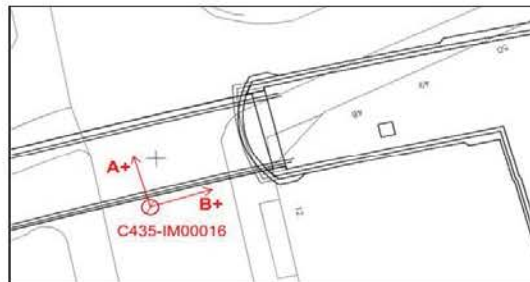
REPORT: MANUAL INCLINOMETER
LOCATION: FARRINGDON ROAD
DEVICE: Inclinator C435-IM00016 - READINGS BEFORE AND AFTER EASTBOUND TBM PASSAGE

Eastbound TBM passage: 15/12/2013



MEASURING DATES

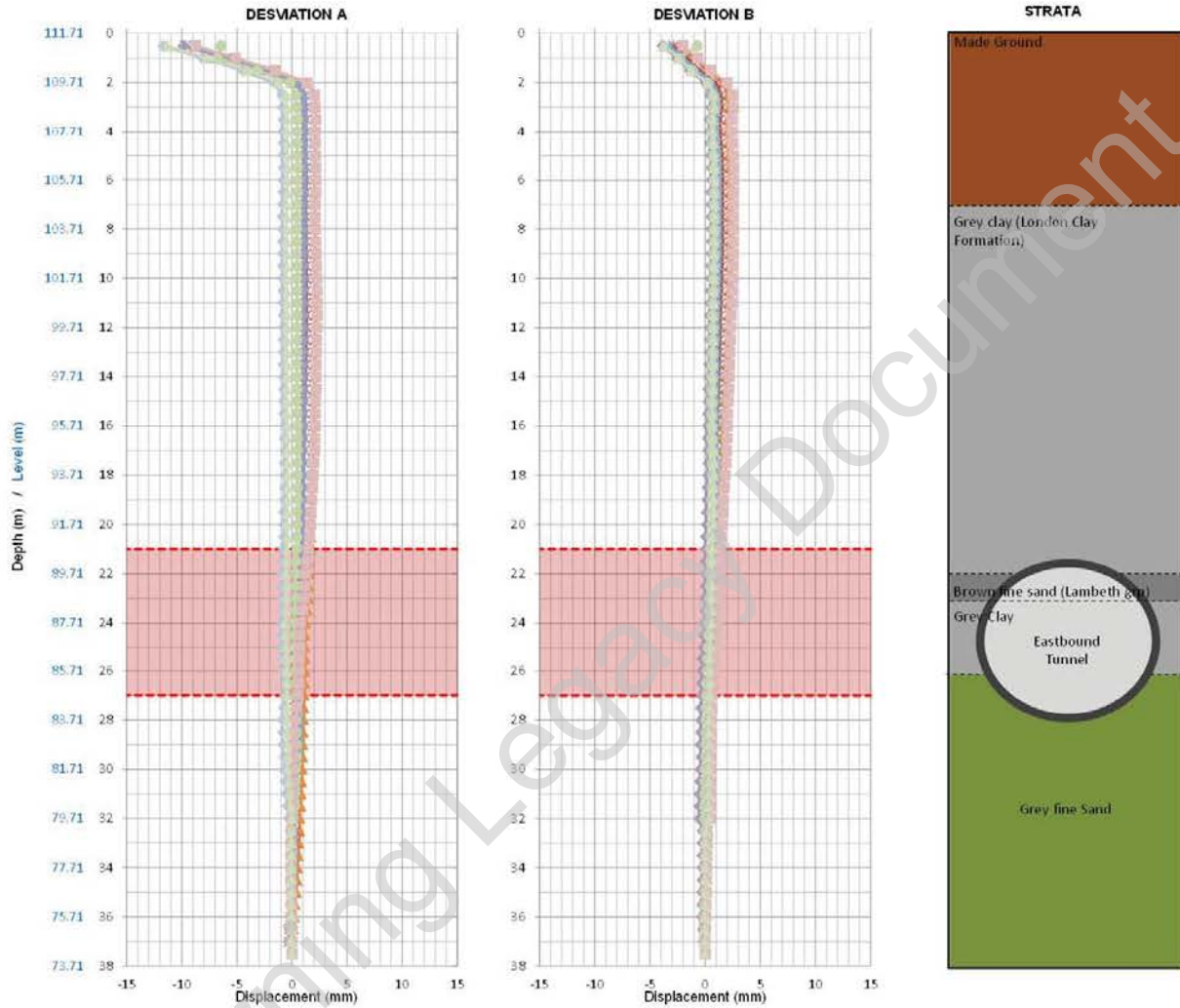
— 16-01-14 — 23-01-14 — 25-01-14 — 05-02-14 — 12-02-14 — 19-02-14 — 27-02-14 — 13-03-14



REMARKS:
 Readings before and after Eastbound TBM passage did not show any significant displacement.

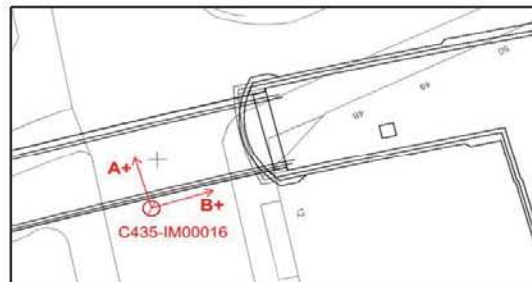
REPORT: MANUAL INCLINOMETER
LOCATION: FARRINGDON ROAD
DEVICE: Inclinometer C435-IM00016 - READINGS BEFORE AND AFTER STW1 ENLARGEMENT

STW1 Enlargement: 24/04/2014



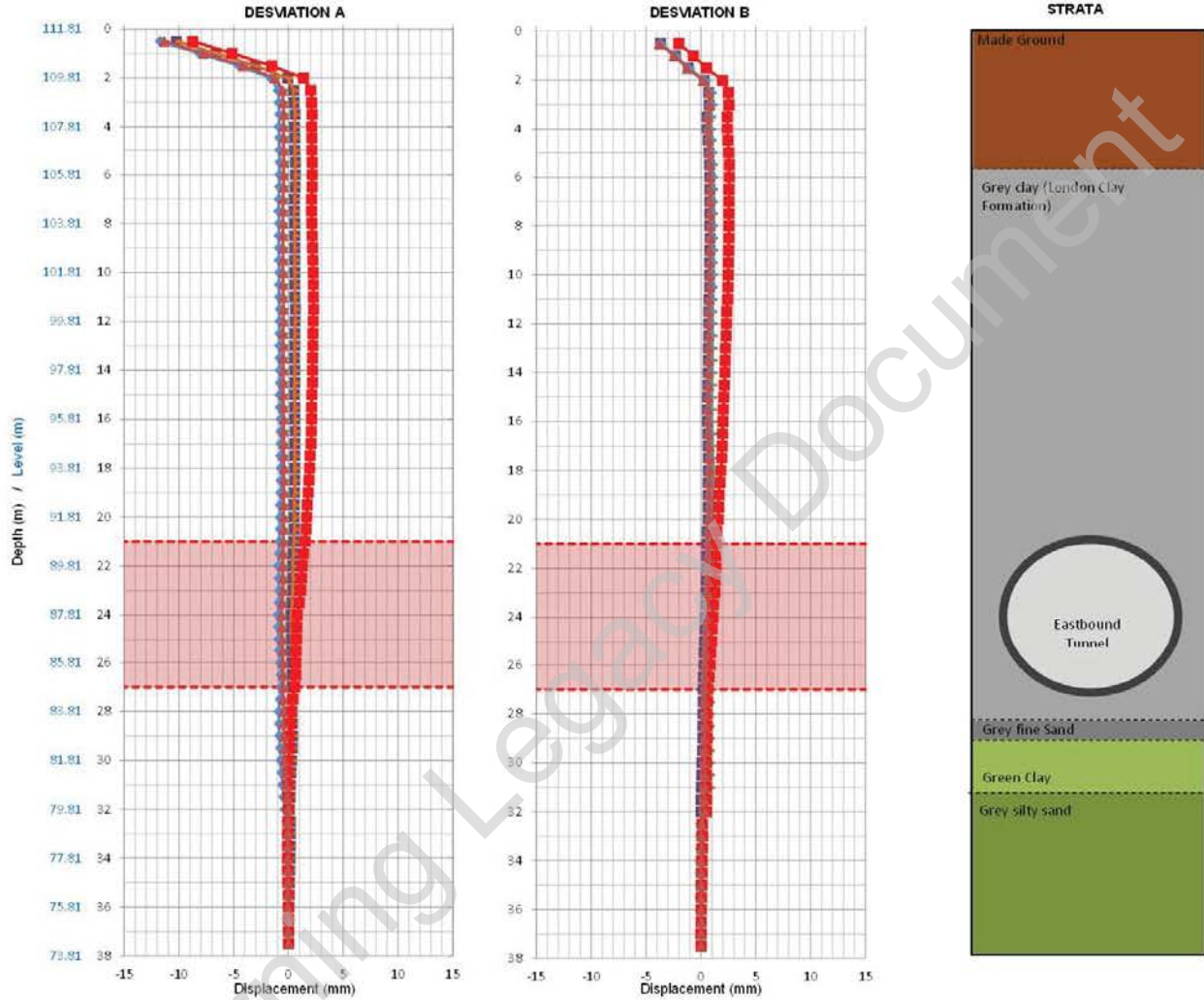
MEASURING DATES

28-02-14 02-04-14 10-01-14 19-04-14 21-04-14 14-05-14 21-05-14 28-05-14



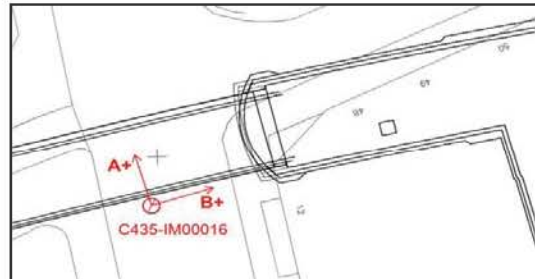
REMARKS:
 Readings during STW1 Enlargement works did not show any significant displacement.

REPORT: MANUAL INCLINOMETER
LOCATION: FARRINGDON ROAD
DEVICE: Inclinator C435-IM00016 - ALL READINGS



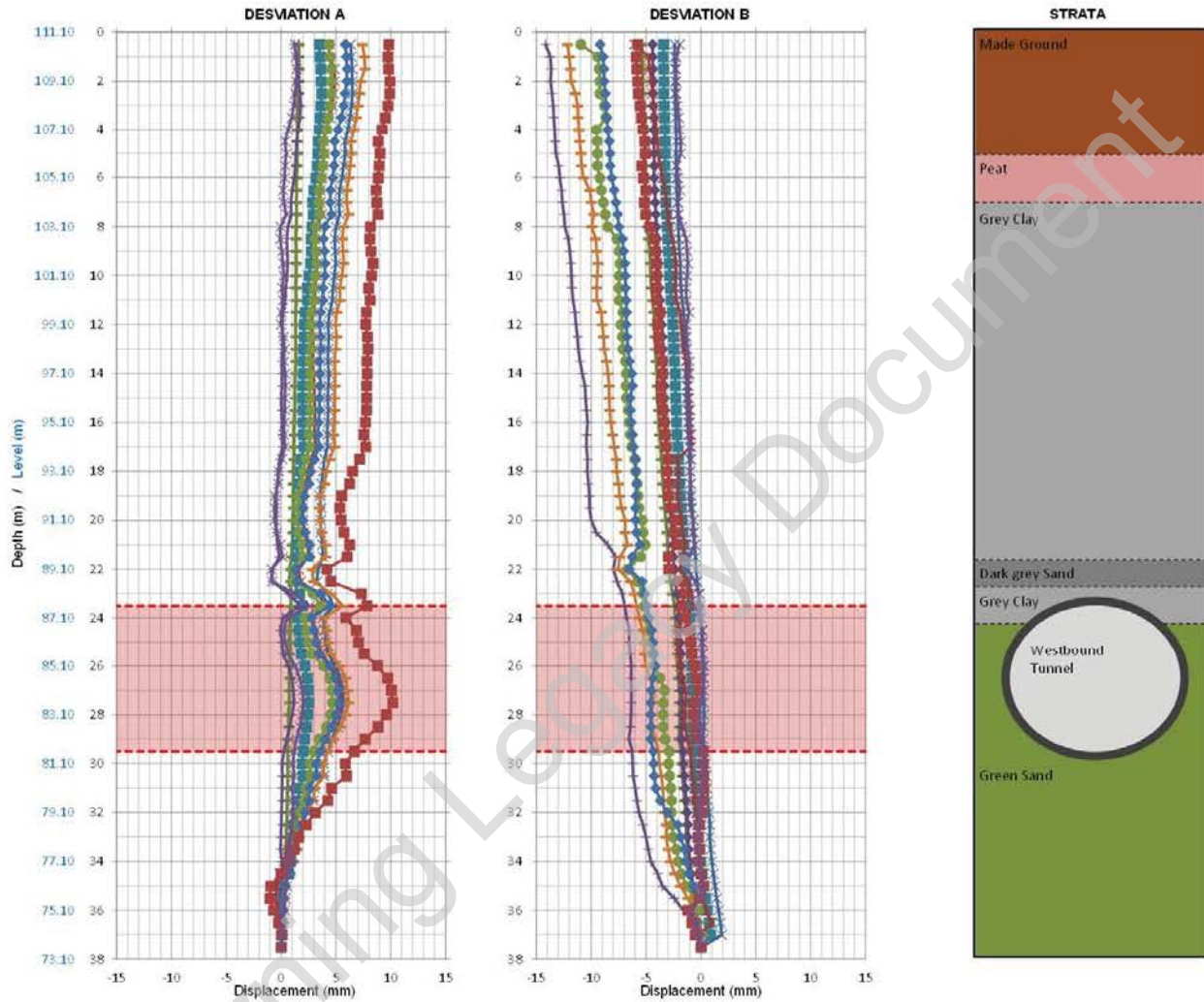
MEASURING DATES

— 25-04-14
 — 28-04-14
 — 05-05-14
 — 14-05-14
 — 21-05-14
 — 28-05-14



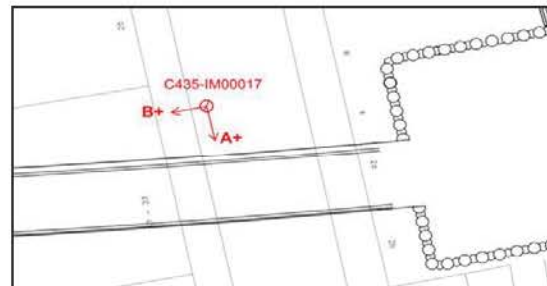
REMARKS:
 Readings after works do not show important horizontal displacements. 5mm displacement maximum on top.

REPORT: MANUAL INCLINOMETER
LOCATION: FARRINGDON ROAD
DEVICE: Inclinometer C435-IM00017 - READINGS BEFORE AND AFTER WESTBOUND TBM PASSAGE



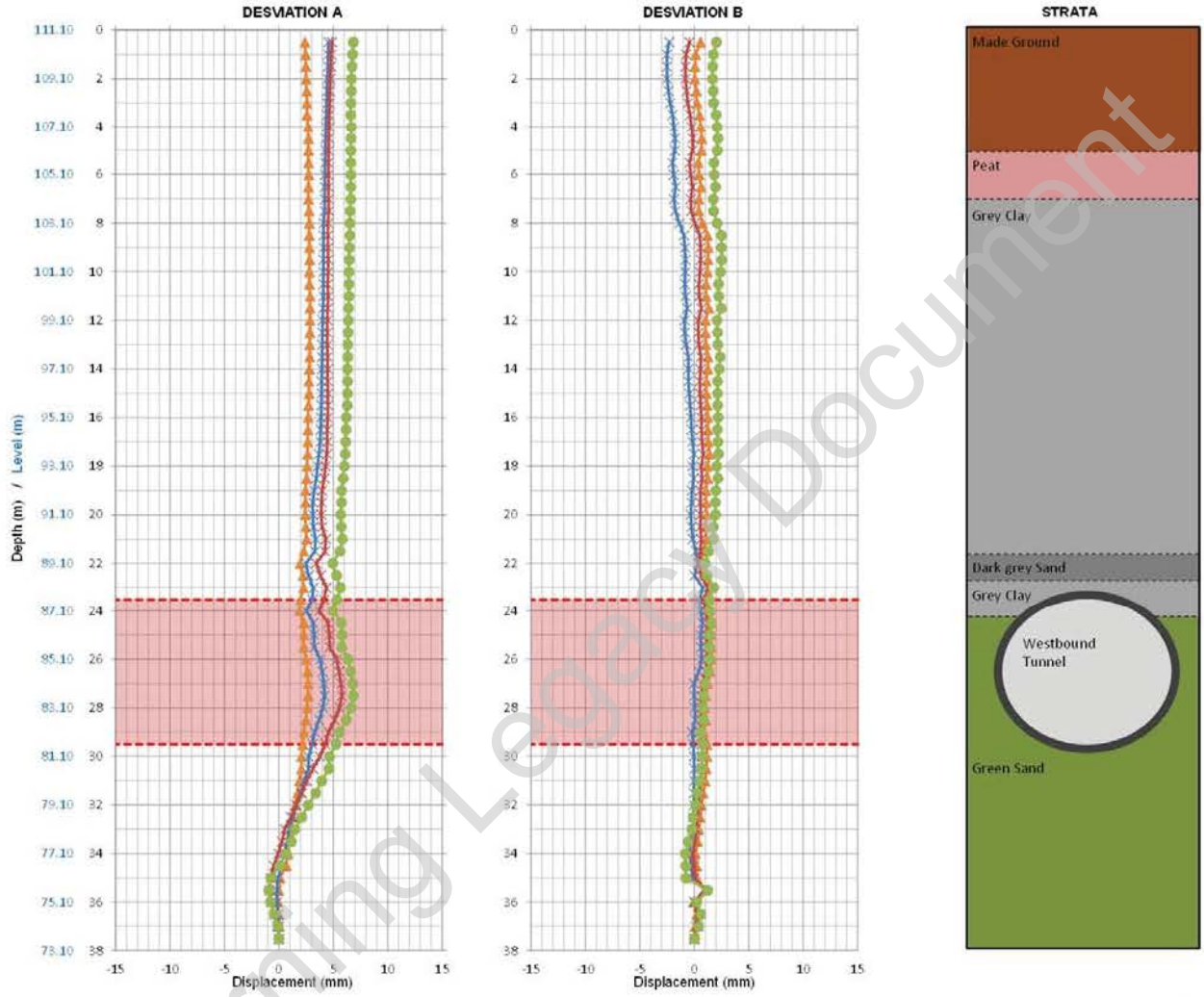
MEASURING DATES

- 27-08-13 — 05-09-13 — 10-09-13 — 11-09-13 — 12-09-13 — 13-09-13
- 14-09-13 — 15-09-13 — 16-09-13 — 17-09-13 — 20-09-13 — 02-10-13



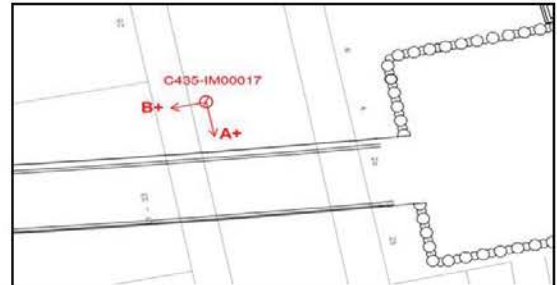
REMARKS:
 Readings before and after Westbound TBM passage showed 9mm horizontal displacement.

REPORT: MANUAL INCLINOMETER
LOCATION: FARRINGDON ROAD
DEVICE: Inclinometer C435-IM00017 - READINGS BEFORE AND AFTER STW3 ENLARGEMENT



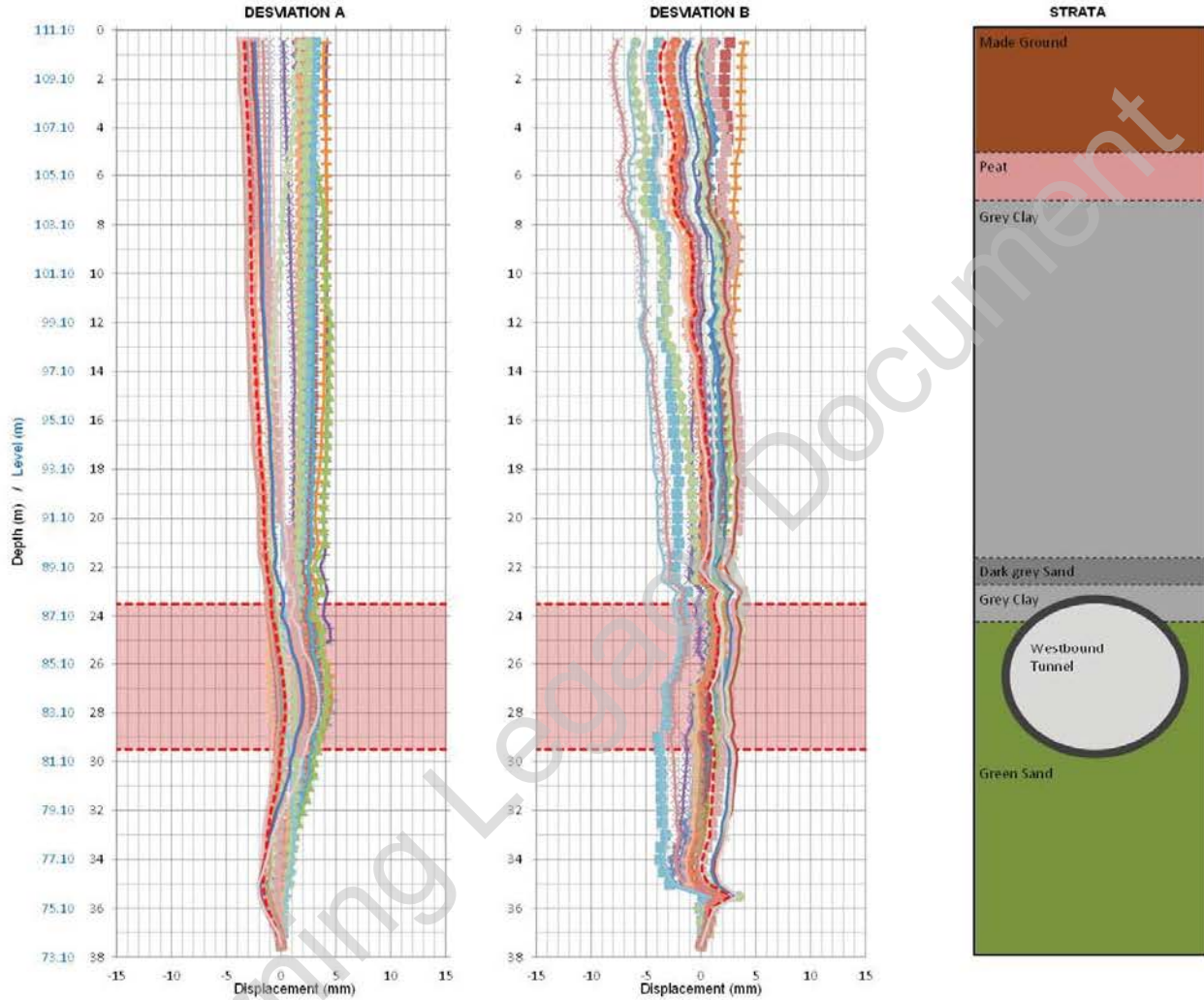
MEASURING DATES

- 18-12-13 (orange triangle)
- 06-01-14 (blue circle)
- 16-01-14 (red square)
- 24-01-14 (green diamond)



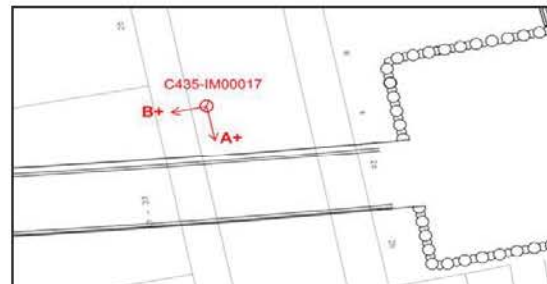
REMARKS:
 Readings before and after STW3 enlargement showed 4mm horizontal displacement.
 STW3 start on 05-01-2014

REPORT: MANUAL INCLINOMETER
LOCATION: FARRINGDON ROAD
DEVICE: Inclinometer C435-IM00017 - READINGS AFTER WORKS



MEASURING DATES

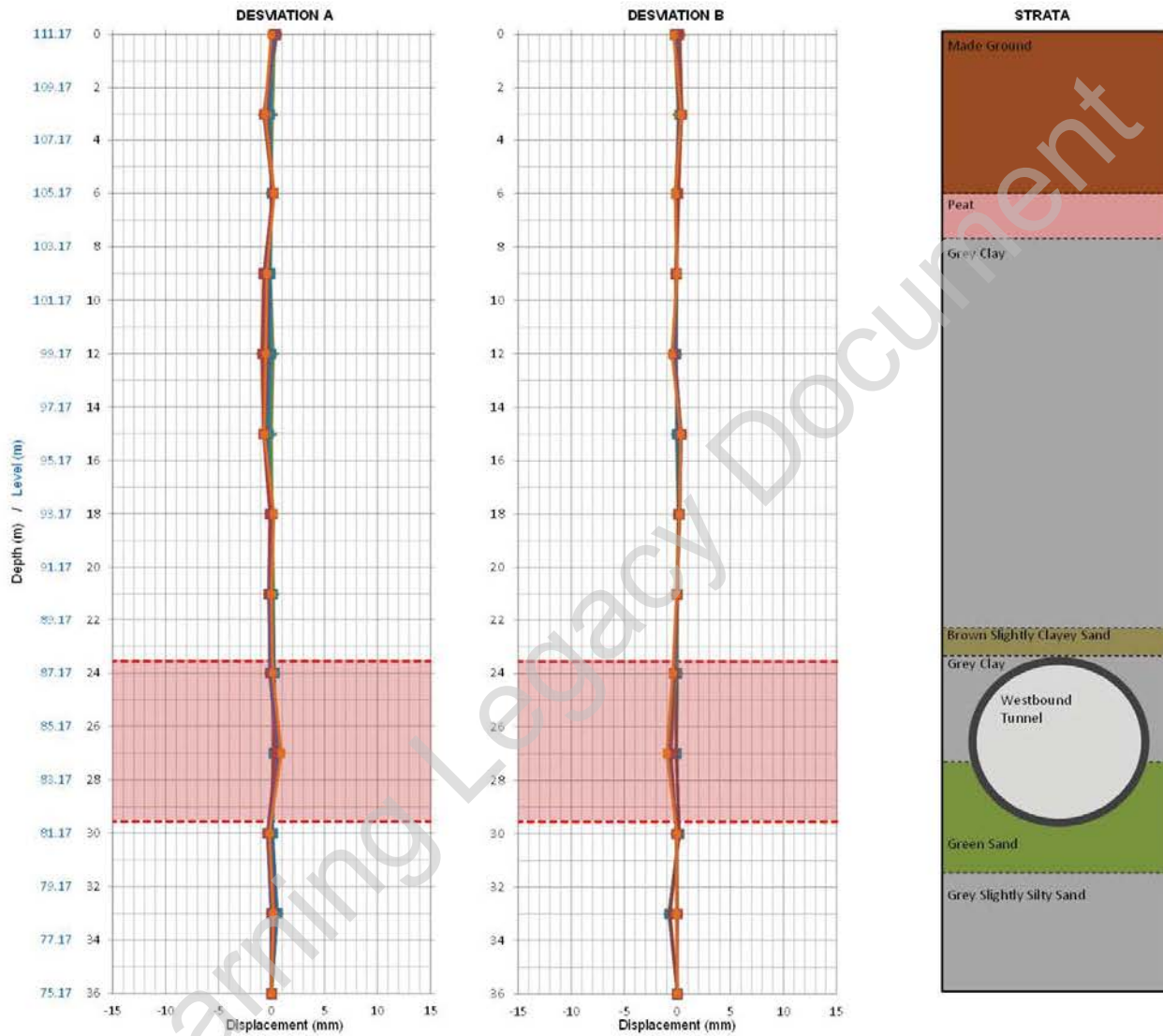
- | | | | | | |
|----------|----------|----------|----------|----------|----------|
| 29-01-14 | 05-02-14 | 12-02-14 | 20-02-14 | 27-02-14 | 19-03-14 |
| 14-03-14 | 26-03-14 | 02-04-14 | 04-04-14 | 11-04-14 | 14-04-14 |
| 15-04-14 | 16-04-14 | 17-04-14 | 18-04-14 | 20-04-14 | 21-04-14 |
| 23-04-14 | 24-04-14 | 28-04-14 | 29-04-14 | 30-04-14 | 01-05-14 |
| 02-05-14 | 05-05-14 | 28-05-14 | | | |



REMARKS:

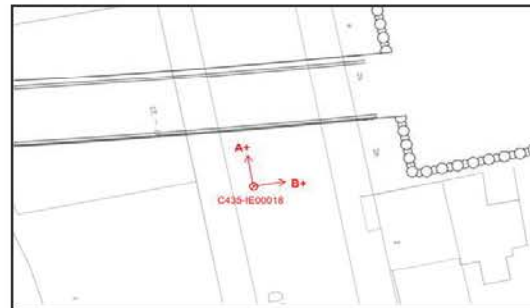
Readings after works do not show important horizontal displacements. 8mm displacement maximum on top.

REPORT: AUTOMATIC INCLINOMETER
LOCATION: FARRINGTON ROAD
DEVICE: Inclinator C435-IM00018 - READINGS BEFORE AND AFTER WESTBOUND TBM PASSAGE



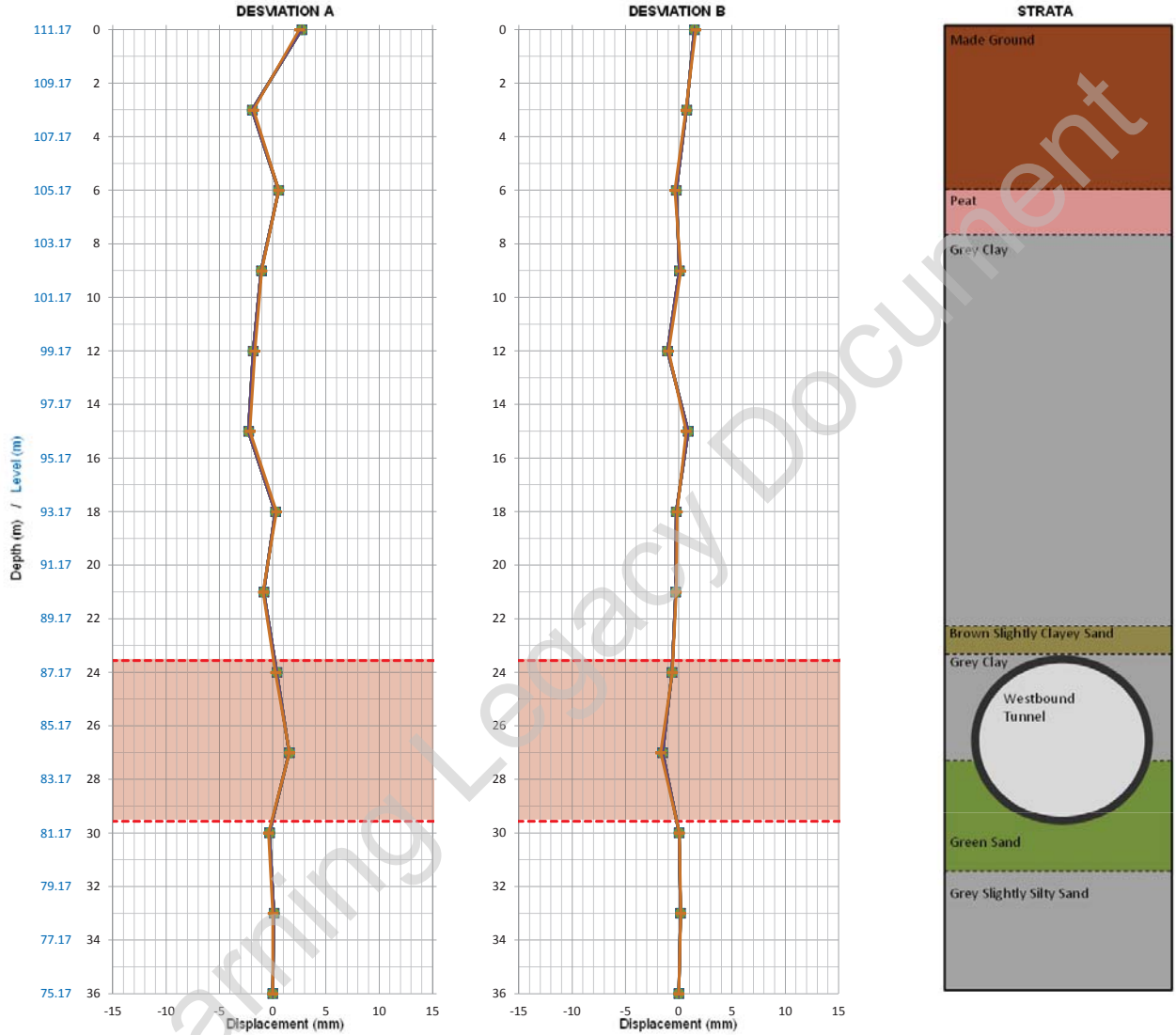
MEASURING DATES

- 01/09/2013
- 03/09/2013
- 05/09/2013
- 07/09/2013
- 09/09/2013
- 11/09/2013
- 13/09/2013
- 15/09/2013
- 17/09/2013
- 19/09/2013
- 21/09/2013
- 23/09/2013
- 25/09/2013



REMARKS:
 Readings before and after westbound TBM passage do not show appreciable horizontal displacement.

REPORT: AUTOMATIC INCLINOMETER
LOCATION: FARRINGTON ROAD
DEVICE: Inclinator C435-IM00018 - READINGS BEFORE AND AFTER STW3 ENLARGEMENT



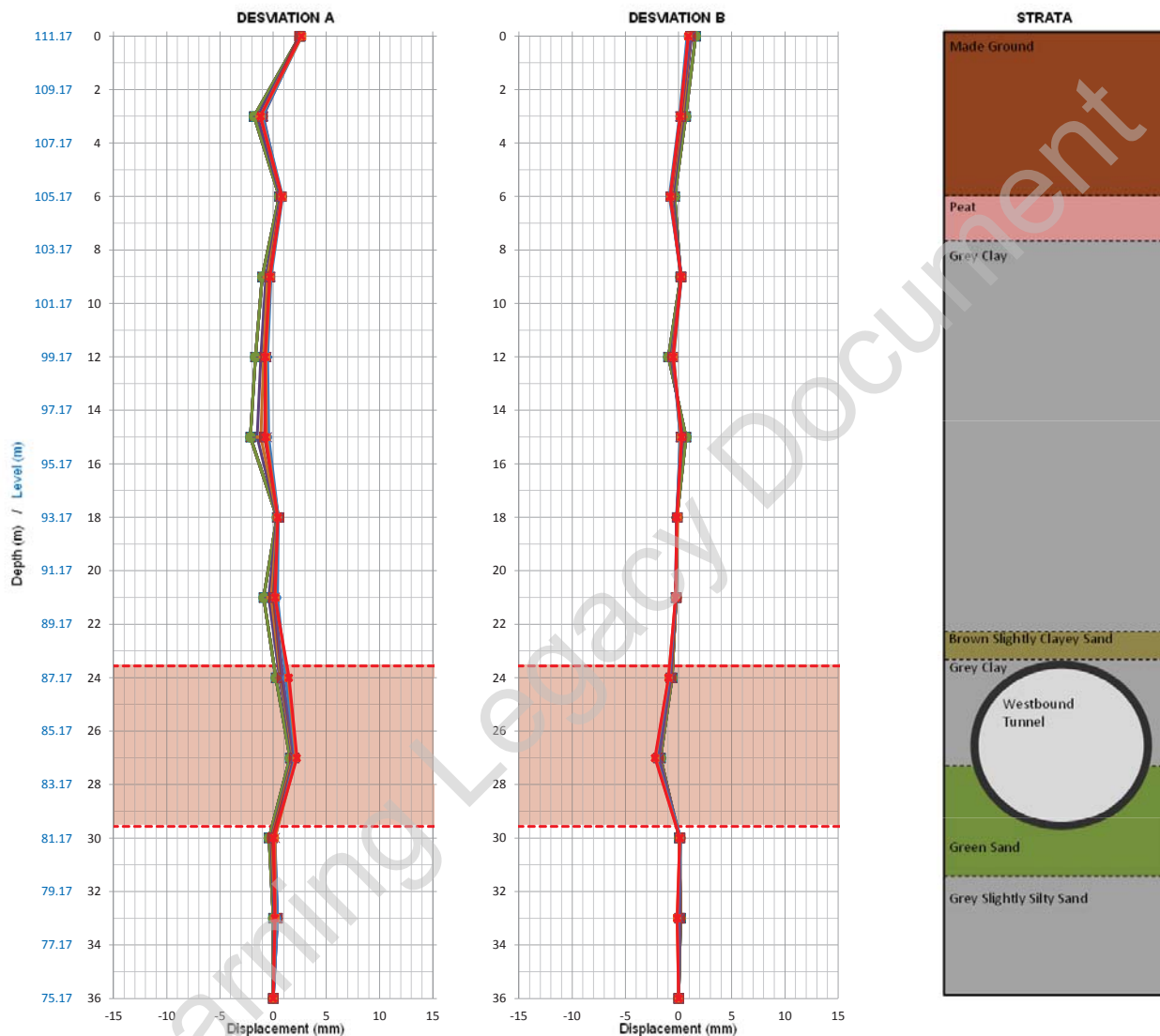
MEASURING DATES

- 01/01/2014
- 03/01/2014
- 05/01/2014
- 07/01/2014
- 09/01/2014
- 11/01/2014
- 13/01/2014
- 15/01/2014
- 17/01/2014



REMARKS:
 Readings before and after STW3 enlargement do not show any appreciable horizontal displacement.

REPORT: AUTOMATIC INCLINOMETER
LOCATION: FARRINGDON ROAD
DEVICE: Inclinator C435-IM00018 - READINGS BEFORE AND AFTER WESTBOUND TBM PASSAGE



MEASURING DATES

- 01/02/2014
- 15/02/2014
- 24/02/2014
- 15/03/2014
- 01/04/2014
- 15/04/2014
- 01/05/2014
- 15/05/2014
- 01/06/2014
- 15/06/2014
- 01/07/2014
- 15/07/2014
- 15/08/2014
- 01/09/2014
- 15/09/2014



REMARKS:
 Readings after works do not show appreciable horizontal displacement.



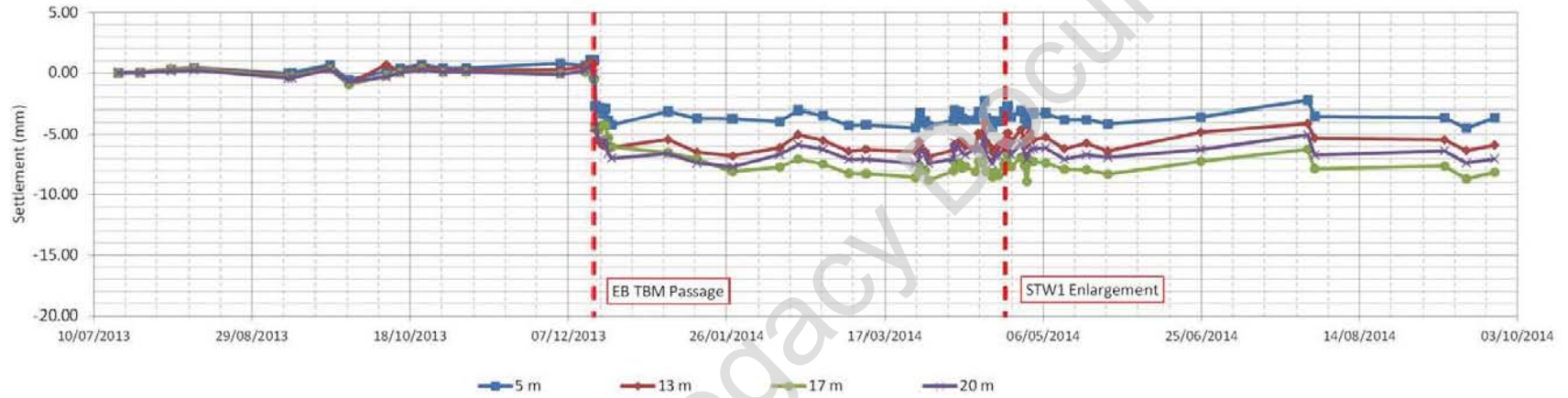
C435 FARRINGDON ROAD



GEOCISA UK

REPORT: Time Plot Levelling
AREA: Greville Street
DEVICE: Extensometer

EXTENSOMETER C435-XR01000



REMARKS:

The settlement rate after all works is less than 0,5mm/year, so extensometer data is stable.





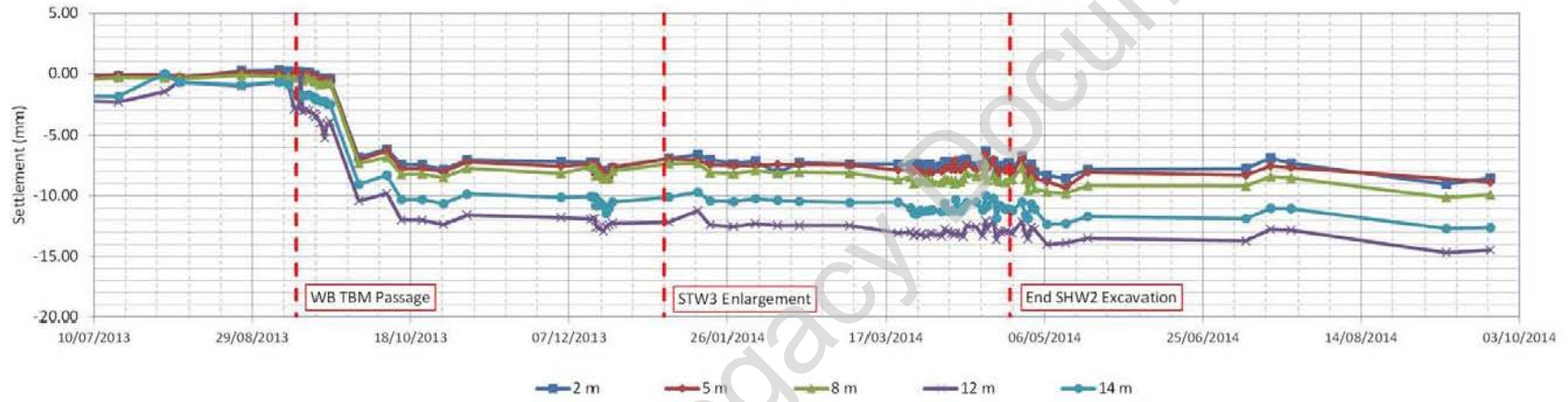
C435 FARRINGDON ROAD



GEOCISA UK

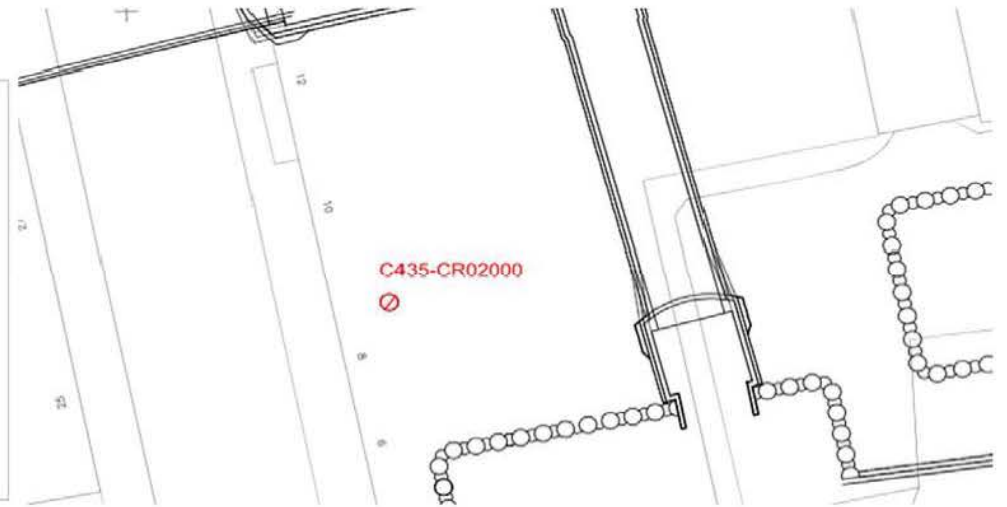
REPORT: Time Plot Levelling
AREA: Greville Street
DEVICE: Extensometer

EXTENSOMETER C435-XR02000



REMARKS:

The settlement rate after all works is less than 1,6mm/year, so extensometer data is stable.





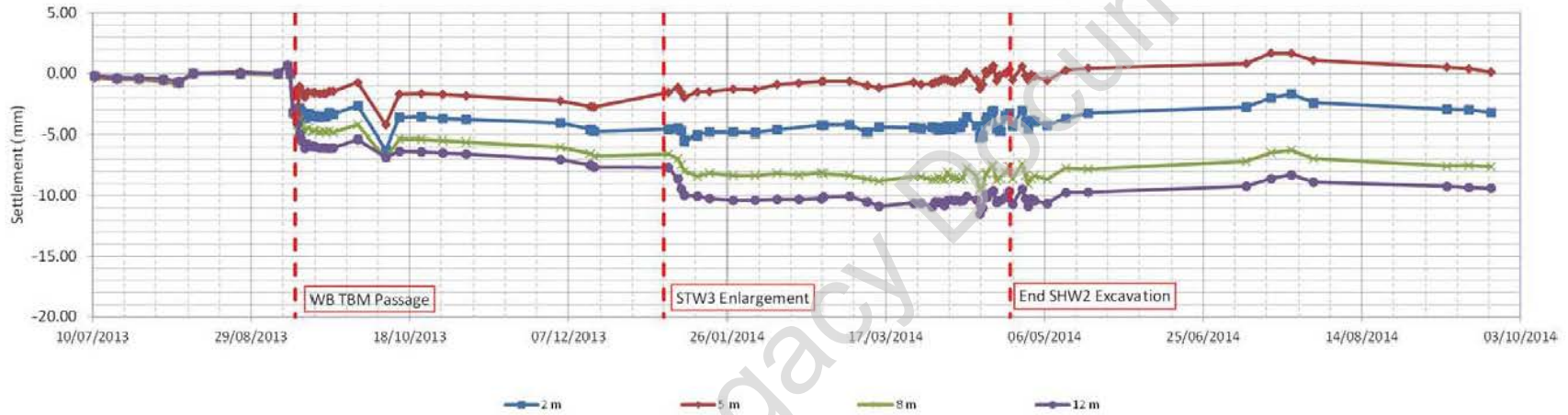
C435 FARRINGDON ROAD



GEOCISA UK

REPORT: Time Plot Levelling
AREA: Greville Street
DEVICE: Extensometer

EXTENSOMETER C435-XR03000



REMARKS:

The settlement rate after all works is less than 1,0mm/year, so extensometer data is stable.

