



# C305 - Eastern Running Tunnels

## I&M Close Out Report for Jubilee Line Running Tunnels and Covered Way at Canning Town Portal (LU/31) & LU Footbridge over DLR tracks at Canning Town Junction

CRL Document Number: C305-DSJ-C2-RGN-CRG03-50401

Supplier Document Number:

Contract MDL reference C08.079

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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: [Redacted] Role: CM Name: [Redacted] Date: 22/6/16

Sign: \_\_\_\_\_ Role: \_\_\_\_\_ Name: \_\_\_\_\_ Date: \_\_\_\_\_

### 2b. Review by Stakeholder (if required):

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

### 3. Acceptance by Crossrail.

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**I&M Close Out Report for Jubilee Line Running Tunnels and Covered Way at Canning Town Portal (LU/31) & LU Footbridge over DLR tracks at Canning Town Junction**

**C305 Crossrail Eastern Running Tunnels**

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| Revision: | Date:    | Prepared by: | Checked by: | Engineering Approved by: |
|-----------|----------|--------------|-------------|--------------------------|
| 2.0       | 10/06/16 | [REDACTED]   | [REDACTED]  | [REDACTED]               |
|           |          | [REDACTED]   | [REDACTED]  | [REDACTED]               |

**Document History :**

| Revision: | Date: | Prepared by: | Checked by: | Engineering Approved by: |
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Learning Legacy Document

## 1. CLOSE OUT REPORT PURPOSE

The purpose of this close out report is to summarise the ground movements related to C305 construction activities for Jubilee Line running tunnels and covered way at Canning Town portal (LU/31) and LU footbridge over DLR tracks at Canning Town junction, based on the C704 monitoring system and C305 manual monitoring system. This report incorporates the existing C704 decommissioning agreement for this asset (C704 Instrumentation Decommissioning Agreement Jubilee Line Running Tunnels and Covered Way at Canning Town Portal (LU/31) & LU Footbridge over DLR tracks at Canning Town Junction (C704-XRL-C-AAG-J003-50001) whereby the C704 monitoring system has been shown to be at an acceptably small settlement rate and suitable for decommissioning.

To provide a summary of the effects of C305 construction activities on the asset, the C305 manual verification readings have been reviewed alongside the C704 automatic monitoring system for completeness. This report has been produced to close out the requirement for C305 monitoring reviews in connection with this asset.

## 2. LOCATION OF THE WORKS

The instrumentation included within this report is situated within Area 2 of the C305 Drive G running tunnels alignment and covers the extent of the monitoring equipment installed within the predicted zone of influence of Crossrail Works on the following Assets around project chainage 85110:

- The Jubilee Line Running Tunnels and Covered Way (LU/31) located at Canning Town Portal.
- The LU Footbridge located at the Canning Town Junction over the DLR tracks.

### JUBILEE LINE

The Canning Town Portal is located between the LU stations of North Greenwich and Canning Town and is part of the Jubilee line extension from Green Park to Stratford.

### LU FOOTBRIDGE

The LU Footbridge is located near Canning Town Flyover, south of the Canning Town Station. The footbridge provides pedestrian access over the Stratford International to Woolwich Arsenal DLR tracks.

### 3. DOCUMENTATION SUMMARY

| CROSSRAIL NUMBER                  | DOCUMENT NAME   | REASON FOR ISSUE          |
|-----------------------------------|---|---------------------------|
| C701-ITM-C-RGN-CR144_SH011-50001  | C701 Installation Report for LU/31  | Installation report       |
| C704-SOL-C2-RGN-J003-50042        | C704 Installation Report for the LU Footbridge  | Installation report       |
| C122-OVE-C2-RGN-CR144_PT003-50001 | C122 Instrumentation & Monitoring Plan for LU/31 and the LU Footbridge.   | I&M Plan                  |
| C305-XRL-C2-RGN-CR144-50002       | LU/31 Jubilee Line  | Baseline Report           |
| C704-XLR-C-AAG-J003-50001 Rev 1.0 | C704 Instrumentation Decommissioning Agreement Jubilee Line Running Tunnels and Covered Way at Canning Town Portal (LU/31) & LU Footbridge over DLR tracks at Canning Town Junction | Decommissioning Agreement |

### 4. SUMMARY OF INSTRUMENTATION

The total number of instruments covered in this report comprises:

#### JUBILEE LINE

- 66 No. mini prisms (33 along the eastbound and 33 along the westbound Jubilee line, near Canning Town portal).
- 52 No. electrolevels beams (24 along the eastbound in jubilee line eastbound and 28 along the westbound running tunnels of the Jubilee line).
- 4 No. mini prisms (1No. located at each end of each electrolevel beam arrangement).
- 384 No. Precise Levelling Point track markings at 2 m centers (48 pairs on each rail track in the eastbound tunnel and 68 pairs on each rail track in the westbound tunnel). See Appendix B.
- 42 No. Reflective Retro Targets; in both eastbound and westbound Jubilee line running tunnels.

#### LU FOOTBRIDGE

- 6 No. mini prisms (4 no. on the bridge piers (2/pier) and 2 no. on the bridge deck).

### 5. C305 CONSTRUCTION ACTIVITIES

|           | RINGS    | PROJECT CHAINAGE | DATES                    |
|-----------|----------|------------------|--------------------------|
| Eastbound | 55 – 100 | 85070 - 85140    | 19/09/2014 to 29/09/2014 |
| Westbound | 65 – 105 | 85070 - 85140    | 24/06/2014 to 17/07/2014 |

#### Stoppage periods:

- Eastbound Drive-G Ring 83 (Project chainage - 85100) 21/09/14 to 27/09/14
- Westbound Drive-G Ring 81 (Project chainage - 85100) 26/06/14 to 14/07/14

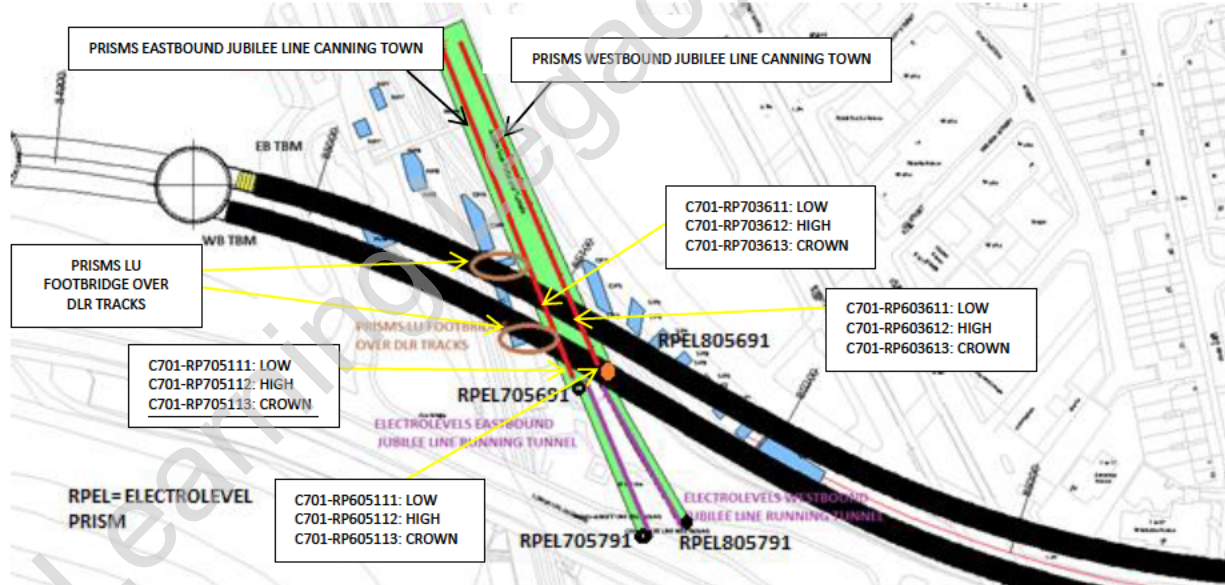
## 6. SUMMARY OF C704 DATA

Below is a table of the summarised ground movements from the readings from the C704 system using the prisms and electrolevels located above the centre of the running tunnel alignment. No offset has been applied to the C704 track monitoring prism data shown in this report.

| Activity     | Maximum Movements (mm)                            |      |      |   |      |      |   |   |                                      |      |       |
|--------------|---|------|------|---|------|------|---|---|--------------------------------------|------|-------|
|              | PRISMS EASTBOUND JUBILEE LINE CANNING TOWN PORTAL |      |      | PRISMS WESTBOUND JUBILEE LINE CANNING TOWN PORTAL |      |      | ELECTROLEVELS EASTBOUND JUBILEE LINE RUNNING TUNNEL | ELECTROLEVELS WESTBOUND JUBILEE LINE RUNNING TUNNEL | PRISMS LU FOOTBRIDGE OVER DLR TRACKS |      |       |
| Coordinates  | X   | Y    | Z    | X   | Y    | Z    | Z   | Z   | X                                    | Y    | Z     |
| WB TBM Drive | -0.2  | -1.1 | -1.5 | -0.2  | -1.2 | -2.4 | -1.8  | -3.1  | -2.2                                 | -1.0 | -3.0  |
| EB TBM Drive | -1.3  | 3.6  | -4.2 | -0.8  | 3.6  | -5.6 | -4.6  | -5.5  | -2.0                                 | 2.6  | -11.8 |

The report summarizes the C305 works in line with the C704 report.

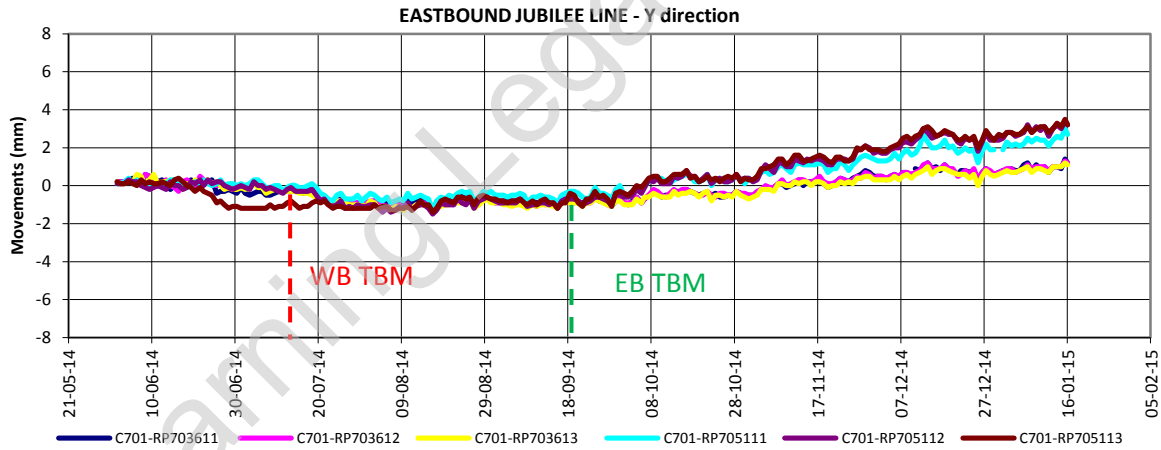
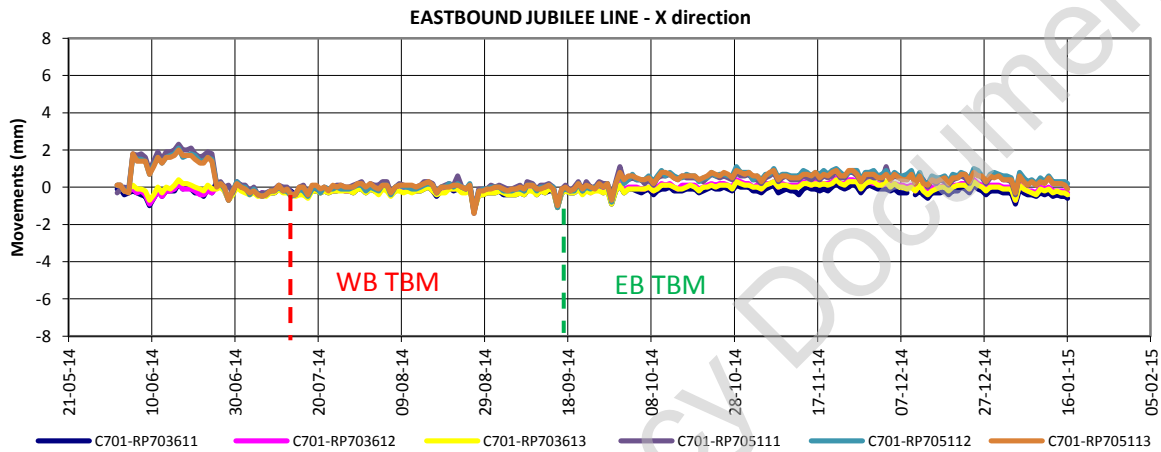
The sketch below shows the location of these electrolevels and prisms on the respective LU Assets in relation to the tunnels.

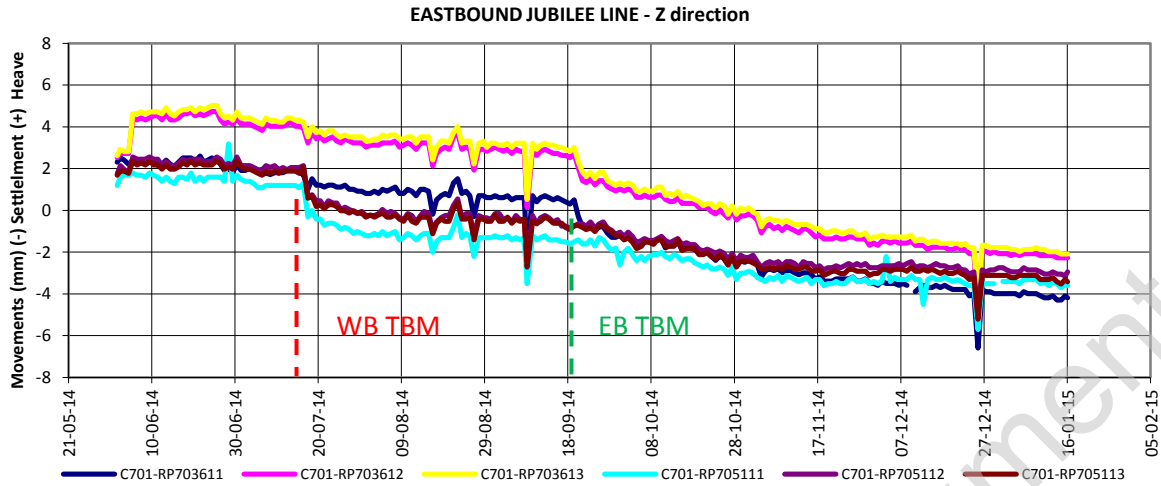


The graphs below are taken from the automatic readings from the C704 system for some prisms/electrolevel arrays illustrating the related construction activities.

Monitoring frequencies and trigger values were specified in Instrumentation and Monitoring Plan: LU/31 Jubilee Line at/near Canning Town Portal (C122-OVE-C2-RGN-CR144\_PT003-50001).

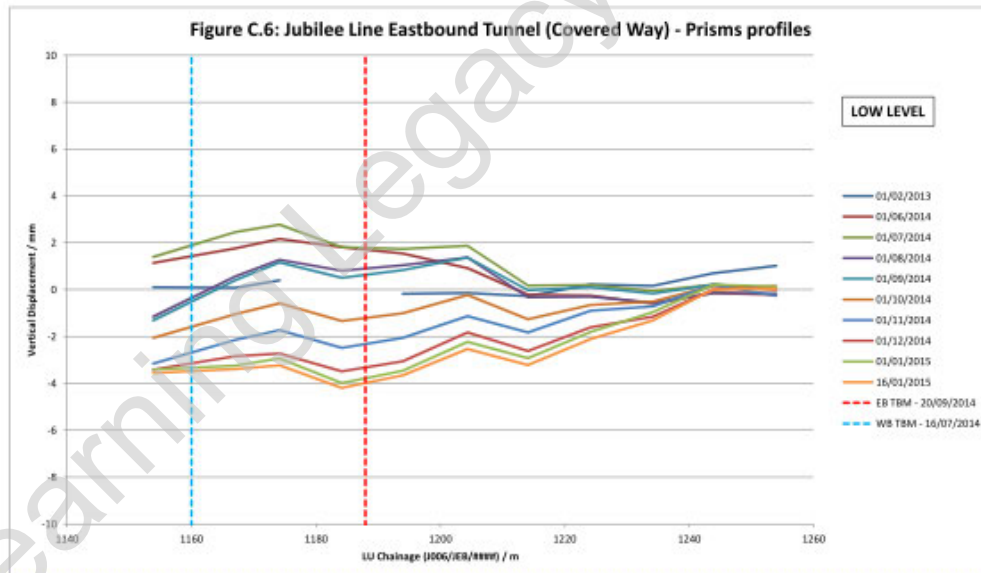
**PRISMS EASTBOUND JUBILEE LINE CANNING TOWN PORTAL**



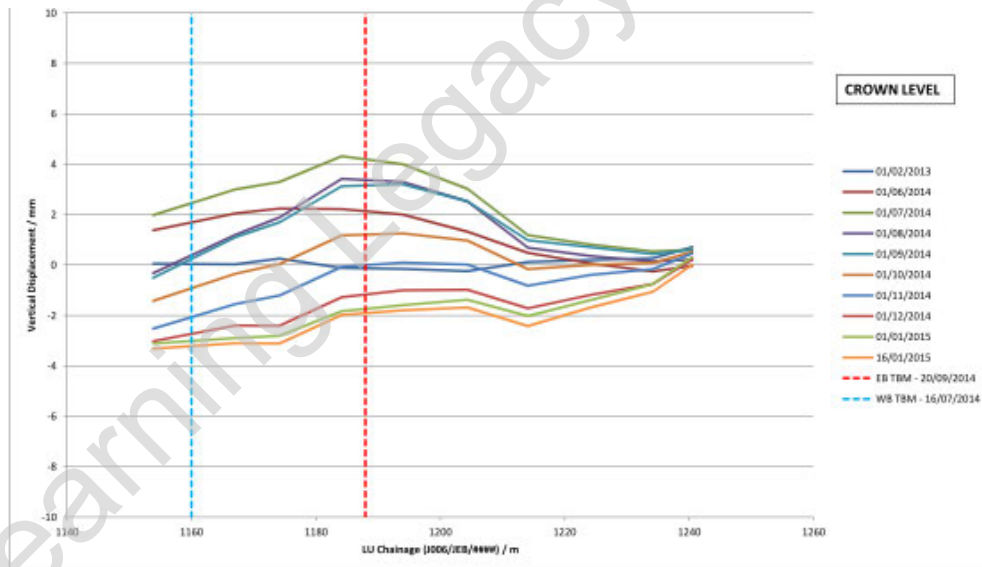
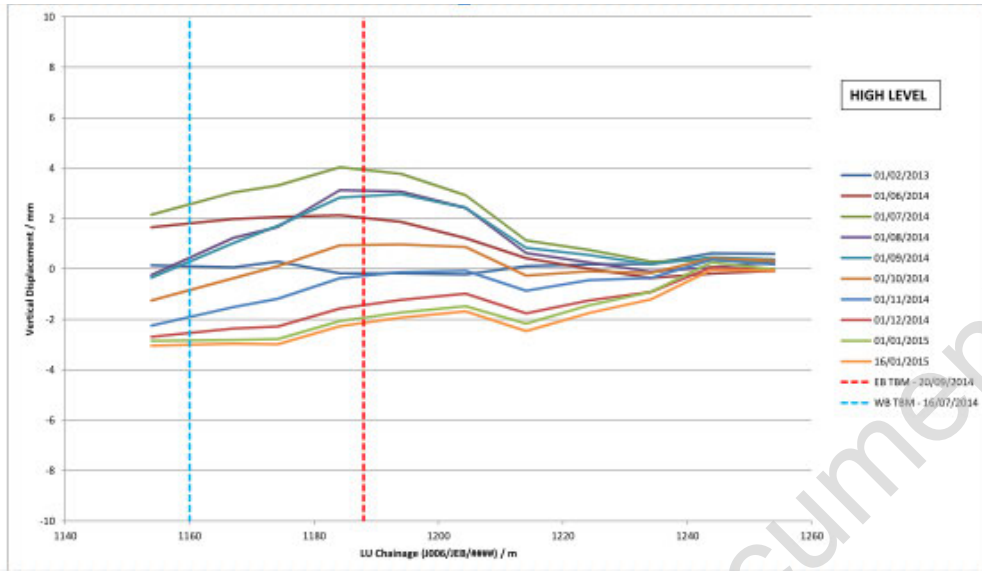


There was a maximum settlement of approximately 1.5 mm after the westbound TBM passage, and the total maximum settlement after the eastbound TBM passage was almost 4.2 mm.

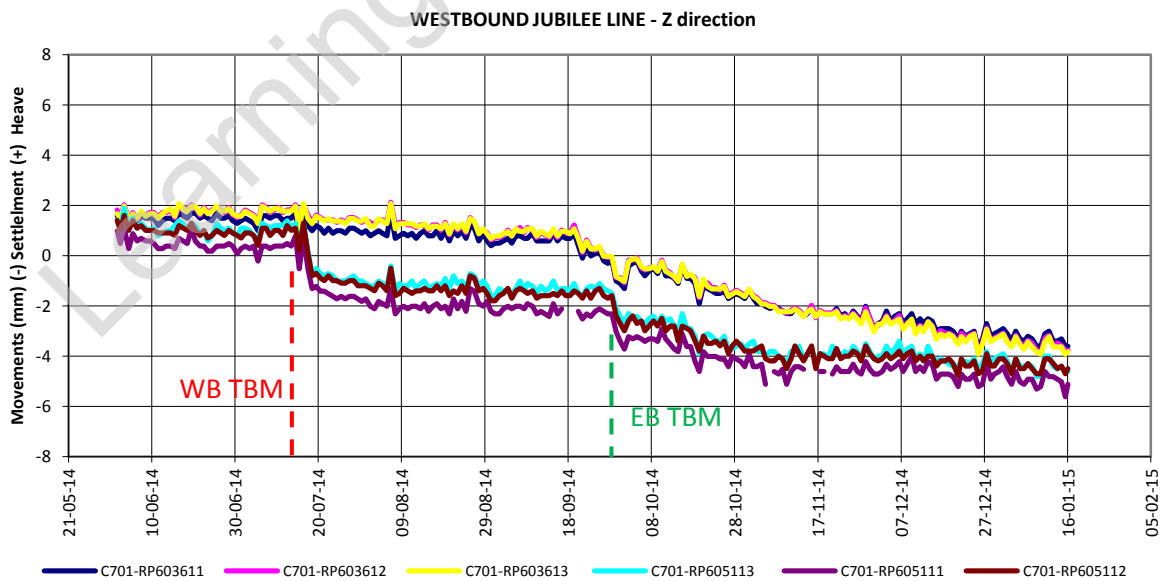
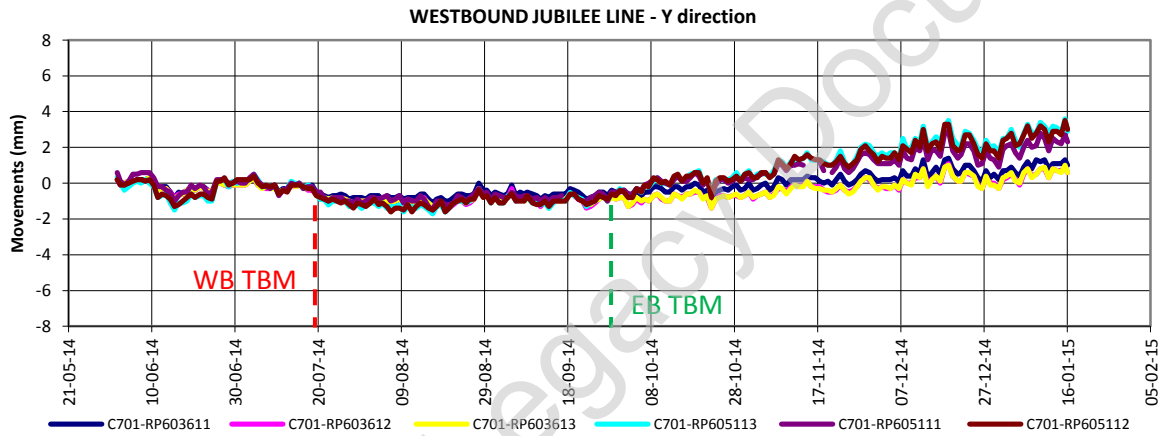
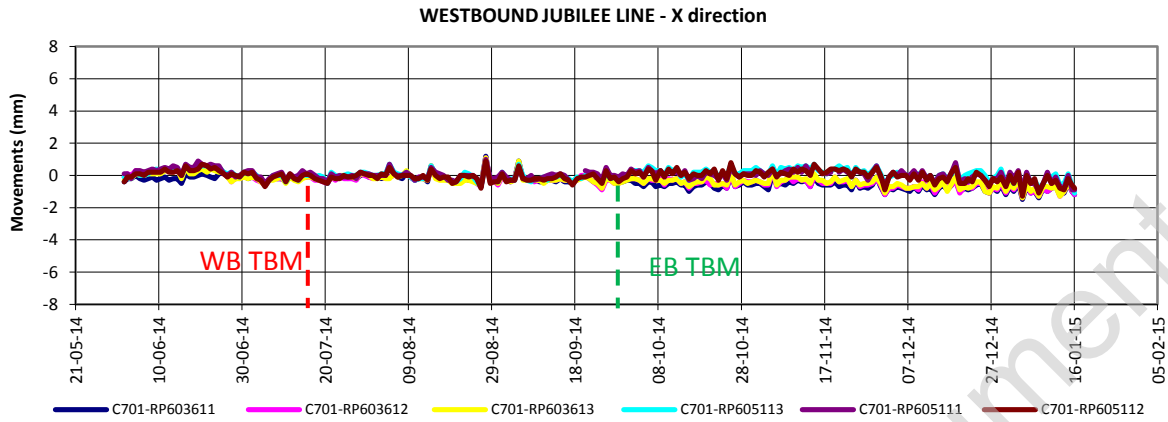
As per C704 Instrumentation Decommissioning Agreement with the number C704-XRL-C-AAG-J003-50001, several profiles are shown below. See Appendix A for further information.





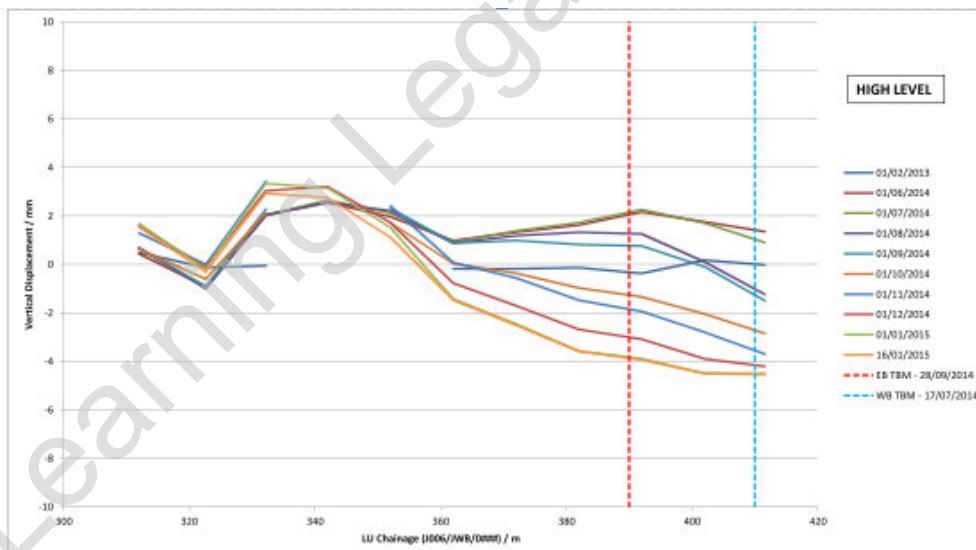
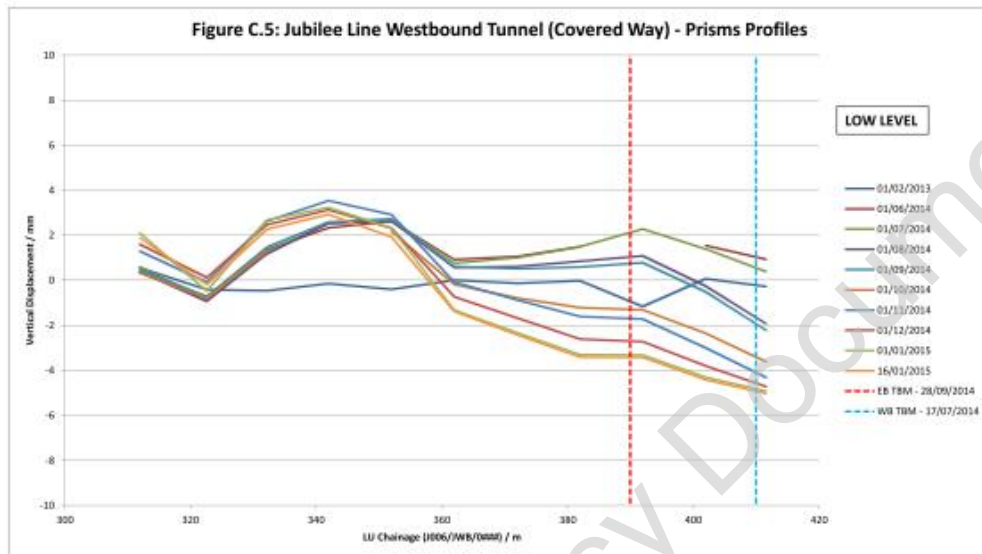


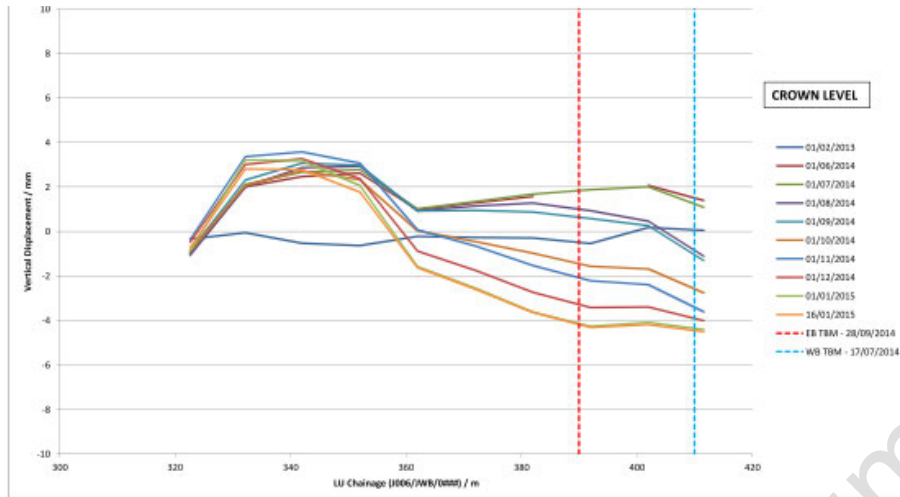
PRISMS WESTBOUND JUBILEE LINE CANNING TOWN PORTAL



There was a maximum settlement of approximately 2.4 mm after the westbound TBM passage, and the total maximum settlement after the eastbound TBM passage was almost 5.6 mm.

As per C704 Instrumentation Decommissioning Agreement with the number C704-XRL-C-AAG-J003-50001, several profiles are shown below. See Appendix A for further information.

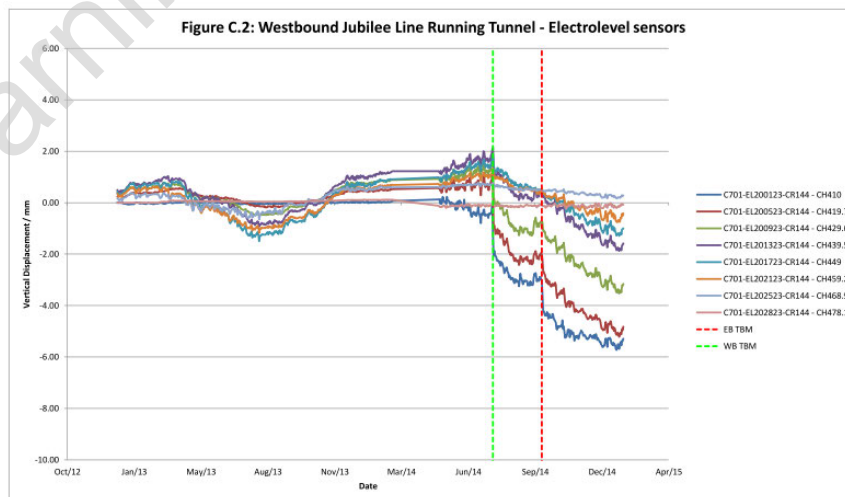


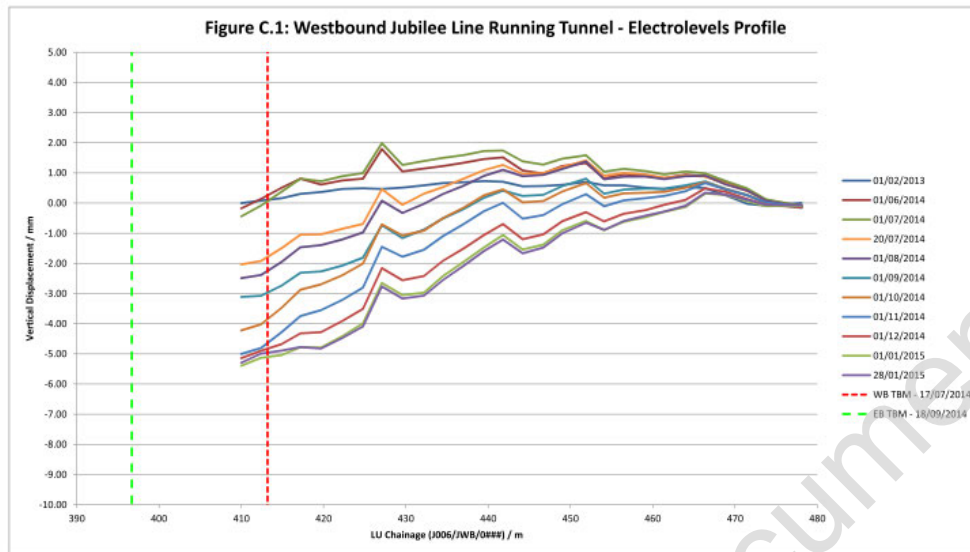


The trigger values of horizontal displacement (mm) of tunnels as per C305-DSJ-C-STP-CRG03-50039 I&M Specific Action Plan G002 Jubilee Line Canning Town (LU31) are 3mm green, 5mm amber and 10mm red and the trigger values of vertical displacement (mm) of tube Westbound tunnel are 17mm green, 22mm amber and 27mm red and vertical displacement (mm) of tube Eastbound tunnel are 12mm green, 15mm amber and 20mm red. The trigger values of vertical displacement (mm) of covered way tunnel are 22mm green, 28mm amber and 35mm red. As can be seen all movements were within the trigger values specified. Horizontal movements and vertical movement do not breach the Amber Trigger.

**ELECTROLEVELS WESTBOUND JUBILEE LINE RUNNING TUNNEL**

Readings and profiles are shown below.

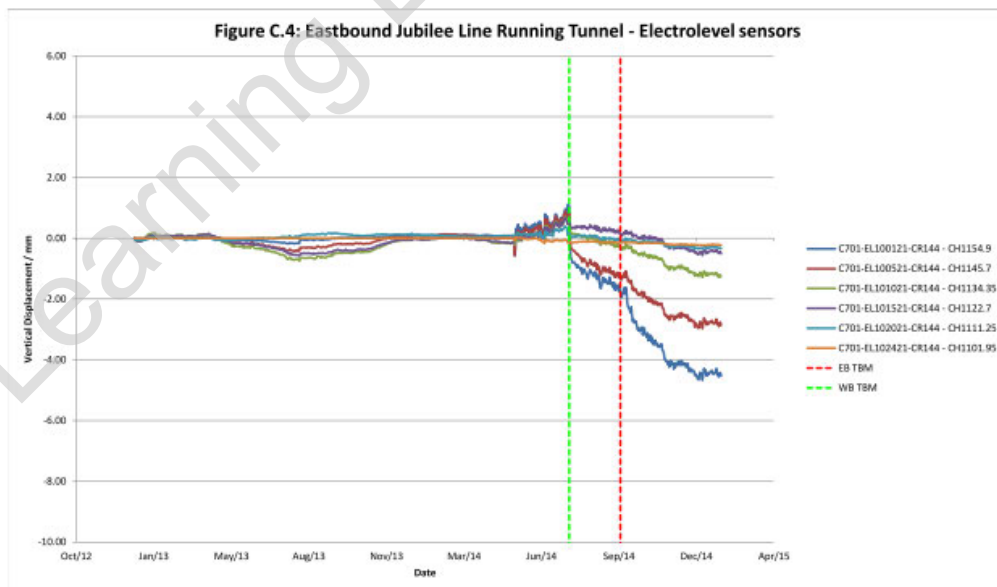


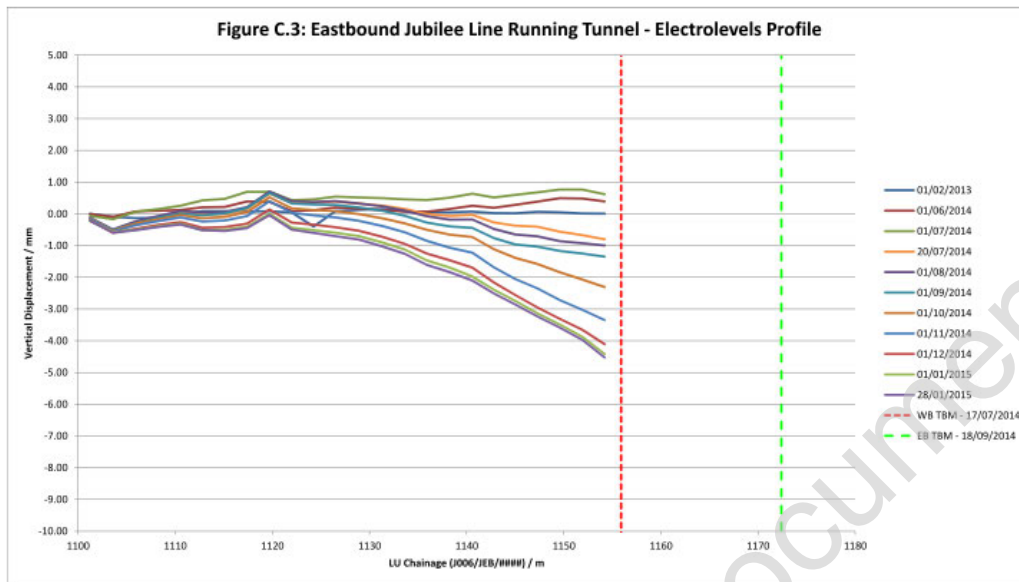


There was a maximum settlement of approximately 3.1 mm after the westbound TBM passage, and the total maximum settlement after the eastbound TBM passage was almost 5.5 mm.

**ELECTROLEVELS EASTBOUND JUBILEE LINE RUNNING TUNNEL**

Readings and profiles are shown below.



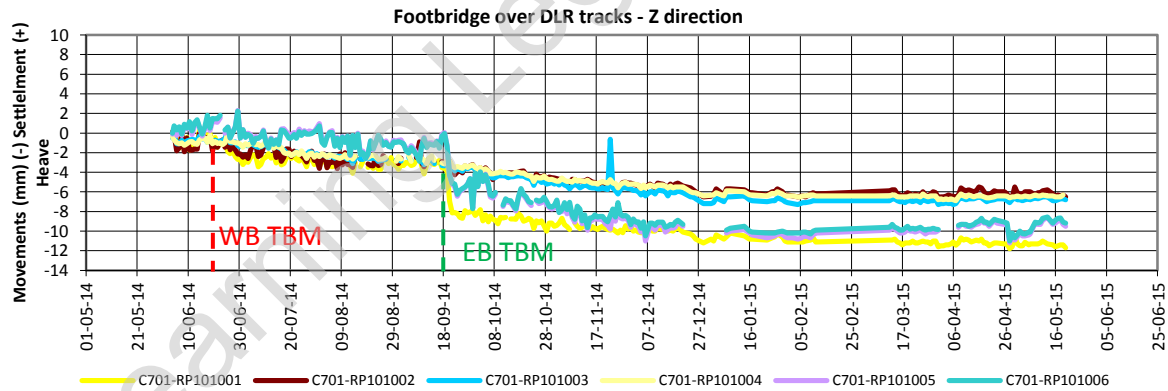
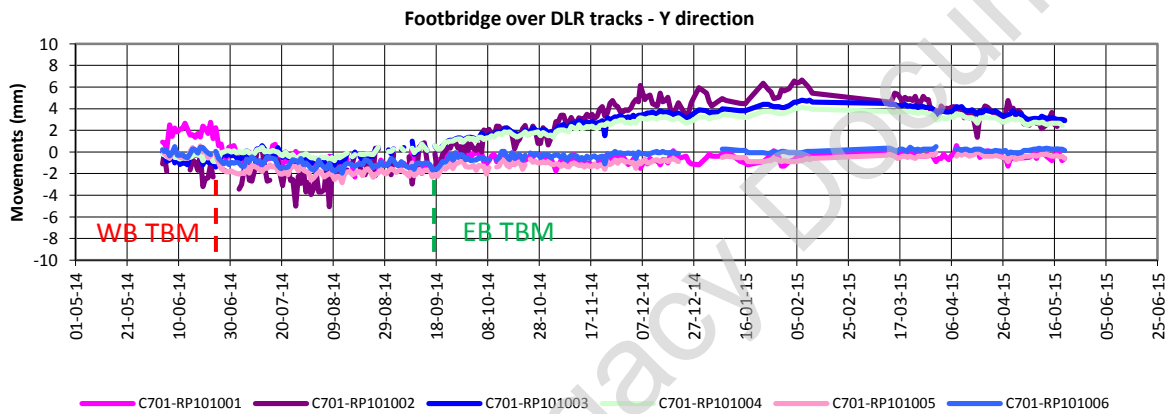
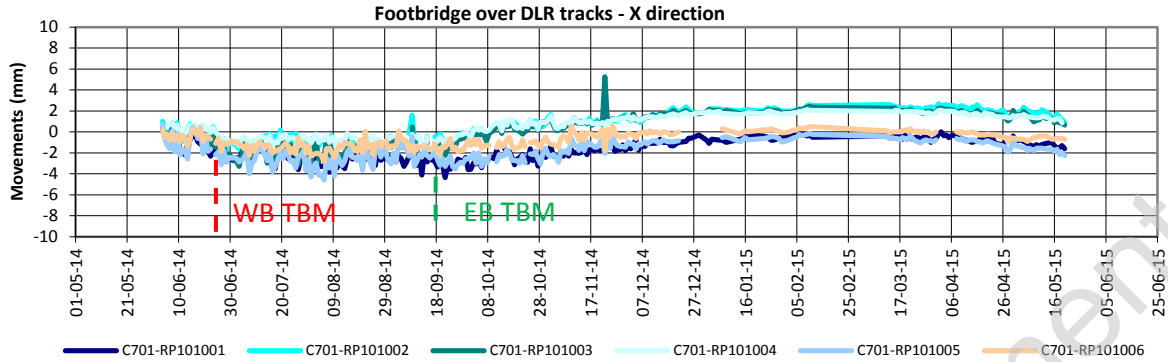


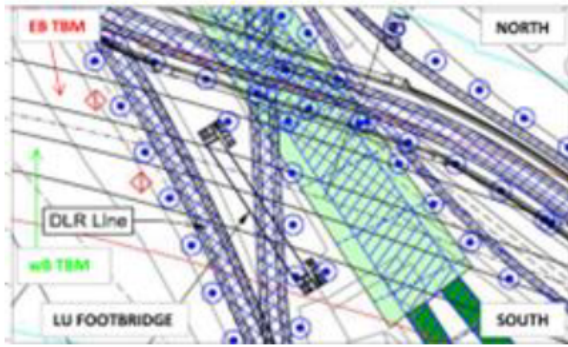
There was a maximum settlement of approximately 1.8 mm after the westbound TBM passage, and the total maximum settlement after the eastbound TBM passage was almost 4.6 mm.

The trigger values of vertical displacement (mm) of tunnels as per C305-DSJ-C-STP-CRG03-50039 I&M Specific Action Plan G002 Jubilee Line Canning Town (LU31) are 17mm green, 22mm amber and 27mm red for the Westbound and 12mm green, 15mm amber and 20mm red for the Eastbound. As can be seen all movements were within the trigger values specified. Vertical movement does not breach the Amber Trigger.

The trigger values of differential displacement (mm) of tunnels as per C305-DSJ-C-STP-CRG03-50039 I&M Specific Action Plan G002 Jubilee Line Canning Town (LU31) are 3mm green, 5mm amber and 10mm red for the Westbound and 5mm green, 7mm amber and 12mm red for the Eastbound. As can be seen all movements were within the trigger values specified. Differential displacement does not breach the Amber Trigger.

PRISMS LU FOOTBRIDGE OVER DLR TRACKS





There was a maximum settlement of approximately 3 mm after the westbound TBM passage, and the total maximum settlement after the eastbound TBM passage was almost 11.8 mm.

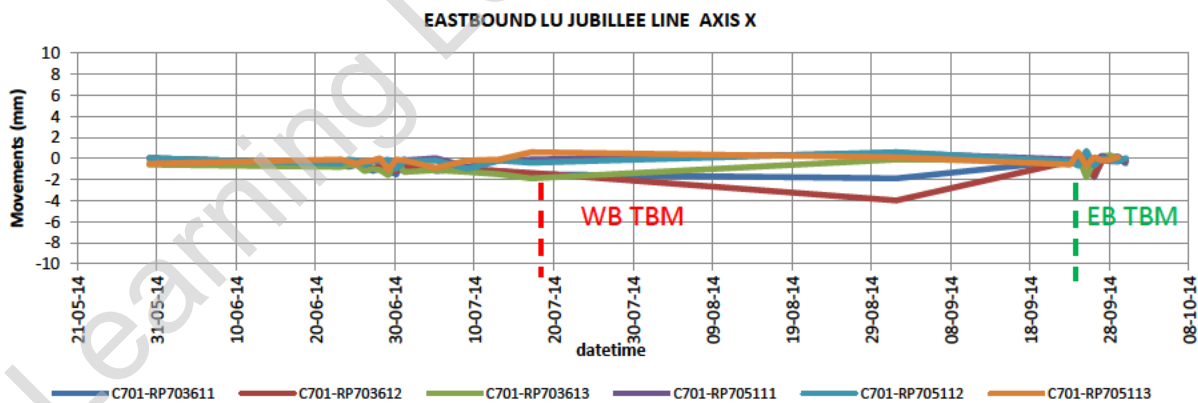
There are several gaps in the readings due to some vulnerable total stations being removed for the Christmas break as C701 has had them stolen from there previously.

The trigger values of vertical displacement (mm) of footbridge as per C305-DSJ-C-STP-CRG03-50039 I&M Specific Action Plan G002 Jubilee Line Canning Town (LU31) are 20mm green, 25mm amber and 30mm red and 3mm green, 5mm amber and 10mm red for horizontal movements. As can be seen all movements were within the trigger values specified. The horizontal movements and vertical movement do not breach the Amber Trigger.

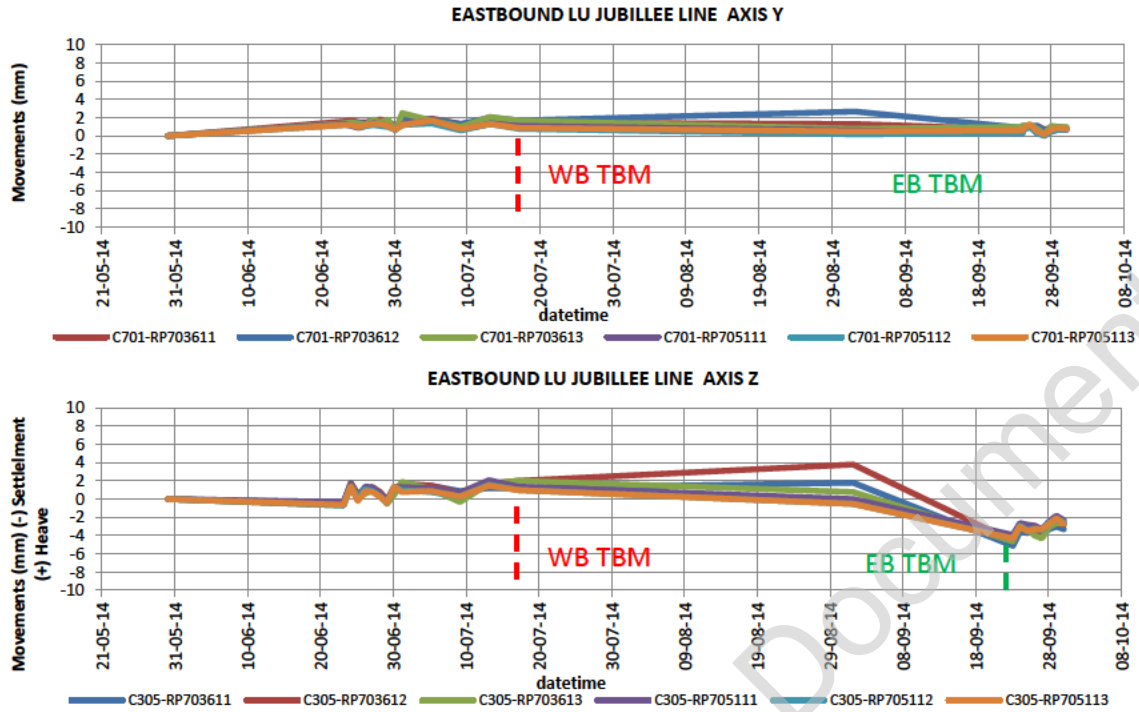
#### 7. C305 MANUAL VERIFICATION READINGS

During the passage of the TBMs, manual readings were taken to verify the data provided from the C704 system was accurate and reliable.

#### PRISMS EASTBOUND JUBILEE LINE CANNING TOWN PORTAL



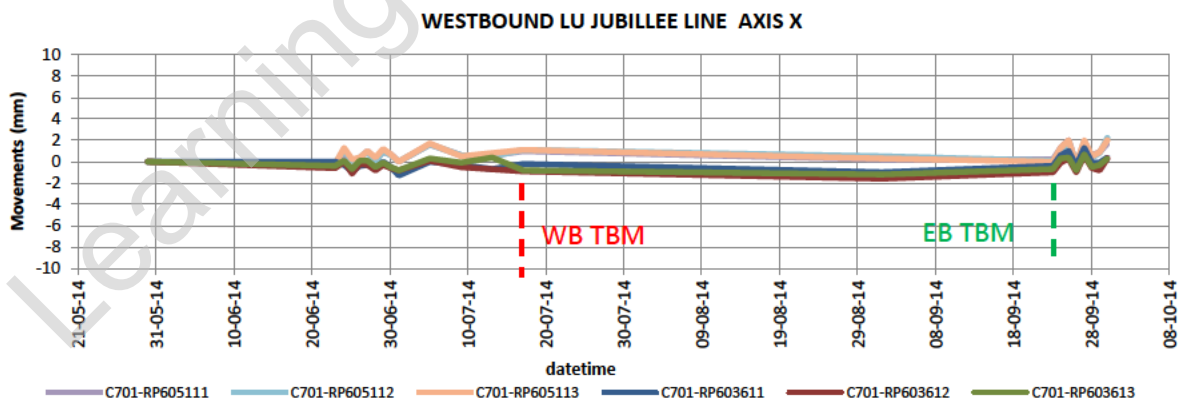


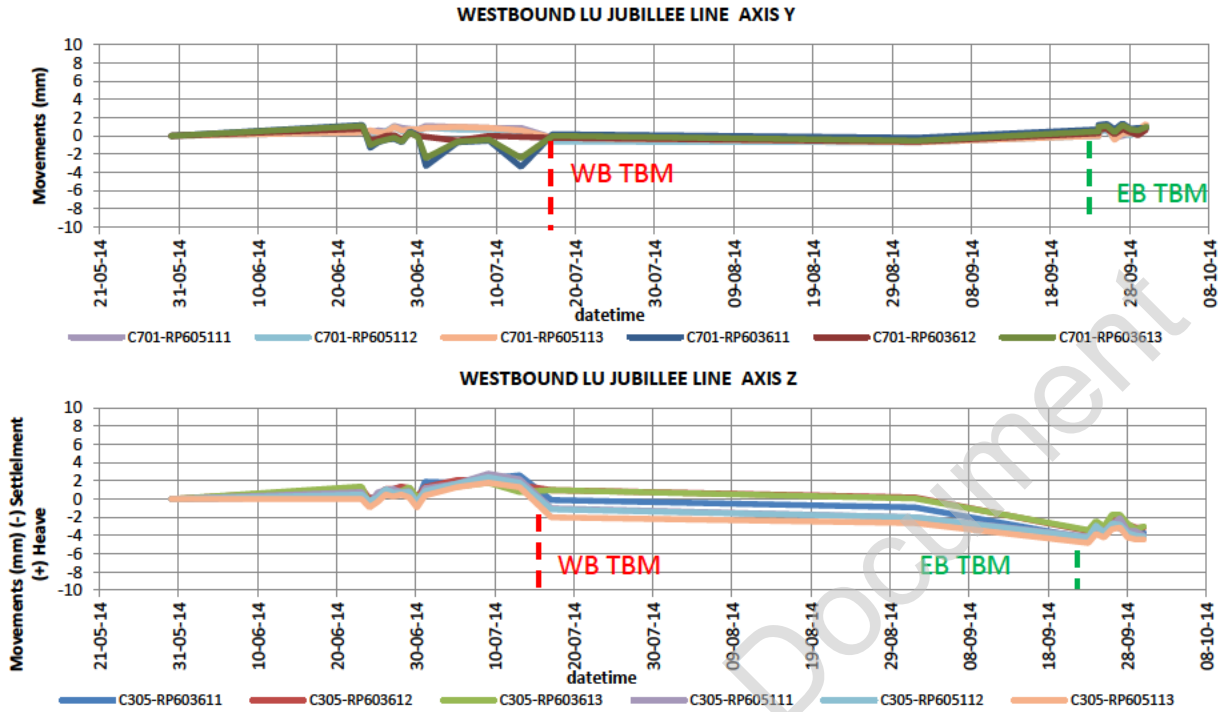


There was a maximum settlement of approximately 1.2 mm after the westbound TMB passage, and the total maximum settlement after the eastbound TBM passage was almost 5 mm.

As observed, the results of manual readings are similar to the automatic readings.

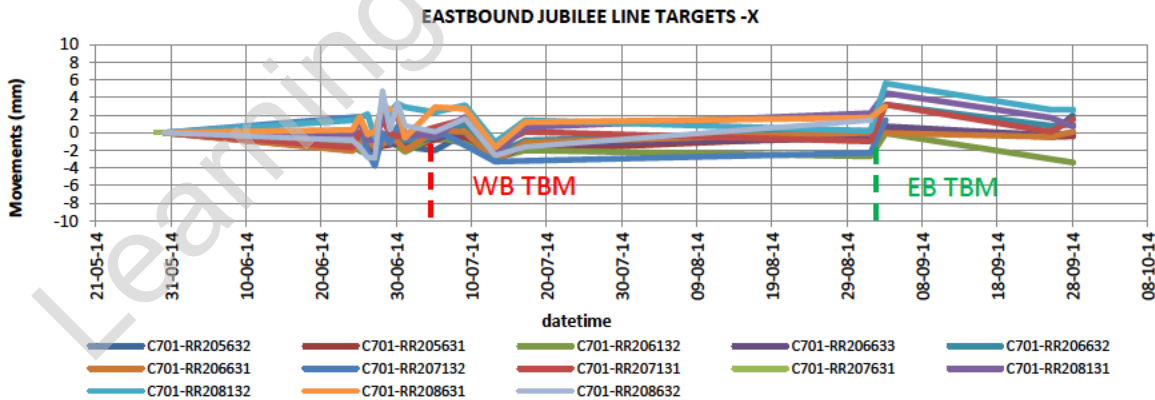
**PRISMS WESTBOUND JUBILEE LINE CANNING TOWN PORTAL**

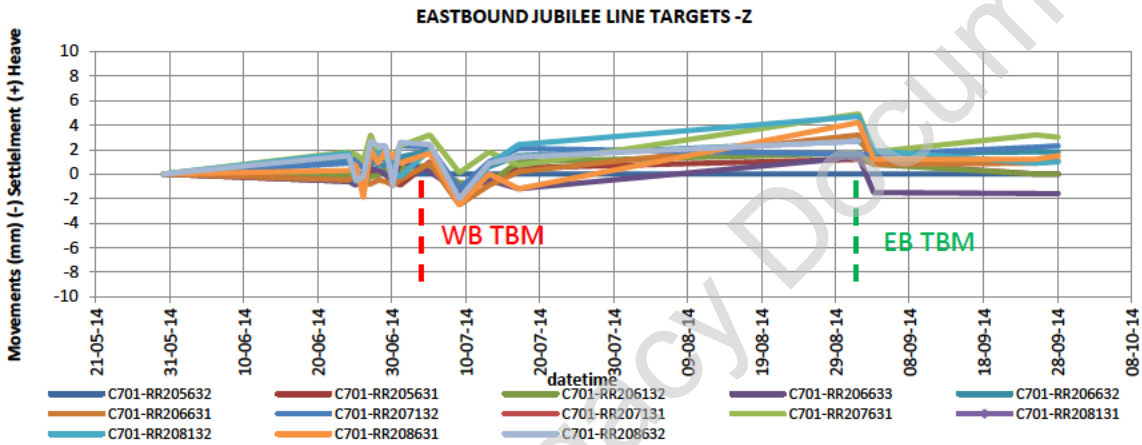
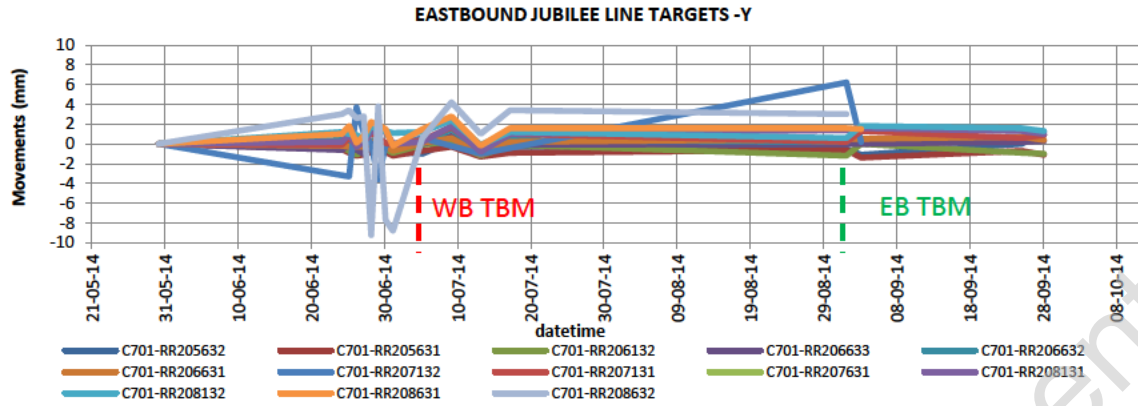




There was a maximum settlement of approximately 2.5 mm after the westbound TBM passage, and the total maximum settlement after the eastbound TBM passage was almost 5.2 mm.

**C305 TARGETS EASTBOUND JUBILEE LINE RUNNING TUNNEL**

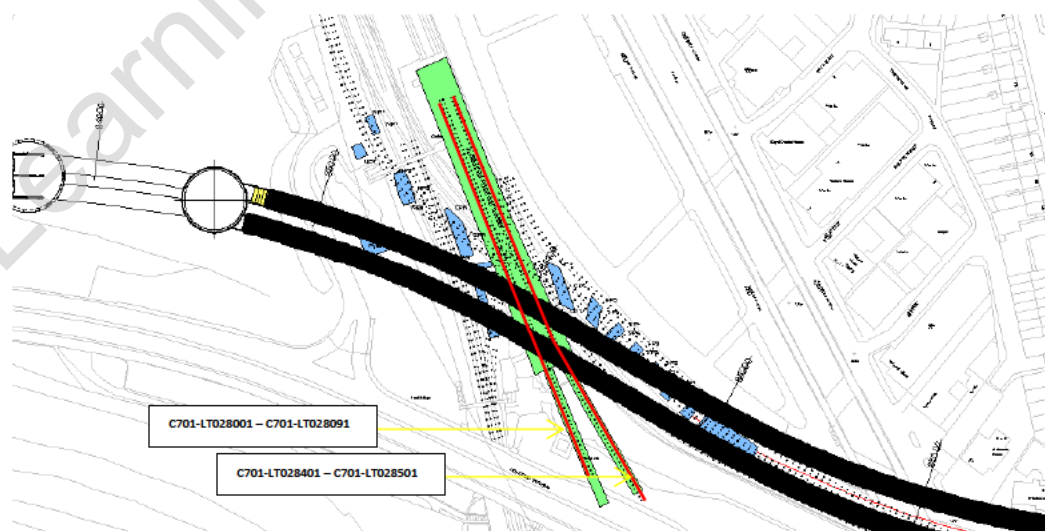




There was a total maximum settlement of approximately 1.5 mm after the westbound and eastbound TBM passage.

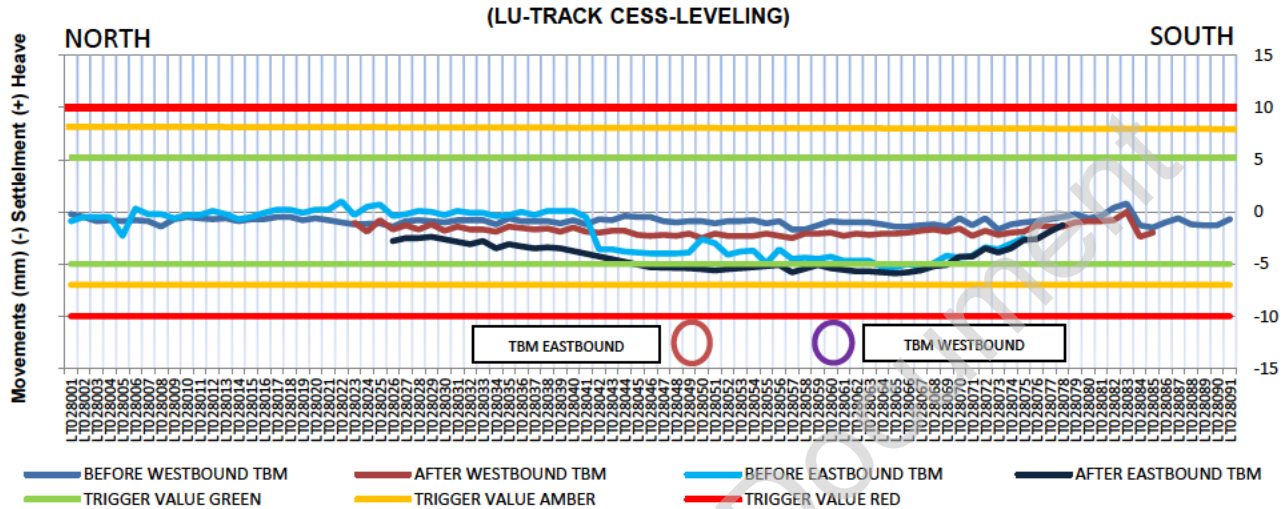
**C305 TRACK LEVELING JUBILEE LINE**

The locations of the track leveling are shown in the sketch below.



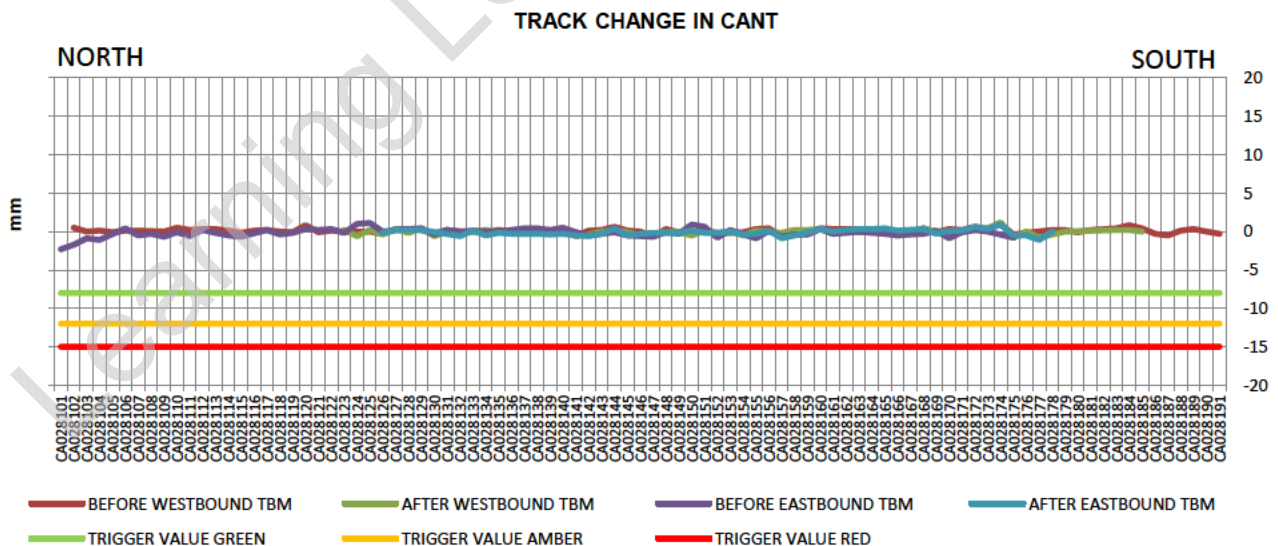
C305 TRACK LEVELING EASTBOUND JUBILEE LINE

SETTLEMENT

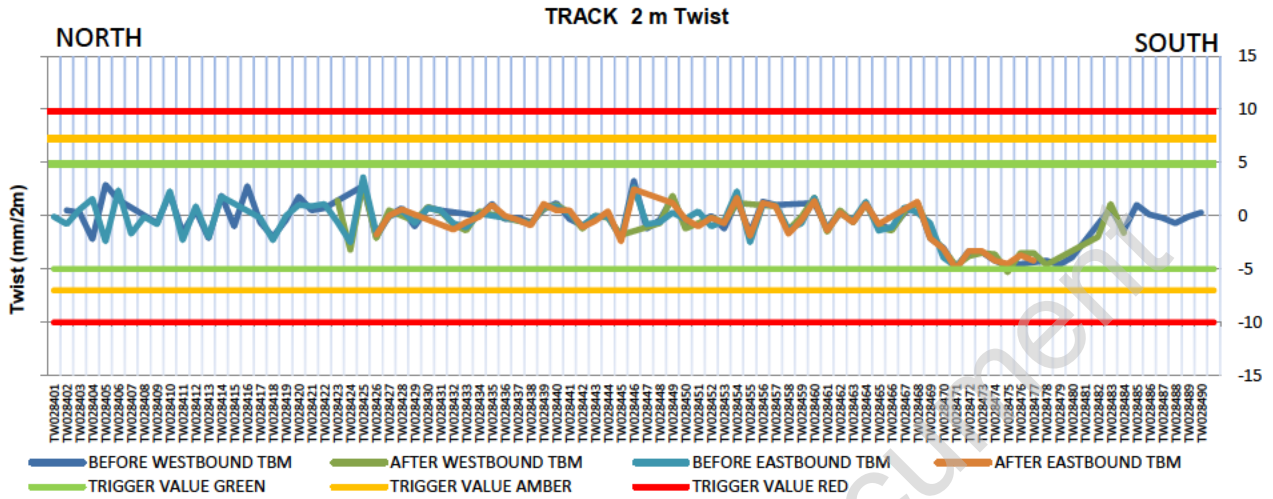


There was a maximum settlement of approximately 2 mm after the westbound TBM passage, the maximum settlement after the eastbound TBM passage was almost 5 mm, and the total maximum settlement after the both TBM transits was approximately 5 mm.

CHANGE IN CANT



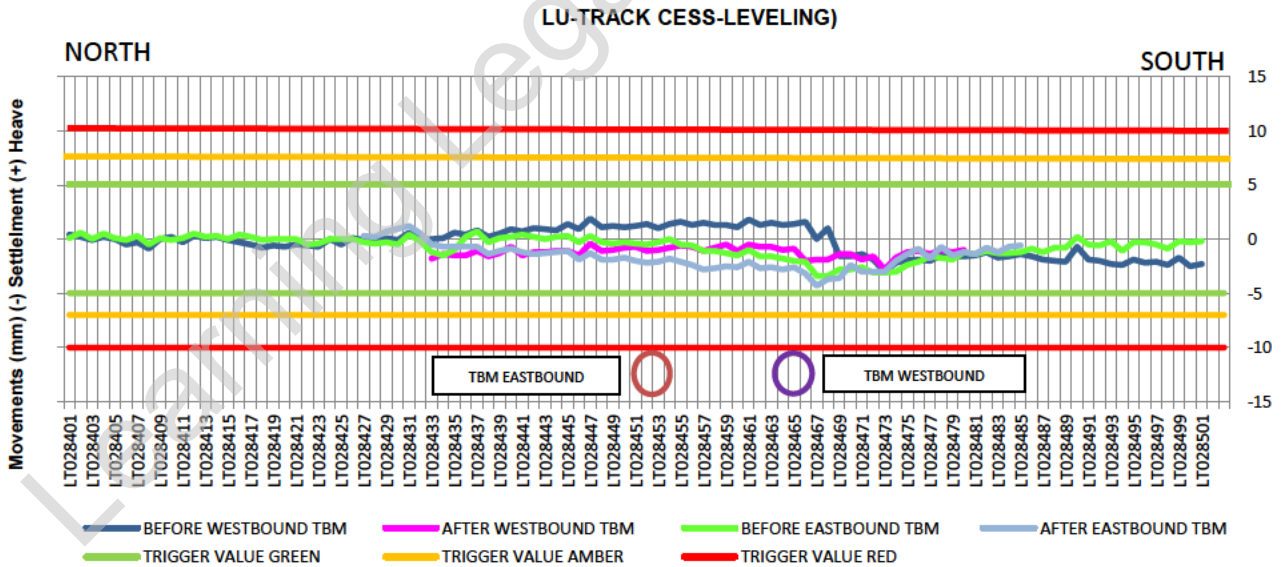
**TWIST**



No significant changes of twist and change in cant were detected.

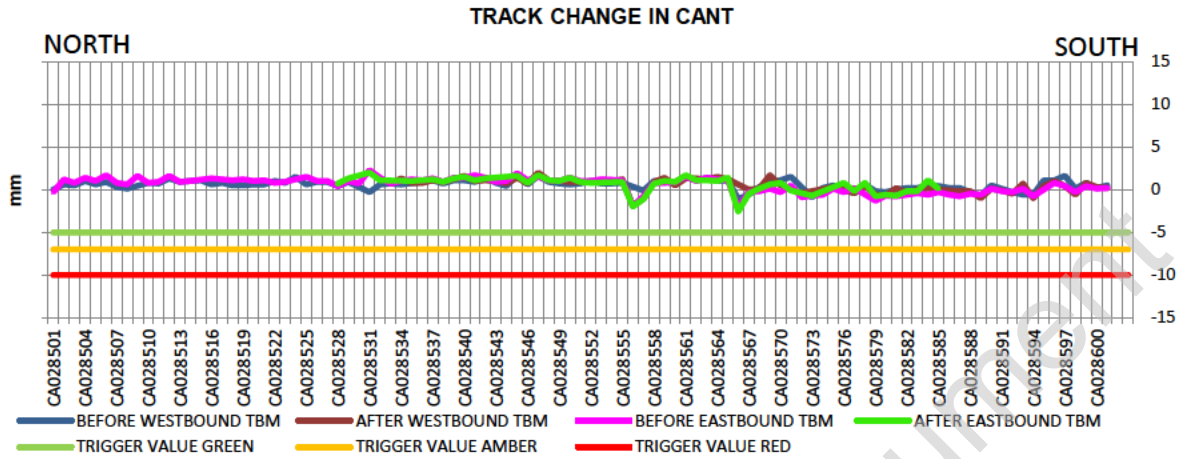
**C305 TRACK LEVELLING WESTBOUND JUBILEE LINE**

**SETTLEMENT**

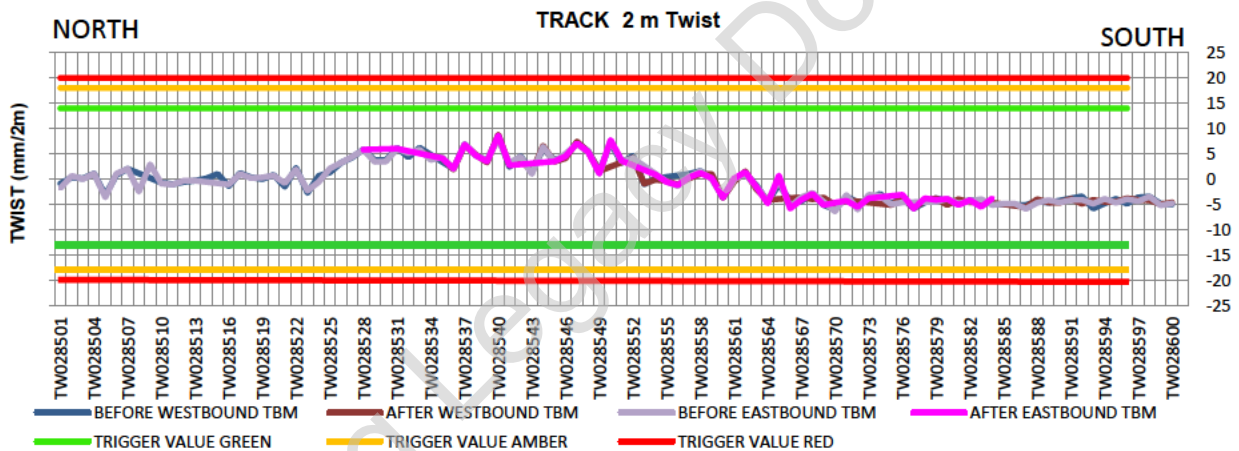


There was a maximum settlement of approximately 3.2 mm after the westbound TBM passage, the maximum settlement after the Eastbound TBM passage was almost 2 mm, and the total maximum settlement after the both TBM transits was approximately 3.2 mm.

**CHANGE IN CANT**



**TWIST**



No significant changes of twist and change in cant were detected. Trigger values shown on the graphs are as per C122 I&M Plan (C305-DSJ-C-STP-CRG03-50039). As can be seen all movements were within the trigger values specified.

**8. SUMMARY**

This review of both the C305 manual verification data and C704 automatic system data concludes that the impact of the C305 works was within the predictions as per the trigger values specified in the C122 I&M Plan (C305-DSJ-C-STP-CRG03-50039). The conclusion in the document: "C704 Instrumentation Decommissioning Agreement Jubilee Line Running Tunnels and Covered Way at Canning Town Portal (LU/31) & LU footbridge over DLR tracks at Canning Town Junction- C704-XLR-C-AAG-J003-50001 Rev 1.0" (attached as an appendix A in this document) states the long term ground movements have reached an acceptably small rate, and proposes to decommission the automatic system and that manual monitoring should cease.

Learning Legacy Document

**APPENDIX A:  
DECOMMISSIONING AGREEMENT**



# Crossrail Delivery – Contract C704

## C704 Instrumentation Decommissioning Agreement Jubilee Line Running Tunnels and Covered Way at Canning Town Portal (LU/31) & LU Footbridge over DLR tracks at Canning Town Junction

Document Number: C704-XRL-C-AAG-J003-50001

### Document History:

| Revision   | Date:    | Prepared by: | Checked by: | Approved by: | Reason for Issue                                |
|--|----------|--------------|-------------|--------------|---|
| 1.0  | 16-04-15 | [REDACTED]   | [REDACTED]  | [REDACTED]   | First issue that incorporates CEG/C122 comments |
| Formal Acceptance by Chief Engineers Group (CEG) |          |              |             | Accepted by: | [REDACTED]                                      |
|  |          |              |             | [REDACTED]   | [REDACTED]                                      |

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**C704 Instrumentation - Decommissioning Agreement**  
**Jubilee Line Running Tunnels and Covered Way at Canning Town Portal (LU/31)**  
**& LU Footbridge over DLR tracks at Canning Town Junction**  
**C704-XRL-C-AAG-J003-50001 Rev 1.0**

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**Jubilee Line Running Tunnels and Covered Way at Canning Town Portal (LU/31)**  
**& LU Footbridge over DLR tracks at Canning Town Junction**  
**C704-XRL-C-AAG-J003-50001 Rev 1.0**

## **1 Purpose**

Following detailed assessment of the impact of CRL works on the individual Assets by C122 and as part of CRL's resulting risk management strategy, a comprehensive Instrumentation & Monitoring (I&M) systems have been installed by C701 in the Jubilee Line Running Tunnels and Covered Way at Canning Town Portal and by C704 on the LU Footbridge over the DLR tracks at Canning Town Junction.

The Canning Town Portal is located between the LU stations of North Greenwich and Canning Town and is part of the Jubilee line extension from Green Park to Stratford. The LU Footbridge is located at the Canning Town Junction over the DLR tracks, south of the Canning town station.

The C701 and C704 I&M systems have been installed in advance of CRL construction activities to record necessary background monitoring data. Currently C704 provide monitoring data from the systems.

C701 have also installed a manual system (retro targets) in the Jubilee Line Running Tunnels to be used by C305 as back up and to validate the automatic system.

The latest CRL work that affected the two Assets was the C305 Eastbound TBM drive passing in September 2014.

This document aims to provide a basis on which all relevant parties can agree on C704 decommissioning of the automatic I&M system from the Assets.

Given its purpose, the document has been intentionally drafted by C704 as a high level reference summary to be used by decision makers and not as a detailed technical report. Comments have been provided on the quality and the reliability of the data collected, but any engineering considerations with regards to the impact induced by CRL works on the Assets and to the residual risk (associated with long term movements/deformations) to the Assets will be provided by the Main Contractors' close-out/final reports in consultation with CRL/C122.

## **2 Scope**

This document covers the extent of the monitoring equipment installed within the predicted zone of influence of CRL Works on the following Assets:

- The Jubilee Line Running Tunnels and Covered Way (LU/31) located at Canning Town Portal;
- The LU Footbridge located at the Canning Town Junction over the DLR tracks.

### **2.1 Jubilee Line**

The Canning Town Portal is located between the LU stations of North Greenwich and Canning Town and is part of the Jubilee line extension from Green Park to Stratford. The Canning Town Portal comprises a covered way (CW50, occupying the southern end of the structure) and an open-cut section located to the north. The running tunnels (TT436E and TT436W) connect into the portal headwall.

The scope of the installation is defined by the I&M drawing C122-OVE-C2-DDA-CR001\_Z-31124 (see Appendix A).

This includes:

## **C704 Instrumentation - Decommissioning Agreement**

### **Jubilee Line Running Tunnels and Covered Way at Canning Town Portal (LU/31) & LU Footbridge over DLR tracks at Canning Town Junction**

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- Both running tunnels to the south of Canning Town Portal towards North Greenwich station (J006/JEB/1102 to J006/JEB/1154 and J006/JWB/479 to J006/JWB/410).
- The covered way occupying the southern end of Canning Town Portal (J006/JEB/1154 to J006/JEB/1255 and J006/JWB/410 to J006/JWB/309).

## **2.2 LU Footbridge**

The LU Footbridge is located at the Canning Town Junction over the DLR tracks, south of the Canning town station.

The scope of the installation is defined by the I&M drawing C122-OVE-C2-DDA-CR001\_Z-31124 (see Appendix A).

## **3 Definitions**

|   |  |
|---|--|
| <b>Assets</b>                                   | Specific LU interfaces covered by this document (LU/31 & the LU Footbridge over the DLR tracks).   |
| <b>CRL</b>                                      | Crossrail.   |
| <b>C122</b>                                     | CRL Contract that assessed excavation-induced ground movements and acts as Designer of C701/C704 I&M systems. C122 assess stability of post-construction monitoring data and confirm no objection to decommissioning of C701/C704 systems.   |
| <b>C701</b>                                     | CRL Contract responsible for the installation/maintenance of the automatic I&M systems in LU/31.   |
| <b>C704</b>                                     | CRL Contract responsible for installation of the I&M system on the LU Footbridge and for maintenance and decommissioning of the I&M systems in LU/31 and on the LU Footbridge. Power isolation between power source and the Power and Communications Enclosure will be carried out by LUL. |
| <b>EL beam</b>                                  | Electrolevel beam.   |
| <b>I&amp;M</b>                                  | Instrumentation & Monitoring.  |
| <b>LUL</b>                                      | London Underground Limited.  |
| <b>PLP</b>                                      | Precise Levelling Point.   |
| <b>Predicted zone of influence of CRL works</b> | Area located within the predicted 1mm greenfield ground surface settlement contour associated with CRL works.  |
| <b>Relevant parties</b>                         | Parties requested to formally agree decommissioning of the automatic I&M system presented in this document: <ul style="list-style-type: none"><li>- <i>London Underground Limited (LUL);</i></li><li>- <i>CRL Chief Engineers Group (CEG).</i></li></ul>                                   |
| <b>RTS</b>                                      | Robotic Total Station.   |

**Jubilee Line Running Tunnels and Covered Way at Canning Town Portal (LU/31)  
& LU Footbridge over DLR tracks at Canning Town Junction**

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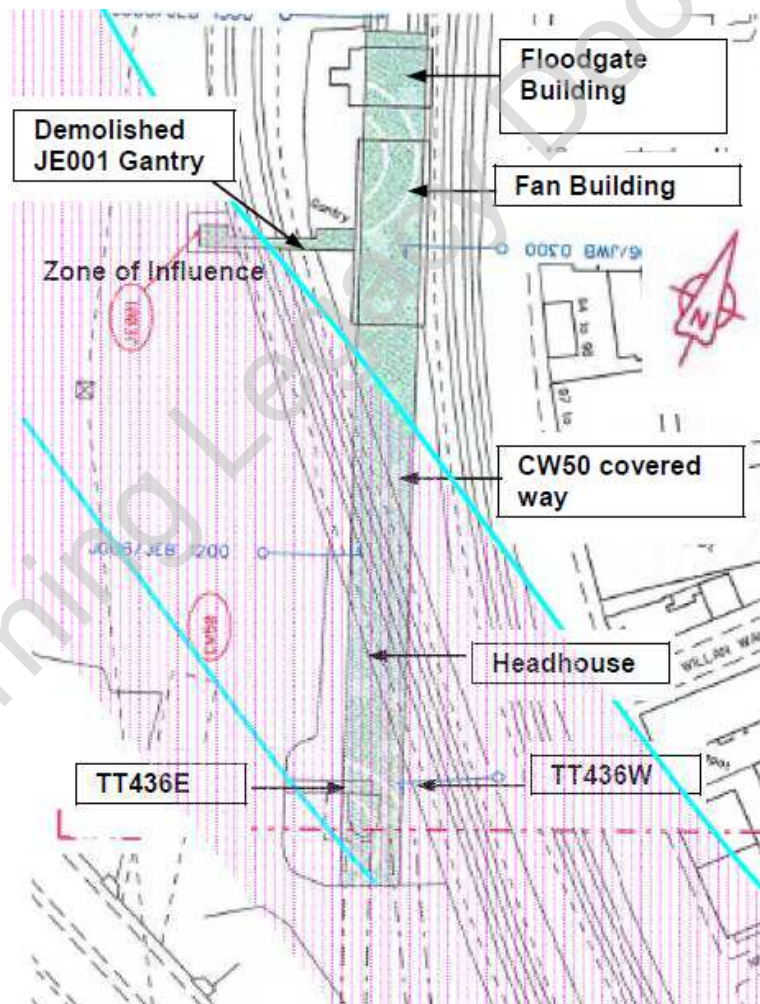
## 4 The Assets

The following sections comprise a brief description of the Assets under consideration. A presentation of the Crossrail works that have affected these assets is also included.

Further details are included in the *Assessment of Ground Movement Effects: LU/31 Jubilee Line at/near Canning Town Portal* (C122-OVE-C2-RAN-CR144\_PT003-00003) and in the *Design Interface Statement DLR Limmo to Royal Victoria (DLR/06) Volume 2 - Royal Victoria Ancillary Structures* (C122-OVE-C2-XST-CR140-50002).

### 4.1 The Jubilee Line Running Tunnels and Portal at Canning Town (LU/31)

The Canning Town Portal is located between the LU stations of North Greenwich and Canning Town. The Canning Town Portal comprises a covered way, occupying the southern end of the structure and an open-cut section located to the north (see Figures 1 & 2 below). A 'fan building' and a floodgate building are both located to the west of the open-cut section. Two individual running tunnels extend south of the portal towards North Greenwich station.



**Figure 1: Jubilee Line assets included in interface LU/31 (Extract from Tube Lines Drawing J006/4). The blue lines do NOT represent the zone of influence associated with Crossrail works.**

**Jubilee Line Running Tunnels and Covered Way at Canning Town Portal (LU/31)  
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From the review of the available information it is understood that the covered part of the Canning Town Portal was built using cut and cover techniques and top-down construction method. The tunnels were constructed using bolted pre-cast concrete trapezoidal segmental linings.

**4.1.1 Covered Way**

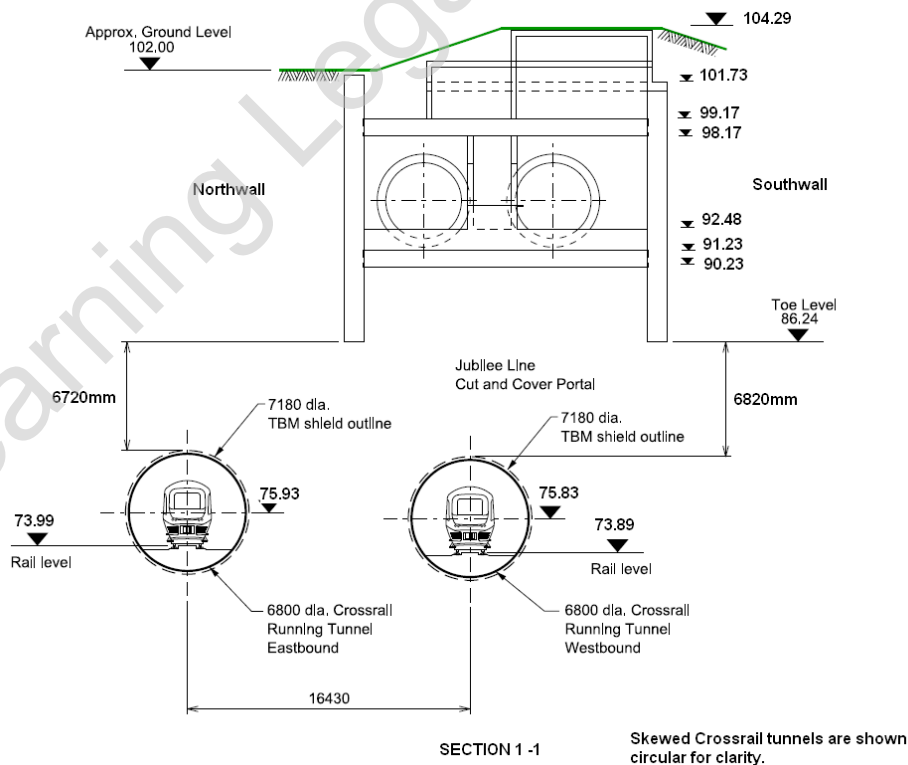
The covered section J006\CW50 is a reinforced concrete box structure formed by base and roof slabs spanning between 1200mm diameter secant pile walls. The structure is approximately 150m long, of which approximately 85m are located within the zone of influence. The roof slab supports the backfill material forming the finished ground level and, on the southern side of the portal, the head house structure (10m x 15m in plan). The thickness of the base slab varies between 750 to 1000mm, whereas the roof slab is 1000mm thick. Central walls separating the eastbound and westbound tracks run along the portal.

**4.1.2 Running Tunnels**

The running tunnels J006\TT436E and J006\TT436W that connect into the portal headwall have internal and external diameters of 4.4m and 4.9m respectively. The tunnel lining is constructed from bolted pre-cast concrete segmental linings, with each ring comprising 5 trapezoidal segments and a key.

**4.1.3 Interface – Bored Tunnel to Box**

The interface connections are at JWB0410 and JEB 1154 for the westbound and east bound tunnels respectively. At these positions it appears from the information available that the pre-cast concrete rings which form the lining to the bored tunnel connect directly to a 600mm thick reinforced concrete headwall.



**Figure 2: Cross-section 1 at Canning Town portal. Extract from Dwg. C122-OVE-C4-DDBCR001\_Z-22470**

**Jubilee Line Running Tunnels and Covered Way at Canning Town Portal (LU/31)  
& LU Footbridge over DLR tracks at Canning Town Junction**

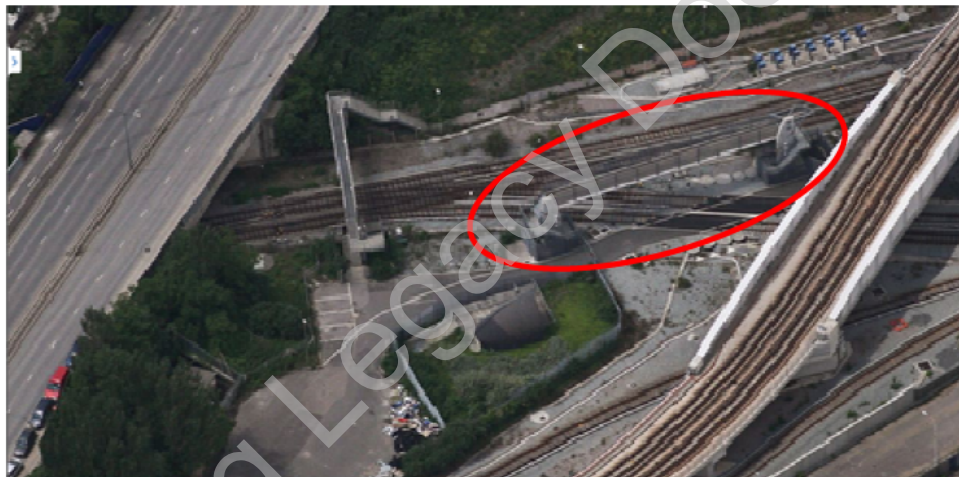
**C704-XRL-C-AAG-J003-50001 Rev 1.0**

An inspection (for analytical assessment purposes) of the covered way, the running tunnels and the connection between covered way and tunnels has been carried out by CRL and was overseen by London Underground in November 2010. These structures were observed to be in a serviceable condition with no obvious signs of structural distress. The observations made during this survey have been used to confirm assets details used in the assessment. Further details of the inspection for analytical assessment can be found in the 'Inspection report' (C122-OVE-C2-RAN-CR144\_PT003-00004).

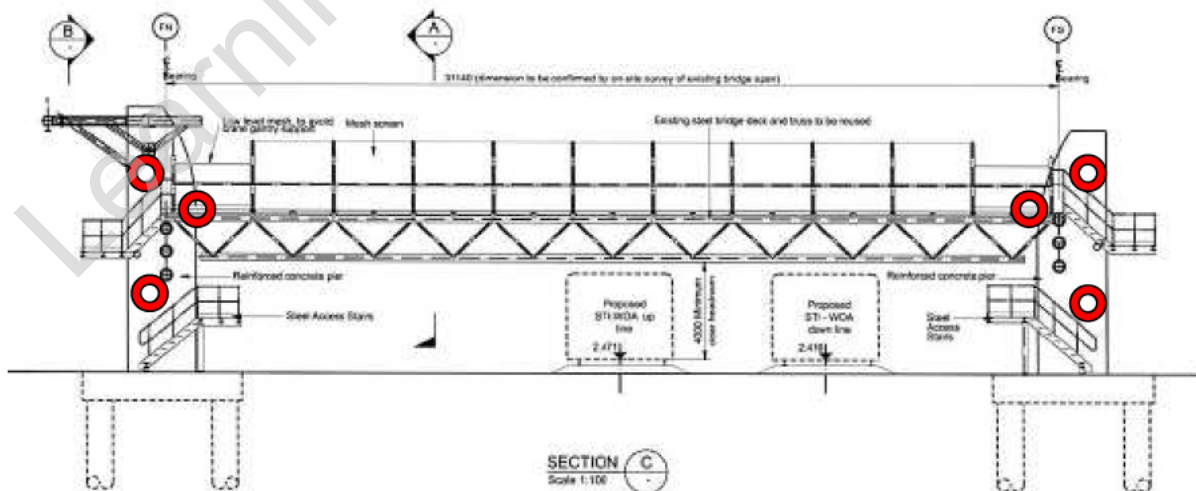
**4.2 The LU Footbridge over DLR tracks**

The LU Footbridge is located at the Canning Town Junction over the DLR tracks, south of the Canning town station (see Figure 3).

A typical cross section through the structure is included in Figure 4, showing the R.C. piles, pile caps & piers, staircases and triangulated steel truss superstructure. Further details are included in the *Design Interface Statement DLR Limmo to Royal Victoria (DLR/06) Volume 2 - Royal Victoria Ancillary Structures (C122-OVE-C2-XST-CR140-50002)*.



**Figure 3: Location of the LU Footbridge under consideration (view from the North)**



**Figure 4: Cross-section through the LU Footbridge (the red circles represent the mini prisms installed by C704 on the structure as described in Section 6.2)**

**Jubilee Line Running Tunnels and Covered Way at Canning Town Portal (LU/31)  
& LU Footbridge over DLR tracks at Canning Town Junction**

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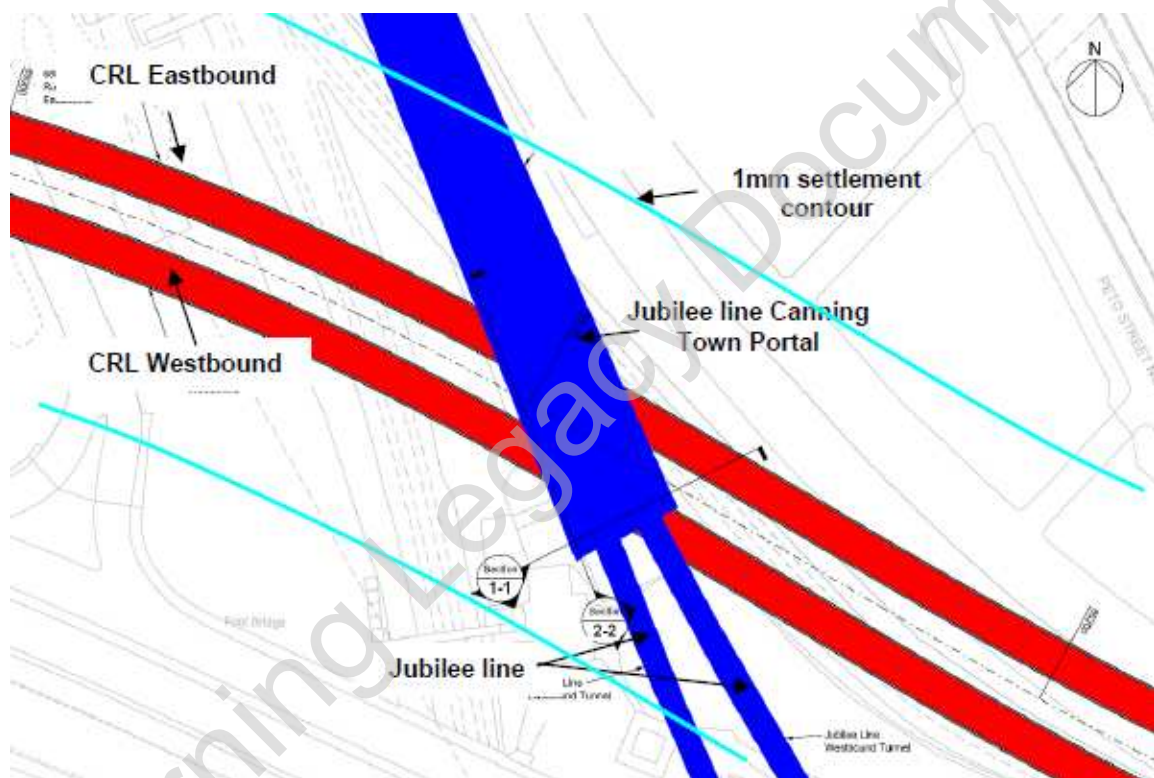
**4.3 CRL Works affecting the Assets**

The CRL works that have affected the two Assets are the direct crossings where the CRL Eastbound and Westbound tunnels that form part of Tunnel Drive G and were built under construction contract C305, underpass the Assets.

The vertical alignment of the Crossrail tunnels is approximately 24m below ground level at the interface location. The Crossrail tunnels internal diameter will be 6.2m and the excavated diameter 7.18m. The tunnel lining will comprise pre-cast fibre-reinforced concrete segments.

**4.3.1 Jubilee Line**

The location of the interface between the proposed Crossrail tunnels and the existing Canning Town Portal is presented in plan in Figure 5 below.



**Figure 5: Crossrail bored tunnels alignment in reference to the Jubilee line bored tunnels and Canning Town Portal**

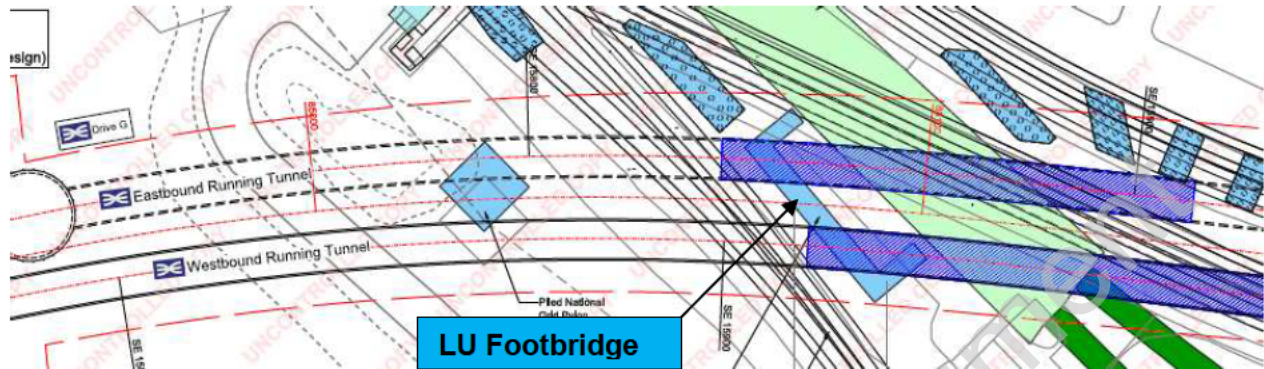
The minimum clearance between the Jubilee line tunnels and the toe level of the piled perimeter wall of the Canning Town Portal is approximately 5 m, whereas the underside of the Portal base slab is approximately 10 m above the Crossrail running tunnels.

The inverts of the Jubilee Line tunnels are located approximately 11.5m above the Crossrail tunnels.

The TBM tunnels have been launched from the Limmo Peninsula Auxillary Shaft which is located some 140m to the west of the Canning Town Portal towards the CRL Victoria Dock Portal to the east of it. This structure, which replaced the original twin shafts at the same location, had no influence on ground movements at LU/31.

#### 4.3.2 LU Footbridge

The location of the interface between the proposed Crossrail tunnels and the existing LU Footbridge is presented in plan in Figure 6 below.



**Figure 6: Crossrail bored tunnels alignment in reference to the LU Footbridge over the DRL tracks at the Canning Town Junction**

The minimum clearance between the Crossrail running tunnels and the toe level of the piles of the LU Footbridge is approximately 5 m.

## 5 Predicted impact of CRL Works on the Assets

The methodology used to assess the predicted impact of CRL works on the Jubilee Line Running Tunnels and Portal at Canning Town (LU/31) and on the LU Footbridge and a summary of the results of these assessments are presented in the following documents:

- *Assessment of Ground Movement Effects: LU/31 Jubilee Line at/near Canning Town Portal (C122-OVE-C2-RAN-CR144\_PT003-00003).*
- *Design Interface Statement DLR Limmo to Royal Victoria (DLR/06) Volume 2 - Royal Victoria Ancillary Structures (C122-OVE-C2-XST-CR140-50002).*

## 6 C701/C704 I&M Systems

### 6.1 Jubilee Line

Instrumentation has been installed in the running tunnels (both Eastbound and Westbound) and in the cut-and-cover box tunnels of the Jubilee Line at/near Canning Town Portal.

- Jubilee line Eastbound running tunnel (J006/JEB/1102 to J006/JEB/1154)
- Jubilee line Westbound running tunnel (J006/JWB/479 to J006/JWB/410)
- Jubilee line Eastbound covered way tunnel (J006/JEB/1154 to J006/JEB/1255)
- Jubilee line Westbound covered way tunnel (J006/JWB/410 to J006/JWB/309)

The automatic and manual I&M system to be installed in the asset under consideration was specified on drawings C122-OVE-C2-DDA-CR001\_Z-31124, C122-OVE-C2-DDB-CR001\_Z-32018 and C122-OVE-C2-DDB-CR001\_Z-32021 (see Appendix A).

Monitoring frequencies and trigger values were specified in *Instrumentation and Monitoring Plan: LU/31 Jubilee Line at/near Canning Town Portal (C122-OVE-C2-RGN-CR144\_PT003-50001)*.



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The installation of this system in LU/31 has been carried out by C701.

As described in detail in C701-ITM-C-RGN-CR144\_SH011-50001 (C701 Installation Report for LU/31), the I&M system comprises the following:

- 66 No. Mini prisms in arrays of three (33 mini prisms or 11 arrays in the east and westbound covered way) at 10m centres.
- 10 No. Mini prisms (1 at the ends of each electrolevel beams string (4 No.) and 3 reference prisms at each end of the worksite outside the zone of influence east bound and westbound (6 No.)).
- 4 No. Robotic Total Station's (2 in the eastbound covered way and 2 in the westbound covered way).
- 52 No. electrolevel beams (24 in the eastbound bored tunnel and 28 in the westbound bored tunnel).
- 2 No. electrolevel beam double multiplexer (Mux) enclosures and associated equipment (1 in the eastbound bored tunnel and 1 in the westbound bored tunnel).
- 116 No. Precise Levelling Point track markings at 2m centres (48 in pairs in the eastbound bored tunnel and 68 in pairs in the westbound bored tunnel).
- 42 No. Reflective Retro Targets in arrays of 3 at 10m centres (6 arrays of 3 in the eastbound and 8 arrays of 3 in the westbound tunnel).
- 4 No. data logger enclosures (2 in the eastbound covered way and 2 in the westbound covered way).
- 1 No. Transformer and 1 No. Comms enclosure in the portal access building.

It is proposed to:

- Leave the communication line in place for future use but to end the associated contract with the relevant provider.
- Leave the retro targets in place providing that they are not facing the direction of travel.

Further details are included in C701-ITMO1-GMS-CR144\_SH011-50001 (C701 Method Statement for LU/31).

## **6.2 LU Footbridge**

Instrumentation has been installed on the LU Footbridge over the DRL tracks located at the Canning Town Junction. The automatic I&M system to be installed in the asset under consideration was specified on drawing C122-OVE-C2-DDA-CR001\_Z-31124.

The installation of this system has been carried out by C704.

As described in detail in C704-SOL-C2-RGN-J003-50042 (C704 Installation Report for the LU Footbridge) and shown in Figure 4, the I&M system comprises 6 no. mini prisms (4 no. on the abutments of the bridge and 2 no. on the deck). These prisms have been monitored automatically by the existing RTS's installed by C701 on DLR assets.

Further details are included in C704-SOL-O1-GMS-J003-50001 (C704 Method Statement for the LU Footbridge).

## **7 Monitoring Results vs. CRL Construction Works**

### **7.1 Jubilee Line**

*Instrumentation and Monitoring Plan: LU/31 Jubilee Line at/near Canning Town Portal (C122-OVE-C2-RGN-CR144\_PT003-50001)* presents trigger values for the following purposes:

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- Asset protection;
- Construction control;
- Track Geometry and Tunnel Clearance.

The present document has been intentionally drafted by C704 as a high level reference summary to be used by decision makers and not as a detailed technical report. It is not the purpose of this document to analyse in detail the construction monitoring results for all monitored parameters, compare these results with associated trigger values and provide engineering considerations on residual risk to the Asset. A brief summary of current trends for LU/31 is included in Appendix C.

The CRL works that have affected the Asset are dated:

- July 2014 (Westbound TBM drive);
- September 2014 (Eastbound TBM drive).

The construction monitoring data recorded by the automatic systems (electrolevels and prisms) indicate a clear correlation with these two excavation phases (see graphs in Appendix C).

The signature of the CRL works associated with the Limmo Peninsula Auxillary Shaft is not identifiable in the construction monitoring data suggesting that these works did not induce any detectable movement in the Assets.

The data recorded from the automatic systems during both construction and closeout monitoring regimes are considered reliable and non-construction related variations are within the expected repeatability for this kind of systems. The data collected reflect the effect of the movements induced by the two TBM drives on the Asset and they are generally consistent with the manual monitoring results obtained by C305 (not presented in this document).

#### 7.1.1 Electrolevels (Running Tunnels)

The settlement curves associated with the first TBM drive (Westbound) and with the cumulative effect of both TBM drives are easily identifiable in the data recorded by the electrolevels (installed longitudinally to the Asset to cover the extent of the running tunnels located within the predicted zone of influence). The maximum cumulative settlement recorded by this automatic system following the two TBM drives is approx.:

- 5.5mm for the Jubilee Line Westbound Running Tunnel;
- 4.5mm for the Jubilee Line Eastbound Running Tunnel.

Results obtained by C305 from manual trackshoe precise levelling have been used to confirm the actual extent of the zone of influence and regularly validate the fixity assumption applied to the southern end of the chain of electrolevels throughout construction works.

The post-TBM data show a progressive stabilization over the closeout monitoring period. The electrolevels have recorded is virtually no vertical displacement over the last 3 months.

#### 7.1.2 Mini Prisms (Covered Way)

The data collected by the automatic optical system (installed in the section of the covered way located within the predicted zone of influence) are considered reliable and to an acceptable degree of accuracy.

The data show a good correlation with the two construction stages that affected the Asset and a satisfactory match with the manual data collected by C305 (not presented in this document).

**Jubilee Line Running Tunnels and Covered Way at Canning Town Portal (LU/31)  
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The maximum cumulative settlement recorded by this automatic system following the two TBM drives is approx.:

- 4.5mm for the Jubilee Line Westbound Running Tunnel;
- 4mm for the Jubilee Line Eastbound Running Tunnel.

This magnitude of movement is similar to that recorded by the electrolevels in the running tunnels.

## **7.2 LU Footbridge**

The data collected by the automatic optical system are considered reliable and to an acceptable degree of accuracy.

The data show a good correlation with the two construction stages (TBM drives) that affected this asset.

The maximum cumulative settlement recorded by this automatic system following the two TBM drives is approx. 11mm at the Northern end of the bridge (which lies directly above the Eastbound TBM drive). The maximum cumulative differential settlement recorded between the Northern and the Southern ends of the structure (approx. 4mm) is consistent with the location and orientation of the bridge in relation to the alignment of the two TBM tunnels.

## **8 Assessment of Closeout Trends**

As highlighted in Section 7 and presented in Appendix C, the two TBM excavation phases are clearly identifiable in the construction monitoring data of the I&M Systems.

Following the Eastbound TBM drive (September 2014), the closeout monitoring regime has been implemented and it is currently on-going.

For the Jubilee Line, continuous monitoring is currently ongoing for the electrolevels in the running tunnels, while the RTS's have been removed from the associated brackets in the covered way in January 2015 (following informal agreement with C122 and LU) based on the stability shown by the post-construction monitoring data. Current closeout trends for the electrolevels highlight a general stabilization with virtually no residual (post-construction) variations (see graphs in Appendix C).

For the LU Footbridge, continuous monitoring is currently ongoing. Current closeout trends for highlight a general stabilization with virtually no residual (post-construction) movements (see graphs in Appendix C).

Based on this, it is proposed to decommission the I&M automatic systems (electrolevels, prisms and RTS brackets) currently installed in LU/31 and the mini prisms installed on the LU Footbridge (the RTS's currently monitoring these prisms are installed on DLR assets and will be decommissioned at a later stage).

It is however proposed to leave the retro targets in place (Jubilee Line Running Tunnels) providing that they are not facing the direction of travel. Their actual orientation will be assessed during the pre-decommissioning site walkthrough.

## **9 Reference Documents**

- C701-ITM-O1-GMS-CR144\_SH011-50001 (C701 Method Statement for LU/31)
- C701-ITM-C-RGN-CR144\_SH011-50001 (C701 Installation Report for LU/31)

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- C122-OVE-C2-RAN-CR144\_PT003-00003 (C122 Assessment Report for LU/31)
- C704-SOL-O1-GMS-J003-50001 (C704 Method Statement for the LU Footbridge)
- C704-SOL-C2-RGN-J003-50042 (C704 Installation Report for the LU Footbridge)
- C122-OVE-C2-XST-CR140-50002 (C122 Assessment Report for the LU Footbridge).
- C122-OVE-C2-RGN-CR144\_PT003-50001 (C122 I&M Plan for LU/31 and the LU Footbridge)
- C122-OVE-C2-DDA-CR001\_Z-31124, C122-OVE-C2-DDB-CR001\_Z-32018 and C122-OVE-C2-DDB-CR001\_Z-32021 (C122 I&M Drawings)
- C122-OVE-C2-RAN-CR144\_PT003-00004 (C122 Inspection report)
- C305-XRL-C2-RGN-CR144-50002 (C305 Baseline Monitoring Report for Jubilee Line Track and Structure LU31)

## **10 Appendices**

**Appendix A** – I&M Drawings C122-OVE-C2-DDA-CR001\_Z-31124

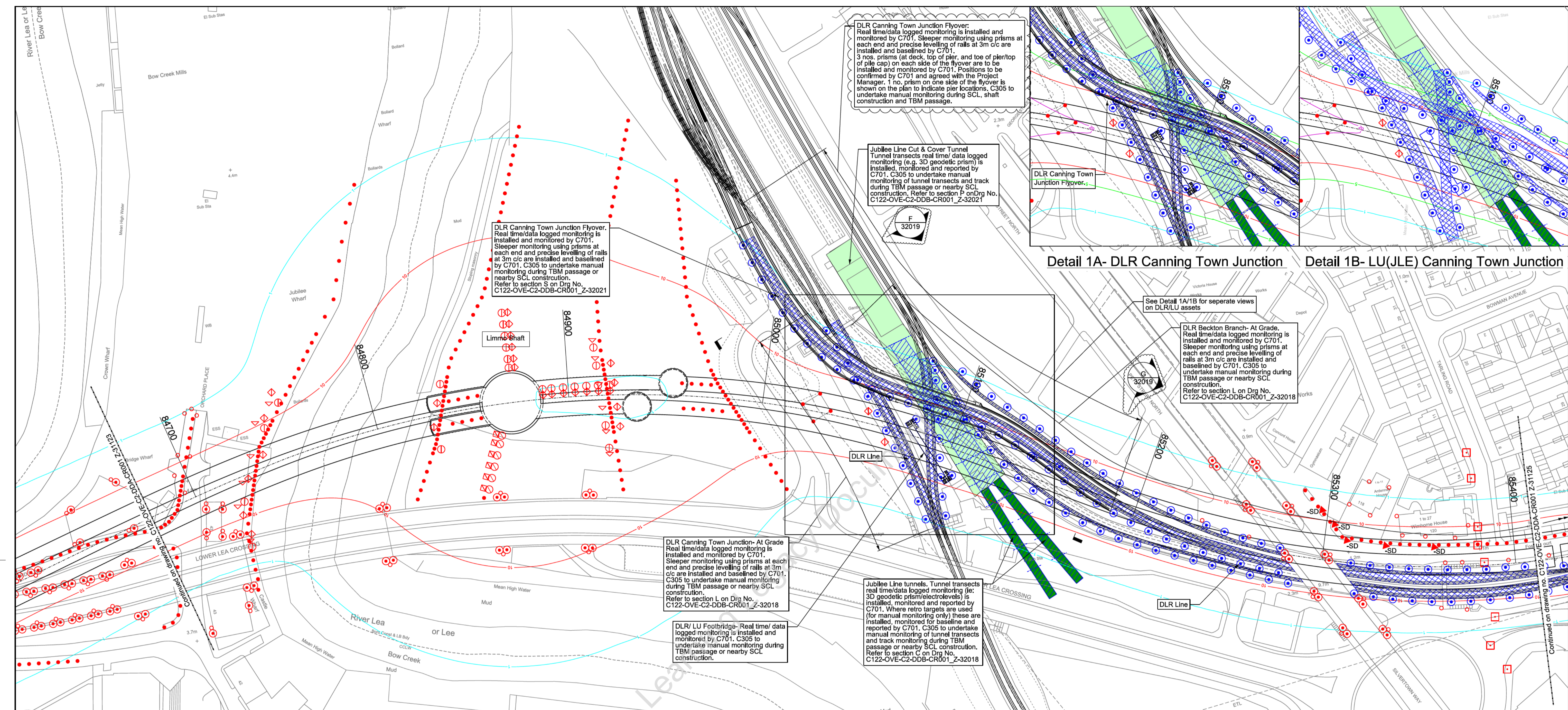
C122-OVE-C2-DDB-CR001\_Z-32018

C122-OVE-C2-DDB-CR001\_Z-32021

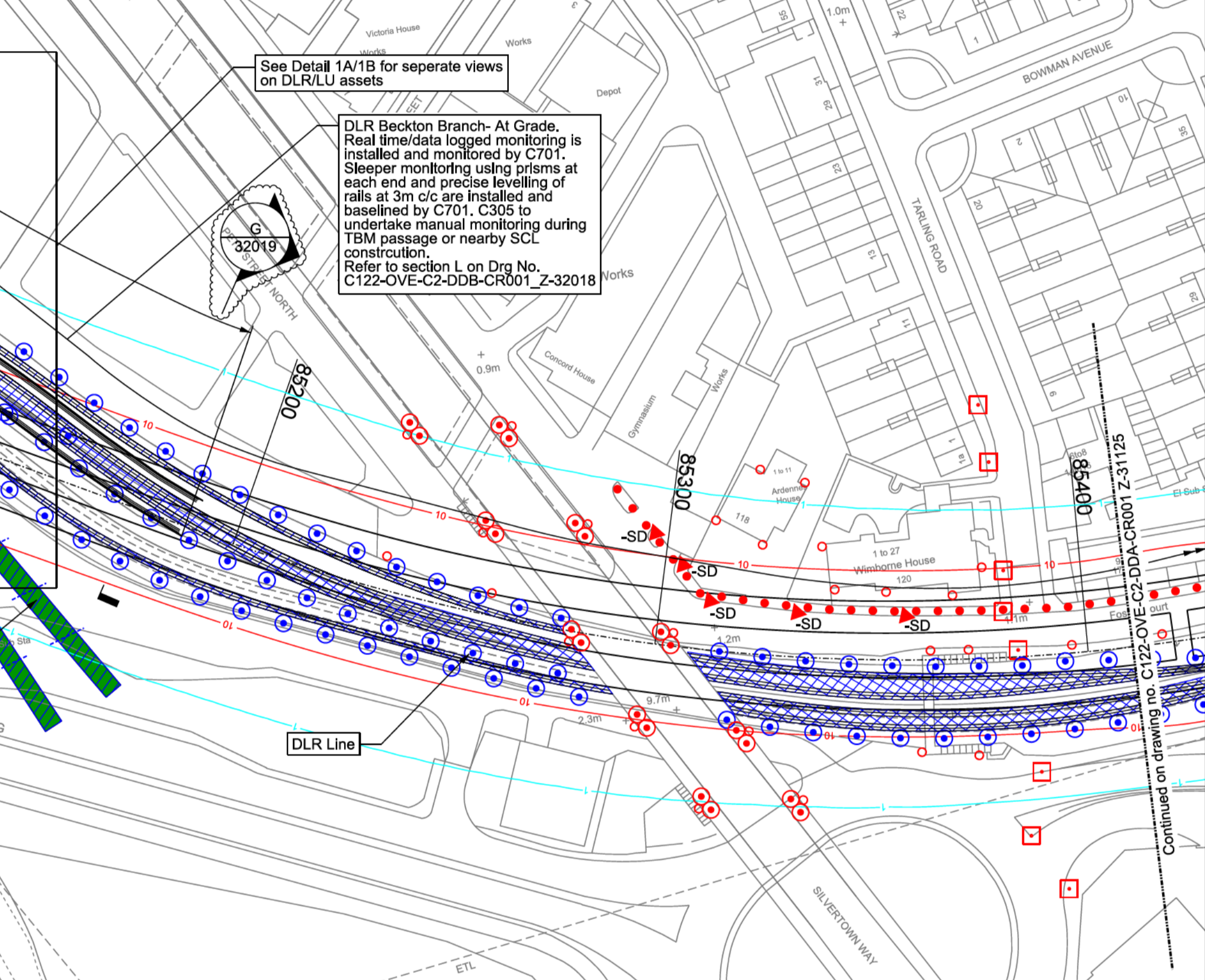
**Appendix B** – I&M As-Built Drawing

**Appendix C** – Summary of monitoring results for LU/31 & LU Footbridge

## **APPENDIX A**



Detail 1A- DLR Canning Town Junction    Detail 1B- LU(JLE) Canning Town Junction



**Legend**

**Parties Responsible for the installation of the I & M**

- C701
- Others

**General**

- Tunnel Alignment
- Track shoe monitoring at 2m centres
- Track shoe monitoring at 3m centres

**Settlement Contours**

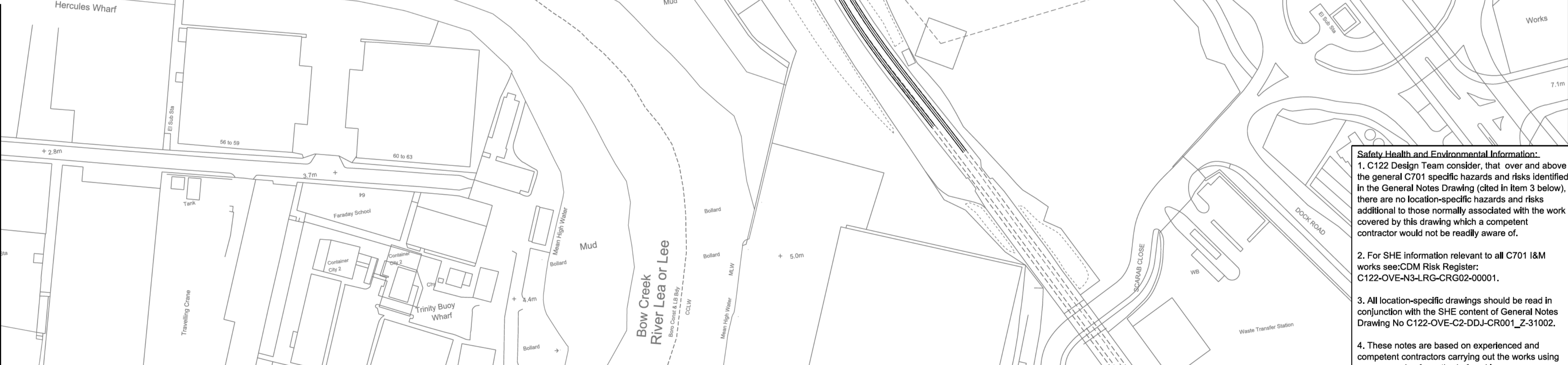
- 1mm Settlement Contour
- 10mm Settlement Contour

**Existing Structures**

- Bored Tunnels
- Cut & Cover Tunnels
- Structures with I & M Commitments
- Mains Sewer (greater than 1.5m<sup>2</sup>)

**Instruments and Monitors**

- Automated Total Station
- Basset Convergence System
- Electrolevel Beams
- Extensometer - Rod
- Inclinometer
- Inclinometer - Electrolevels
- Piezometer - Vibrating Wire
- 3D Geodetic Prisms
- Sockets - BRE Type - Structure
- Studs - Precise Ground Levelling
- Sparse Monitoring Point
- Monitoring Transect in Tunnels
- Deep Datum
- Shallow Datum - Utilities



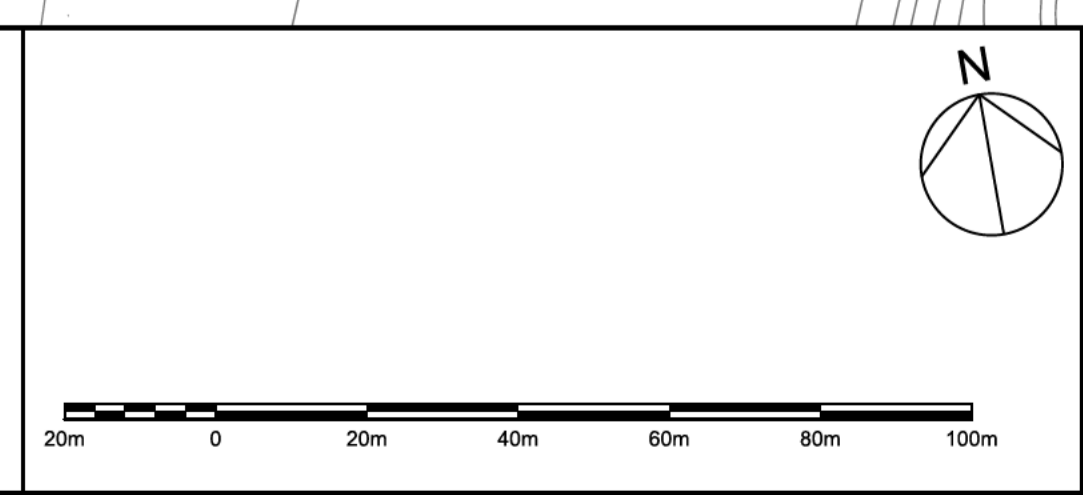
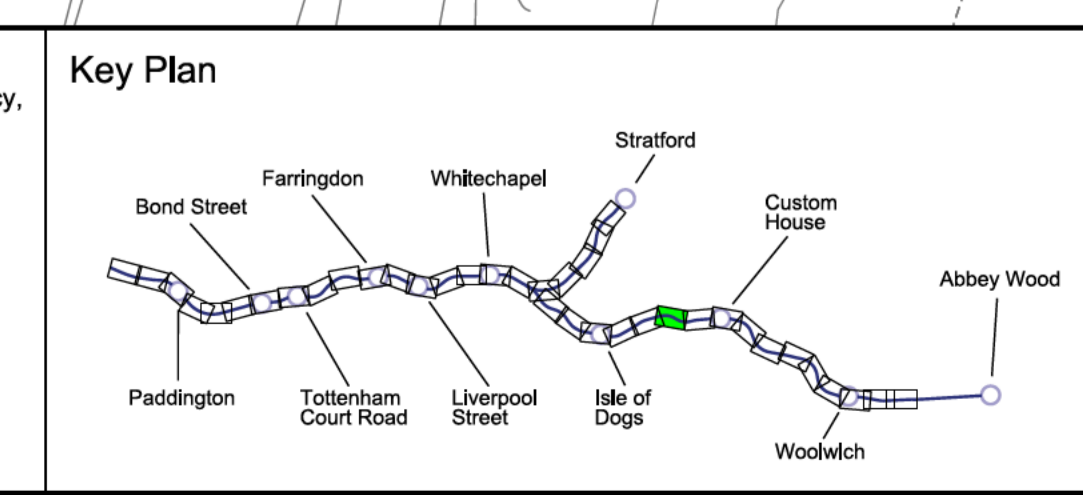
**Notes**

1. For Instrumentation & Monitoring general notes, schedule and monitoring frequency, refer to Drg Nos. C122-OVE-DDJ-CR001\_Z-31002 and C122-OVE-DDJ-CR001\_Z-31007.

| Rev. | Date       | Description   | By | Chkd | App | Auth |
|------|------------|---|----|------|-----|------|
| P01  | 25/11/2010 | Issued for Information                                    | JG | RB   | RM  | —    |
| P02  | 25/03/2011 | —   | JG | CC   | PC  | —    |
| P03  | 14/10/2011 | Minimum requirement for Instrumentation and Monitoring    | AR | JA   | SR  | —    |
| C01  | 09/11/2011 | Issued as FIR for construction                            | AR | JA   | SR  | IT   |
| P04  | 23/05/2012 | Minimum Requirements for I & M - DLR Canning Town Flyover | JJ | JA   | PC  | —    |
| C02  | 29/05/2012 | Issued as FIR for construction                            | JJ | JA   | PC  | IT   |

**Notes**

1. For Instrumentation & Monitoring general notes, schedule and monitoring frequency, refer to Drg Nos. C122-OVE-DDJ-CR001\_Z-31002 and C122-OVE-DDJ-CR001\_Z-31007.



**Crossrail**

**Contract 1**  
Bored Tunnels (Alignment and Track)

**Original:**  
Ove Arup & Partners Limited

**Location:**  
Canning Town

**Title:**  
Instrumentation & Monitoring  
Combined I & M  
Route-wide Plan Sheet 24 of 38  
C701

**Scale:**  
1:1000@A1

**Drawing and CAD file No.:**  
C122-OVE-C2-DDA-CR001\_Z-31124

**By:** J.JANUSZKIEWICZ  
**CHK:** J.APTEJ  
**APP:** P.CHAMLEY  
**Auth:** L.THOMSON

**Rev:** C02  
**Suitability:** A

**www.crossrail.co.uk**

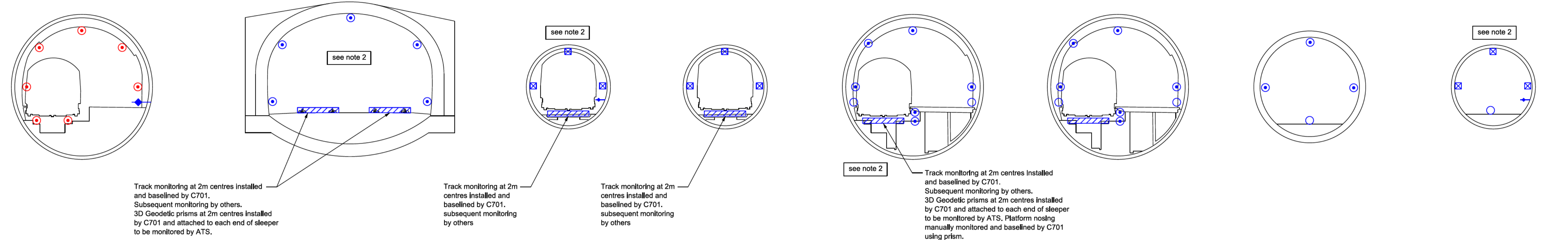
**Safety Health and Environmental Information:**

1. C122 Design Team consider, that over and above the general C701 specific hazards and risks identified in the General Notes Drawing (cited in item 3 below), there are no location-specific hazards and risks additional to those normally associated with the work covered by this drawing which a competent contractor would not be readily aware of.
2. For SHE information relevant to all C701 I&M works see:CDM Risk Register: C122-OVE-N3-LRG-CRG02-00001.
3. All location-specific drawings should be read in conjunction with the SHE content of General Notes Drawing No C122-OVE-C2-DDJ-CR001\_Z-31002.
4. These notes are based on experienced and competent contractors carrying out the works using an approved safe method of working.

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Transects at 10m centres. Track monitoring at 2m centres for LU and 3m centres for NR tracks



**Section A - A**  
Indicative Cross-Section of LU / TCR Transects

**Section B - B**  
Indicative Cross-Section of cut & cover tunnel

**Section C - C**  
Indicative Cross-Section of LU running tunnel Central, Victoria, Bakerloo, Northern, Jubilee & Piccadilly lines  
Electrolevels to be continuous and extend between extents of transects (except in station tunnels)

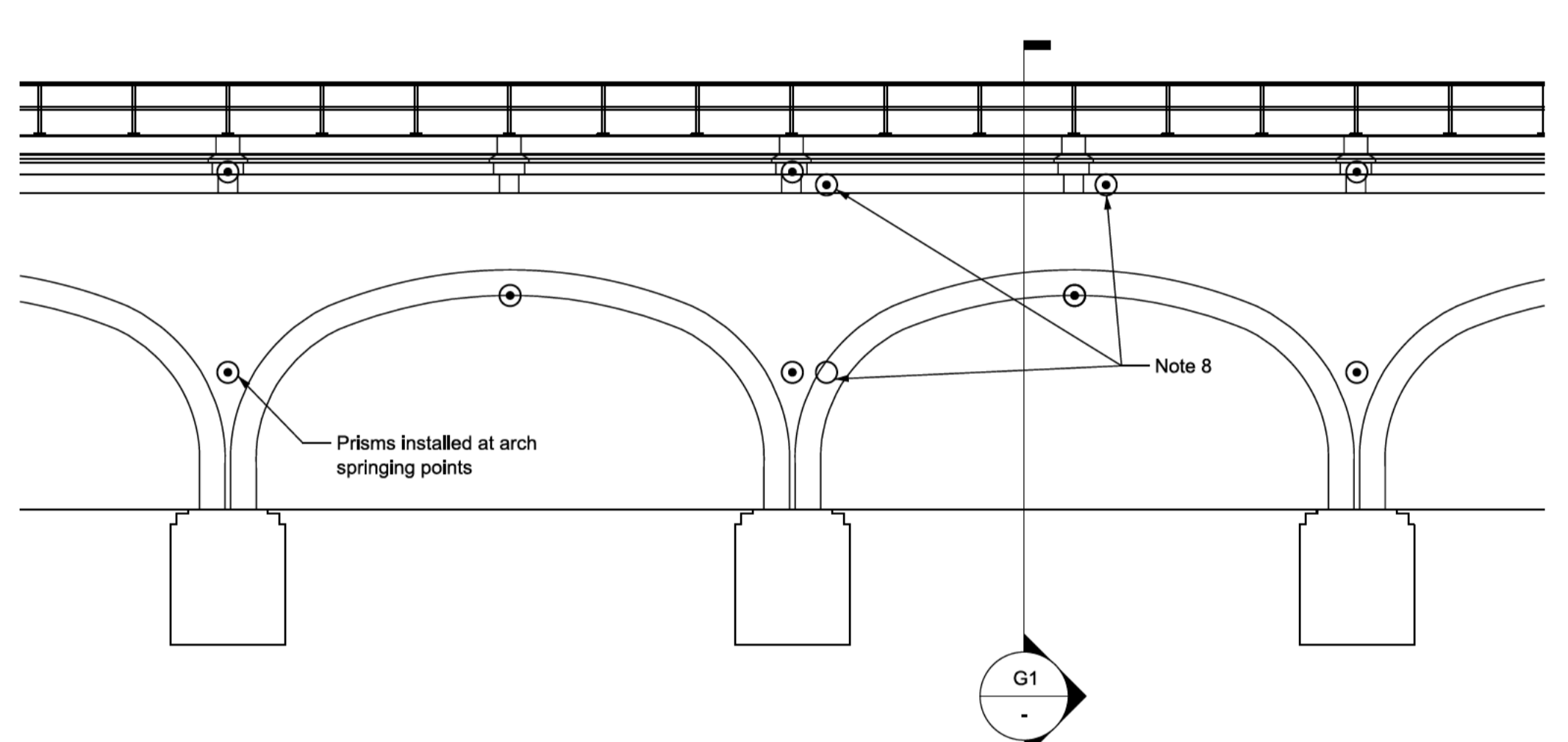
**Section C1 - C1**  
Indicative Cross-Section of LU running tunnel Central Line at Pudding Mill Lane

**Section D - D**  
Indicative Cross-Section of LU platform tunnel Central, Northern and Piccadilly lines

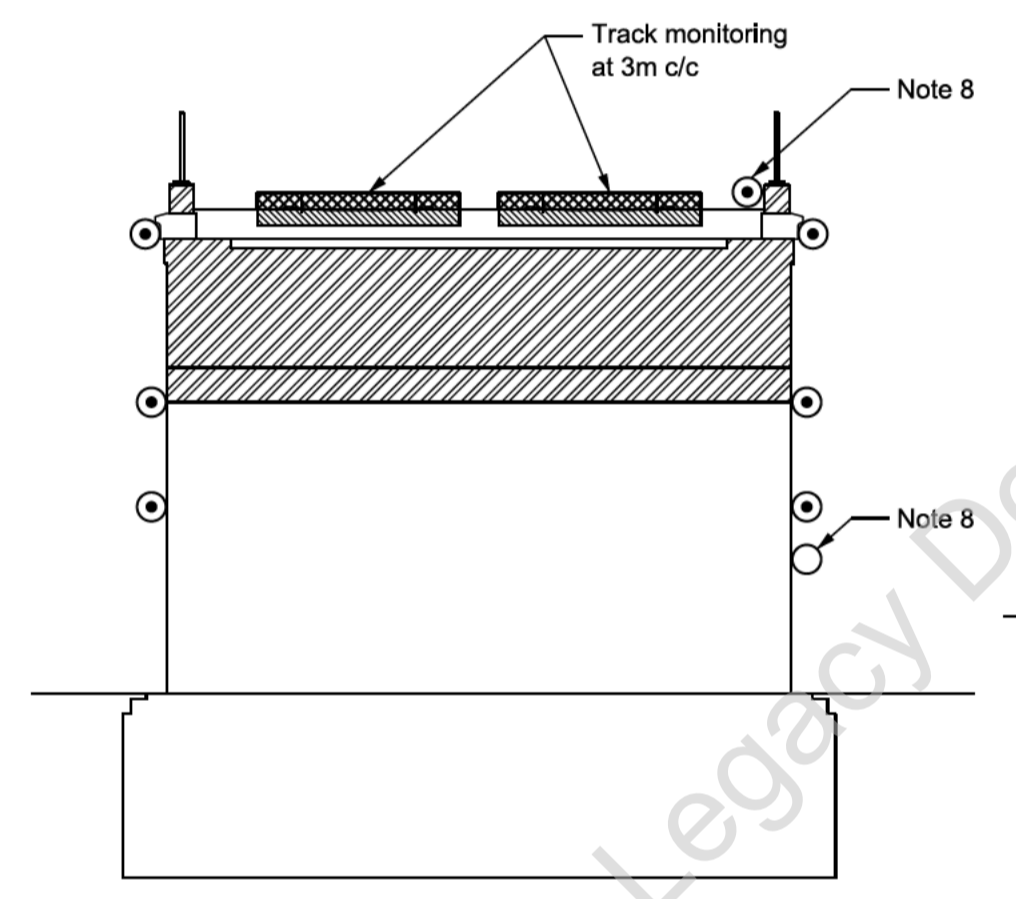
**Section D1**  
Indicative Cross-Section of Northern Line platforms for Moorgate Station

**Section E - E**  
Indicative Cross-Section of BT Statutory Authority Service tunnel, Post Office tunnel and general cable tunnels

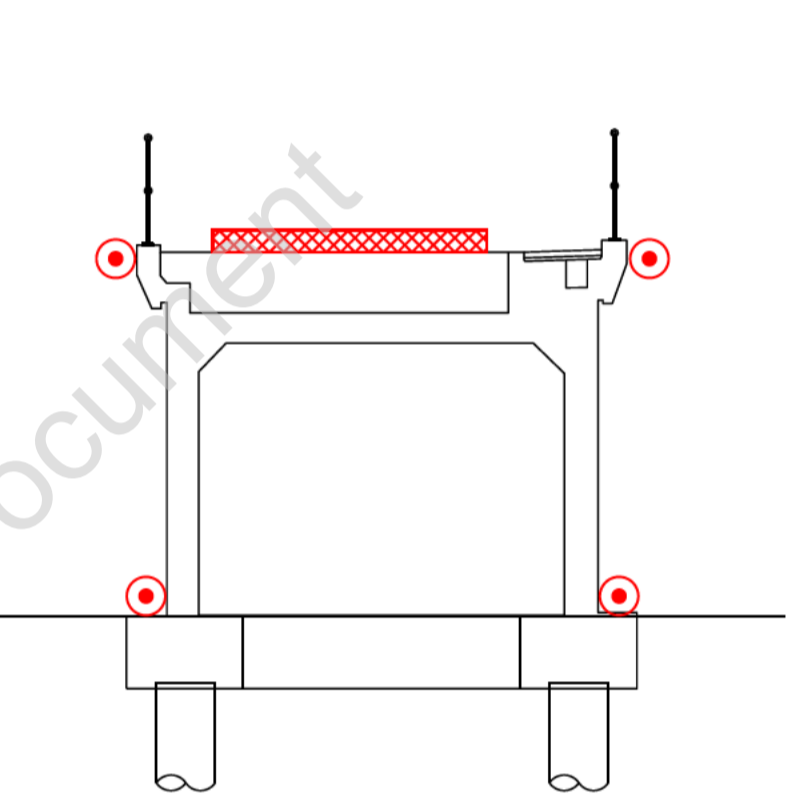
**Section F - F**  
Cross passages



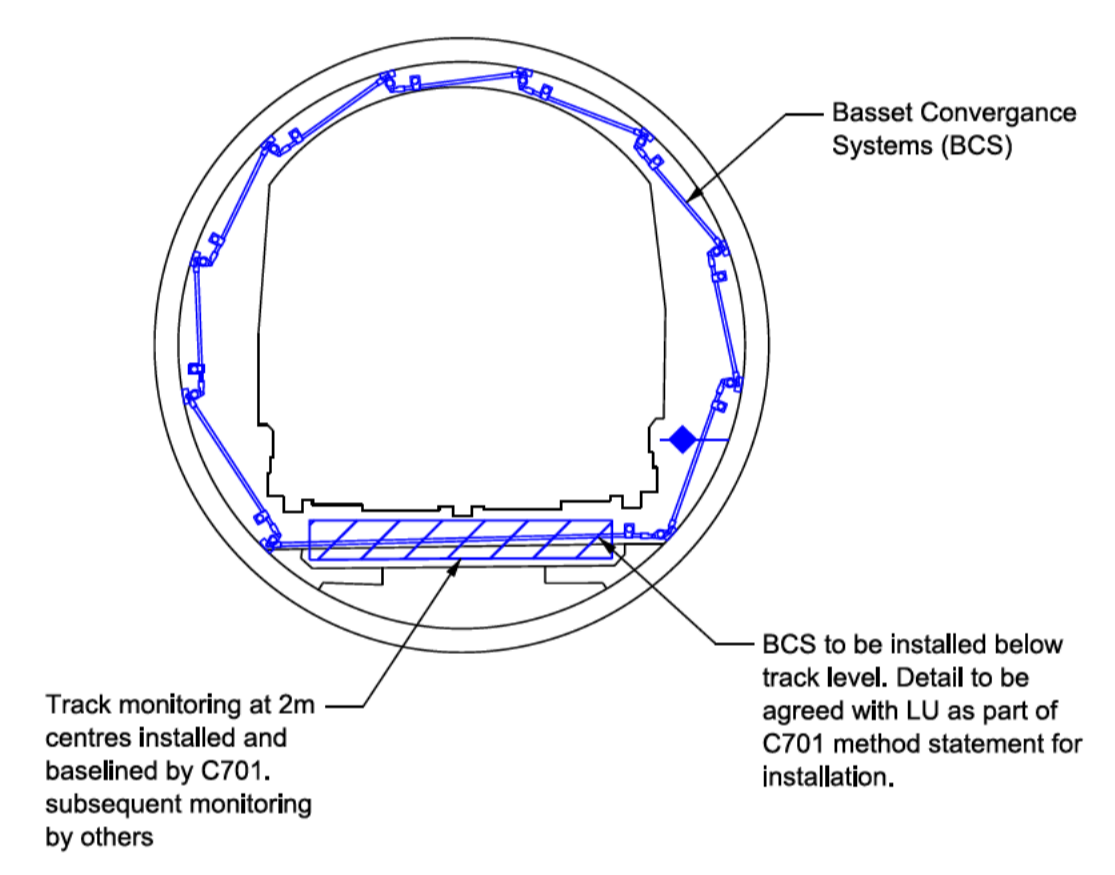
**Elevation G - G**  
Indicative Elevation, masonry arch Viaducts  
-DLR Limehouse Viaduct, (by others)  
-NR Tilbury & southend Viaduct (by C701)  
-LU District Line Viaduct- Bow Road to Bromley by Bow (by C701)



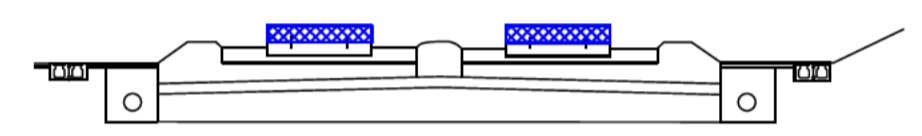
**Section G1**  
Indicative Elevation, masonry arch Viaducts  
-DLR Limehouse Viaduct, (by others)  
-NR Tilbury & southend Viaduct (by C701)  
-LU District Line Viaduct- Bow Road to Bromley by Bow (by C701)



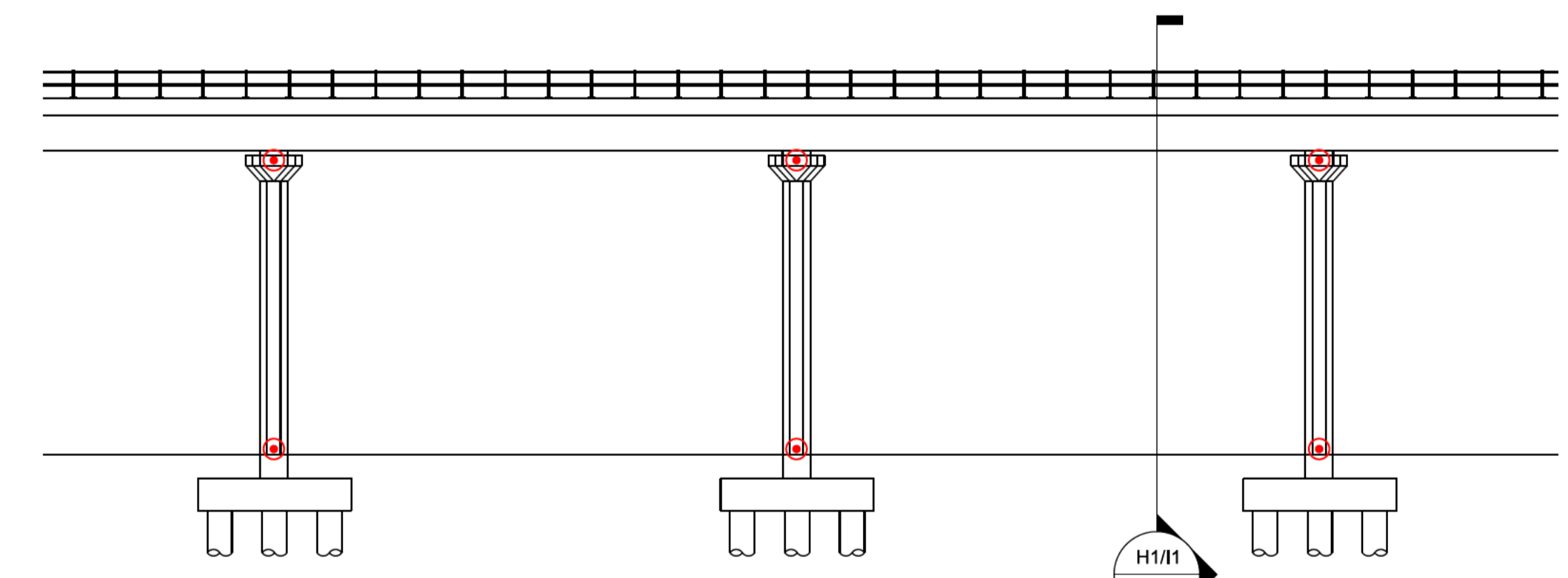
**Section J - J**  
Indicative Cross - Section of DLR Piled Abutments



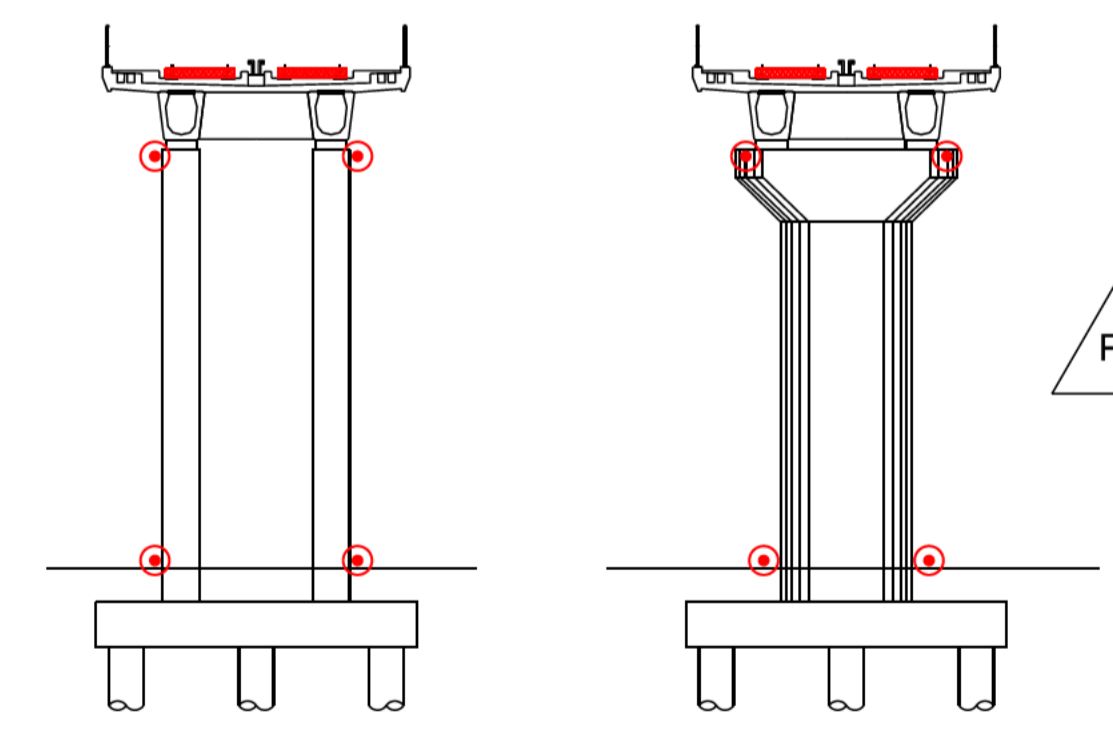
**Section K - K**  
Indicative Cross-Section of LU running tunnel Central, Victoria, Bakerloo, Northern, Jubilee & Piccadilly lines at Basset convergence system location.



**Section L - L**  
Indicative Cross Section of DLR at grade

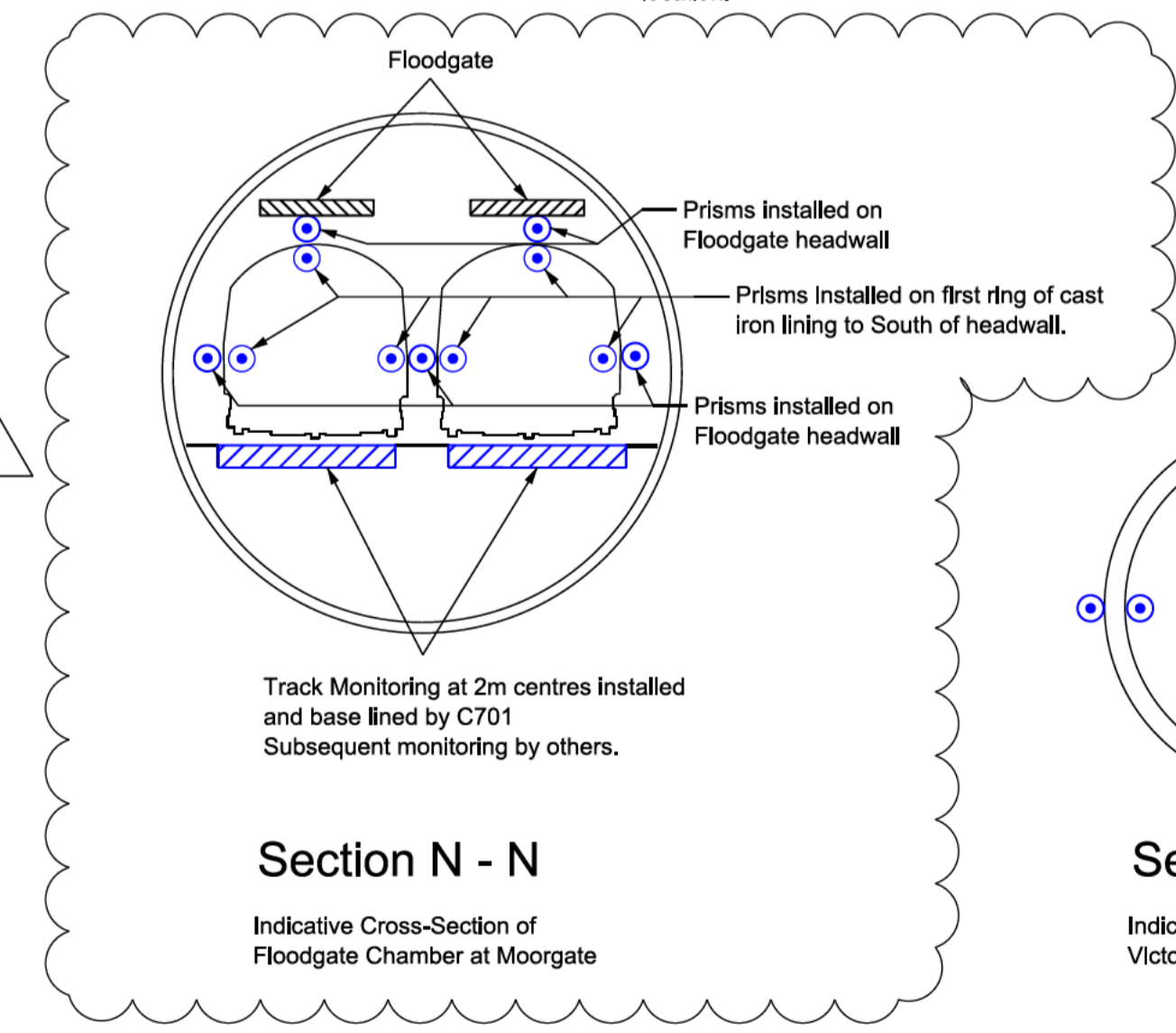


**Elevation H - H / I - I**  
Indicative Elevation, DLR RC Piled Viaduct  
H- Double RC Columns  
I- Single RC Column

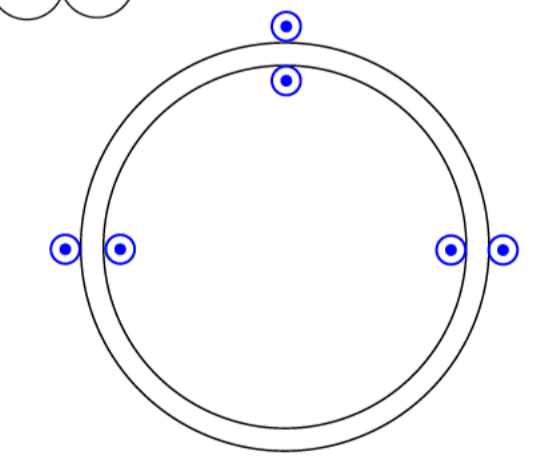


**Section H1**  
Indicative Section, DLR RC Piled Viaduct  
Double RC Columns

**Section I1**  
Indicative Section, DLR RC Piled Viaduct  
Single RC Piler



**Section N - N**  
Indicative Cross-Section of Floodgate Chamber at Moorgate



**Section M - M**  
Indicative Cross-Section of Victoria Line headwall transect

**Legend**

- Installed and monitored By C701
- By Others
- 3D Geodetic Prism (Transects @ 10m c/c)
- Sockets - BRE Type - Structure (Transects @ 10m c/c)
- ▨ Track shoe monitoring at 2m centres
- ▩ Track shoe monitoring at 3m centres
- ◆ Electrolevel Beam
- ⊠ Retro reflective target

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| Rev. | Date       | Description  | By | Chkd | App | Auth |
|------|------------|--|----|------|-----|------|
| P01  | 03/11/2010 | First Issue  | JG | RB   | RM  |      |
| P02  | 25/11/2010 |  | JG | RB   | RM  |      |
| P03  | 21/10/2011 | Minimum requirement for Instrumentation and Monitoring | AR | JA   | SR  |      |
| C01  | 09/11/2011 | Issued as FR for construction                          | AR | JA   | SR  | IT   |
| P04  | 24/05/2012 | Revised to reflect access issues                       | GK | DW   | RM  |      |
| C02  | 04/10/2012 | Issued as FR for construction                          | GK | DW   | RM  | MA   |
| P05  | 07/12/2012 | Issued as FR for construction                          | GK | JA   | RM  |      |
| C03  | 14/01/2013 | Issued as FR for construction                          | GK | JA   | RM  | CT   |

**Notes**

- This drawing is to be read in conjunction with drawing numbers C122-OVE-C2-DDA-CR001\_Z-31101 to 31138 inc.
- Prisms, BRE sockets electrolevels and retro reflective targets are installed and baselined by C701. Precise track monitoring installed and baselined by C701. Others to carry out subsequent manual monitoring (precise levelling) of tunnel / station transects and track.
- Locations of instrumentation are indicative only and subject to confirmation on site by Contractor following verification of location of utilities, obstructions and access.
- Prisms, Retro reflective targets to be installed in positions to satisfaction of LU and NR and to avoid risk of reflectance and potential to affect Tube drivers.
- Positions of ATS to be selected by C701 and proposed for acceptance of Project Manager.

- Generic principles of monitoring identified in sections B-B and C-C. Cross sections vary along alignment from Farringdon to Liverpool St and exact configuration should be agreed between C701 and Project Manager. In some instances section B-B of C122-OVE-C2-DDB-CR001\_Z-32018 may be more appropriate.
- Platform nosing to be marked at 2.00m c/c (LU) or 3.0m c/c (NR) over specified length (in line with the precise levelling points) to show positions for platform train interface surveys.
- The instruments shown are to be installed as an alternative to the original scheme. The alternative scheme consists of a prism on the inside face of the parapet, to be monitored with track ATS, and a BRE socket on the external face at each arch support if access is available.

Contract 1: **Bored Tunnels (Alignment and Track)**

Original: **Ove Arup & Partners Limited**

Location: **Crossrail General**

Contract 2: **Instrumentation and Monitoring Combined I & M for Asset Protection Indicative Cross-Sections C701**

Scale: **NTS@ A1**

Drawing and CAD file No: **C122-OVE-C2-DDB-CR001\_Z-32018**

Rev: **C03**

Suitability: **A**

By: **G.KAVANAGH**

Chk: **J.APTE**

App: **R.MCCRAE**

Auth: **C.THOMAS**

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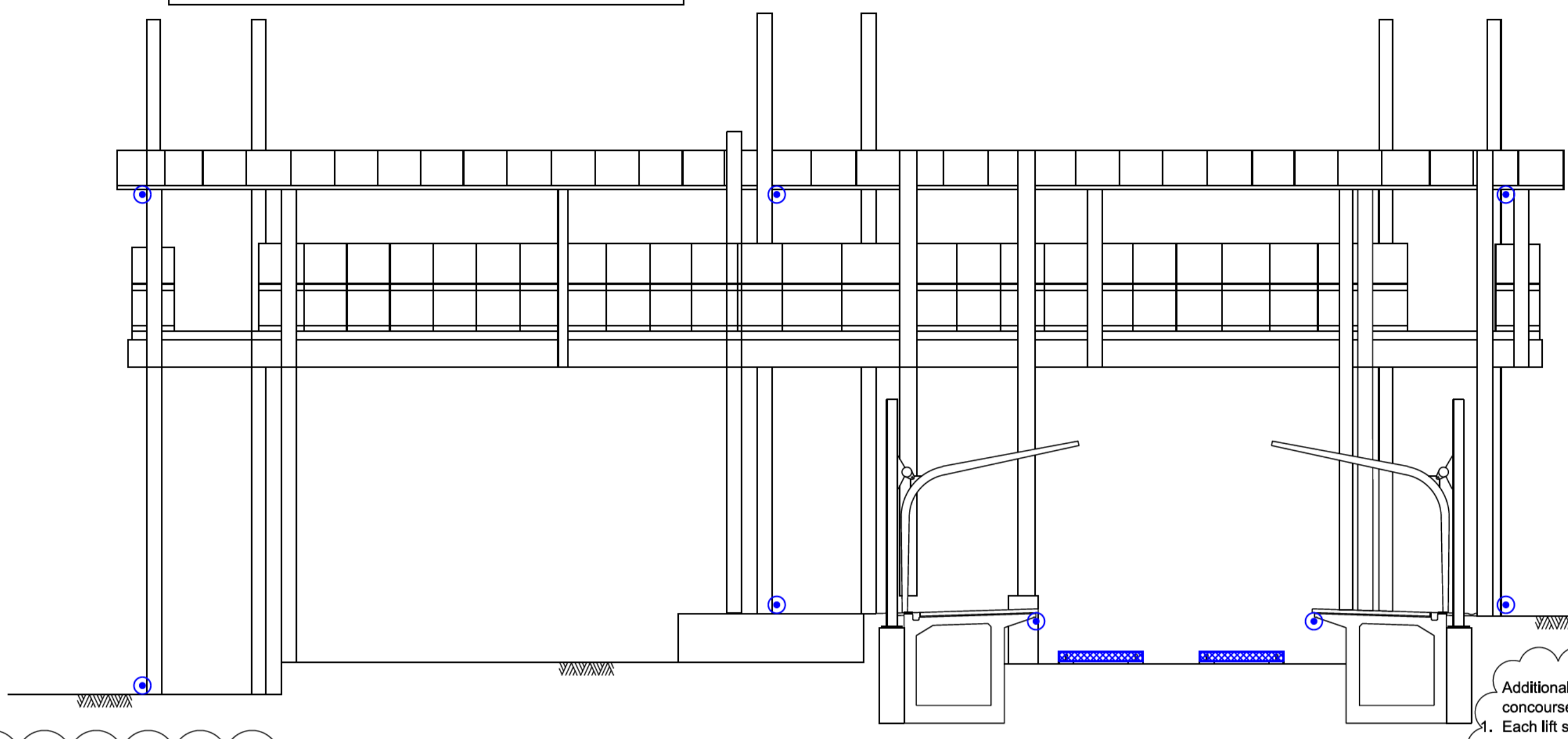
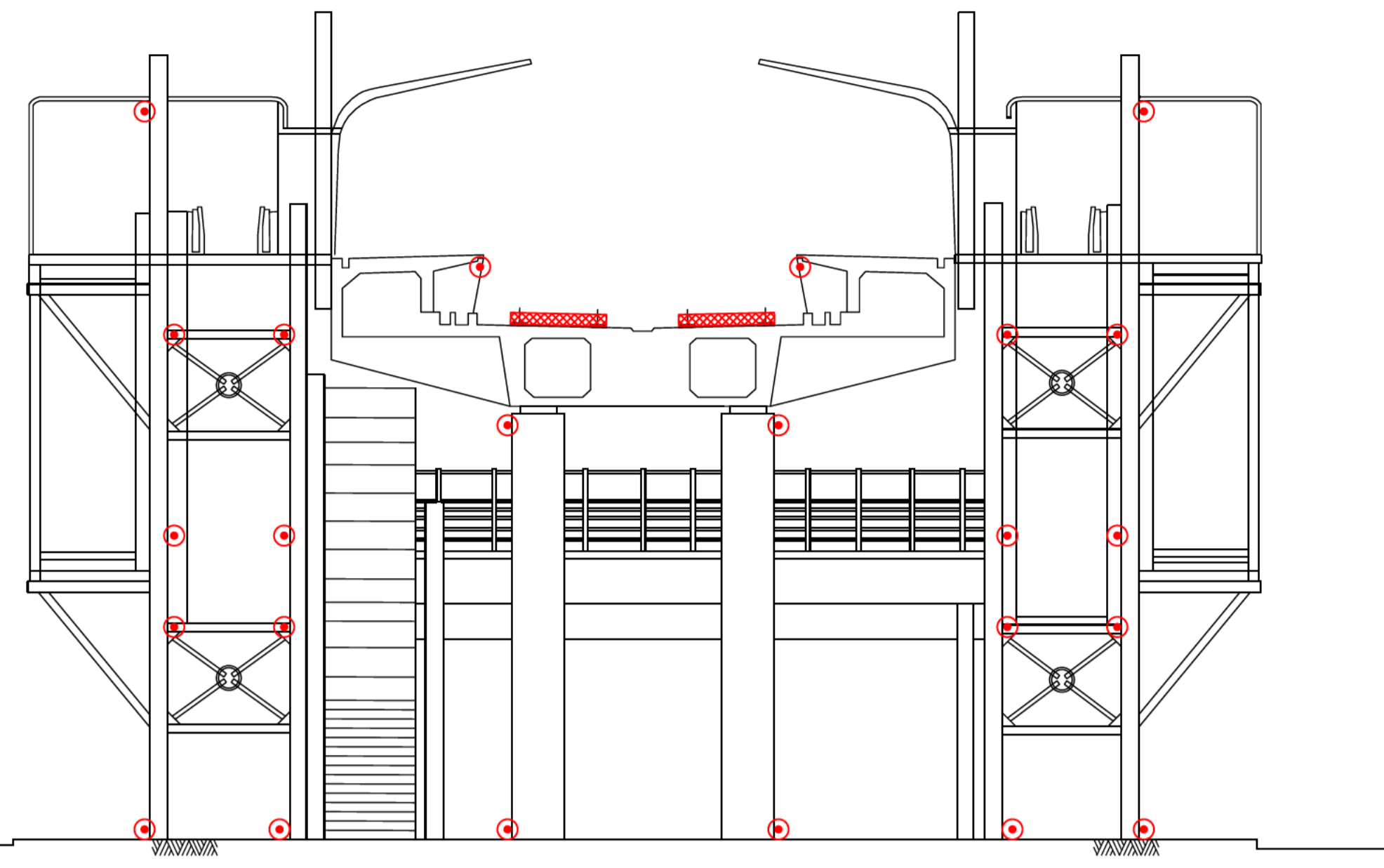
Transects at 10m centres. Track monitoring at 2m centres for LU and 3m centres for NR & LO Tracks

### Legend

- Installed and monitored by C701
- By Others
- 3D Geodetic Prism (Transects @ 10m c/c)
- Sockets - BRE Type - Structure (Transects @ 10m c/c)
- Track shoe monitoring at 2m centres
- Track shoe monitoring at 3m centres
- Electrolevel Beam
- Retro reflective target

For Designers risk assessment, refer to document C122-OVE-N3-LRG-CRG02-00001

Sections shown are indicative only and are not to scale



**Section M - M**  
DLR - East India Quay Station

- Additional I&M by C701 at West India Quay DLR station for the monitoring of lift shaft, escalator, stairs and platform extension piers shall be:
1. Each pier supporting the platform extensions shall be monitored with the installation of 3D prisms on the north side and south side, at top and bottom of the pier.
  2. Each lift shaft shall be monitored with a 3D prism installed at both the base level and the top of two lift support columns, diagonally opposite to each other.
  3. Each escalator support (top, centre, base) is to be monitored with the installation of 3D prisms either side of the escalator, on the horizontal member.
  4. 3D prisms shall be installed at the top and bottom of strategic columns supporting the stairs. The prisms shall be installed on each column pair supporting (a) central support, upper landing and lower landing of pre-extension stairs, and (b) upper landing, mid landing, and lower landing of the extension stairs. Where monitoring has been installed for the horizontal member supporting the escalator only monitoring at the base of the column is required. The locations and number of the prisms to be installed shall be checked and confirmed with the Project Manager.

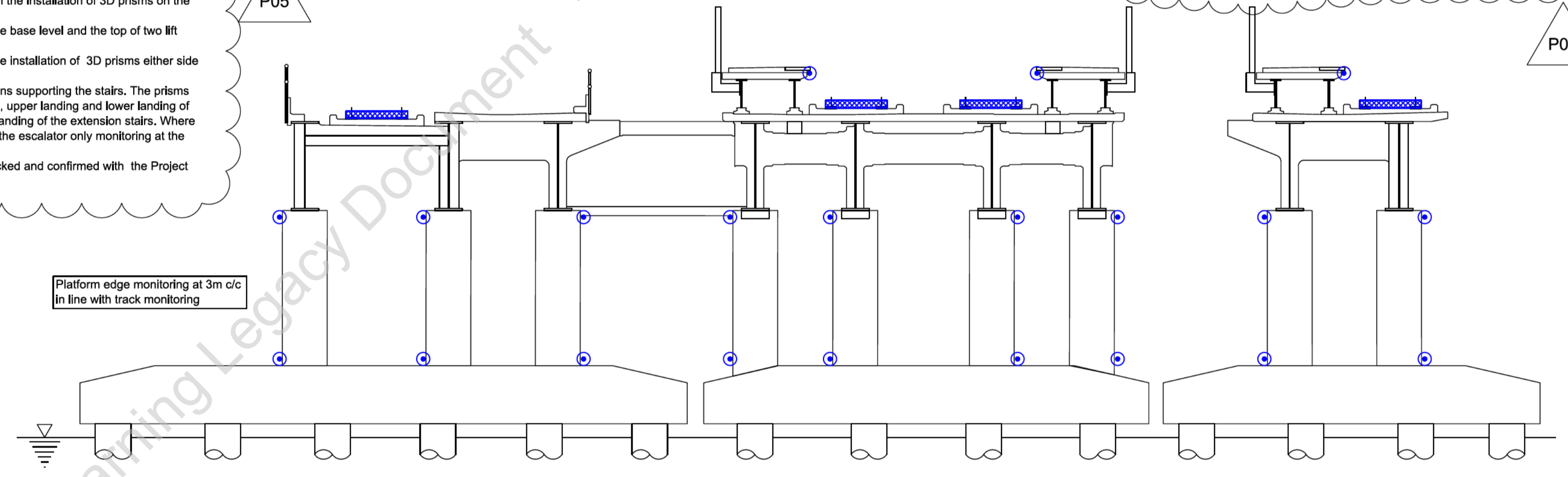
P05

**Section R - R**  
DLR - Royal Victoria Station

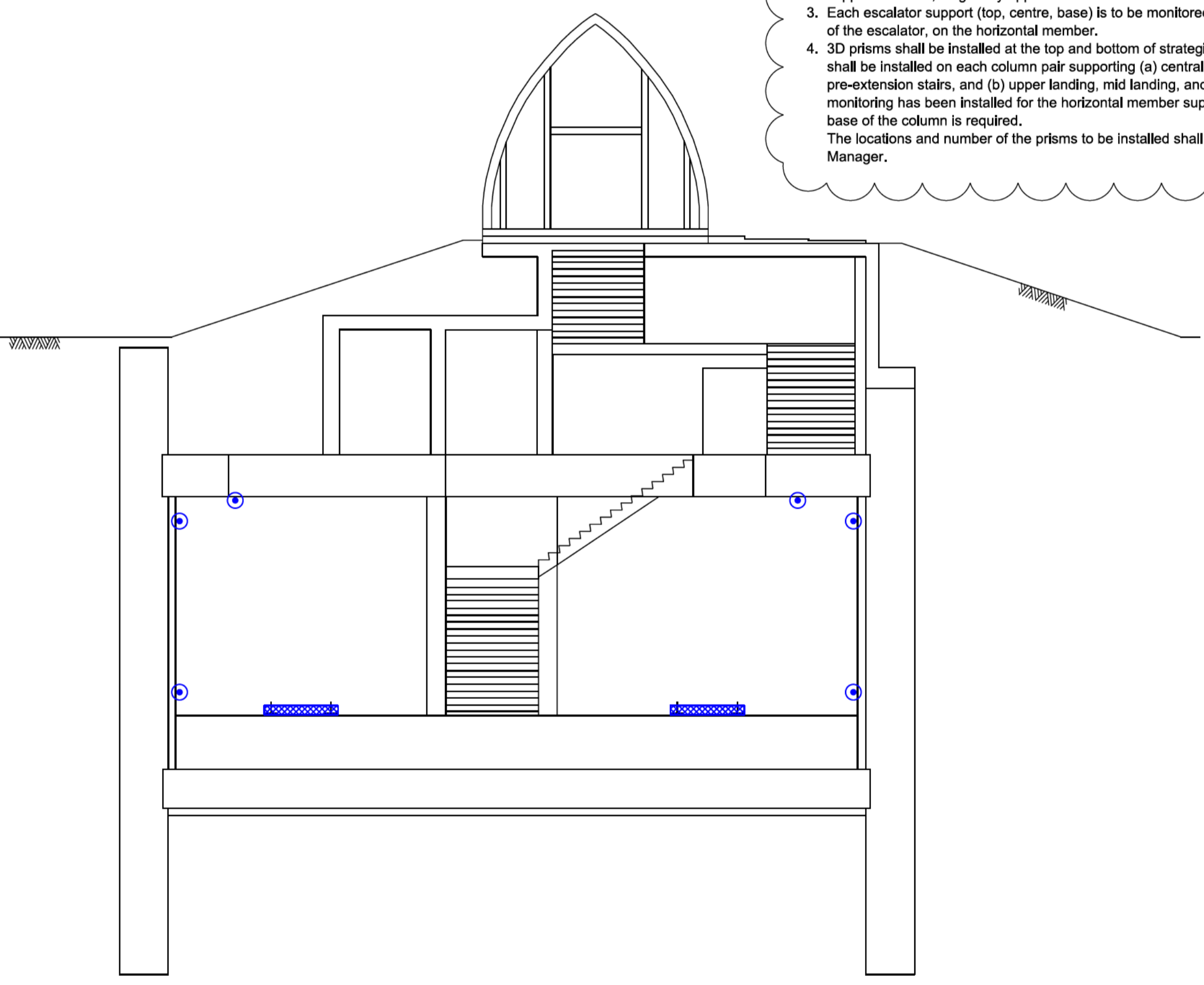
- Additional I&M by C701 at Royal Victoria Station DLR station for the monitoring of lift shaft, high level concourse and stairs shall be:
1. Each lift shaft shall be monitored with a 3D prism installed at both the base level and the top of two lift support columns, diagonally opposite to each other.
  2. 3D prisms shall be installed at the top and bottom of each column supporting the stairs.
  3. 3D prisms shall be installed at the top and bottom of the 4 columns supporting the high level concourse.

P05

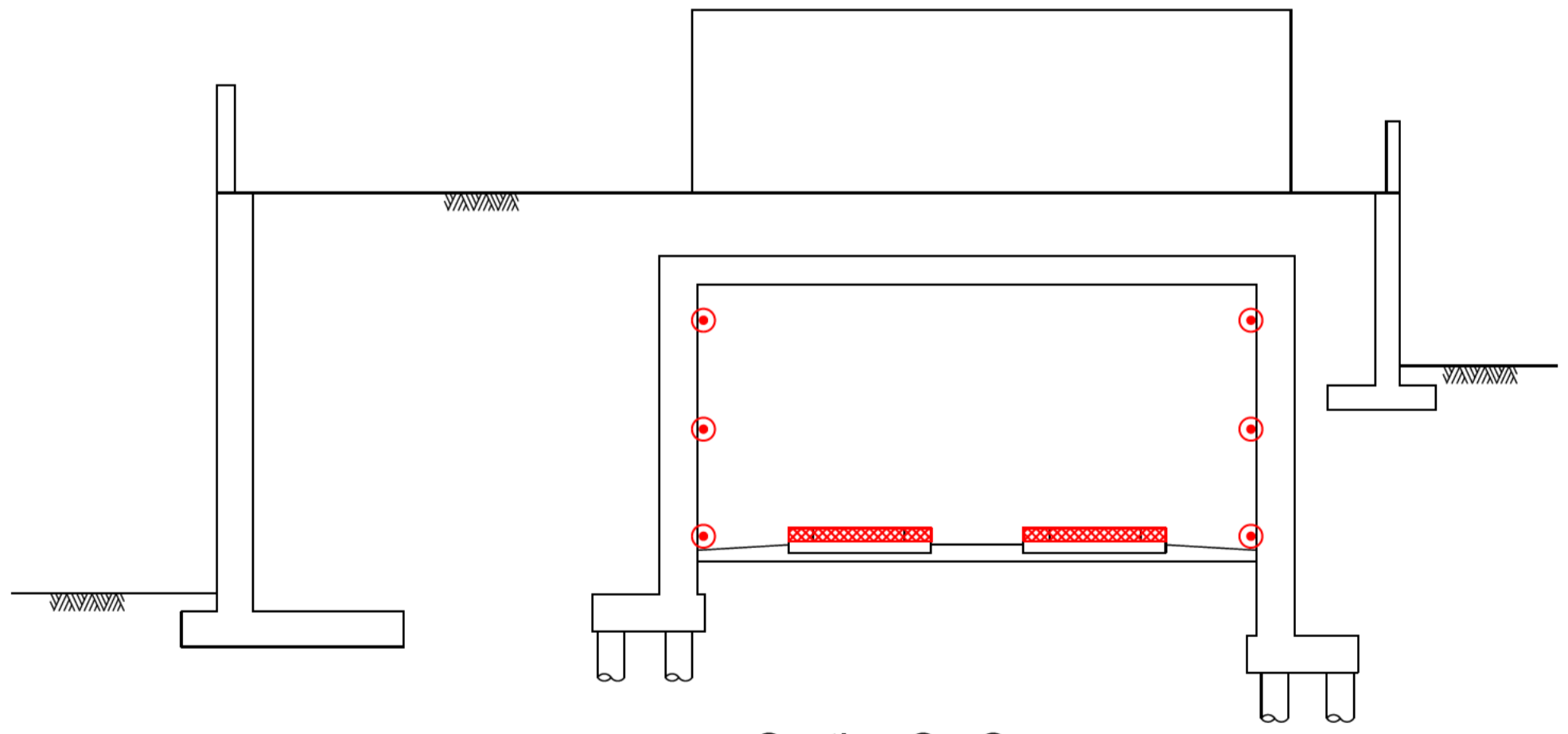
Platform edge monitoring at 3m c/c in line with track monitoring



**Section N - N**  
DLR - West India Quay Station



**Section P - P**  
LU (JLE) - Cut & Cover Tunnel  
Canning Town Junction



**Section Q - Q**  
DLR - Cut & Cover Tunnel at Bow  
(Bow Church to Devons Road)

Copy Approved for Design - Created: 15-JAN-2013

| Rev. | Date       | Description   | By | Chkd | App | Auth |
|------|------------|---|----|------|-----|------|
| P01  | 25/11/2010 | First Issue   | JG | RB   | RM  | -    |
| P02  | 14/10/2011 | Minimum requirement for Instrumentation and Monitoring    | AR | JA   | SR  | -    |
| C01  | 09/11/2011 | Issued as FR for construction                             | AR | JA   | SR  | IT   |
| P03  | 27/01/2012 | Minimum Requirements for I & M - Section F-F, Section G-G | GP | JA   | RM  | -    |
| P04  | 23/05/2012 | Minimum Requirements for I & M - Remove Section S-S       | JJ | JA   | PC  | -    |
| C02  | 29/05/2012 | Issued as FR for construction                             | JJ | JA   | PC  | IT   |
| P05  | 07/12/2012 | Issued as FR for construction                             | GK | JA   | RM  | -    |
| C03  | 14/01/2013 | Issued as FR for construction                             | GK | JA   | RM  | CT   |

**Notes**

1. This drawing is to be read in conjunction with drawing numbers C122-OVE-C2-DDA-CR001\_Z-31101 to 31138 Inc.
2. Prisms, BRE sockets electrolevels and retro reflective targets, basisset convergence system and precise track levelling are installed and baselined under C701. Others to carry out manual monitoring (precise levelling) of tunnel transects and track.
3. Locations of instrumentation are indicative only and subject to confirmation on site by I & M contractor following verification of location of utilities, obstructions and access.
4. Prisms, Retro reflective targets to be installed in positions to satisfaction of LU and to avoid risk of reflectance and potential to affect Train drivers.
5. Positions of ATS to be selected by C701 and proposed for acceptance of Crossrail Instrumentation and Monitoring team.

**Crossrail Limited**  
25 Canada Square  
London  
E14 5LQ

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Contract: **Bored Tunnels (Alignment and Track)**  
Original: **Ove Arup & Partners Limited**  
Location: **Crossrail General**

Title: **Instrumentation and Monitoring**  
Indicative Cross-Sections  
**C701**

Scale: **NTS@ A1** Drawing and CAD file No: **C122-OVE-C2-DDB-CR001\_Z-32021** Rev: **C03** Suitability: **A**

By: **G.KAVANAGH**  
Chk: **J.APTE**  
App: **R.MCCRAE**  
Auth: **C.THOMAS**

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**APPENDIX B**

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**Notes**

- 1 - All points in terms of Crossrail Grid/Datum
- 2 - Control Network subject to Final design and implementation
- 3 - All prisms are Leica L-Bar unless otherwise stated

**Legend**

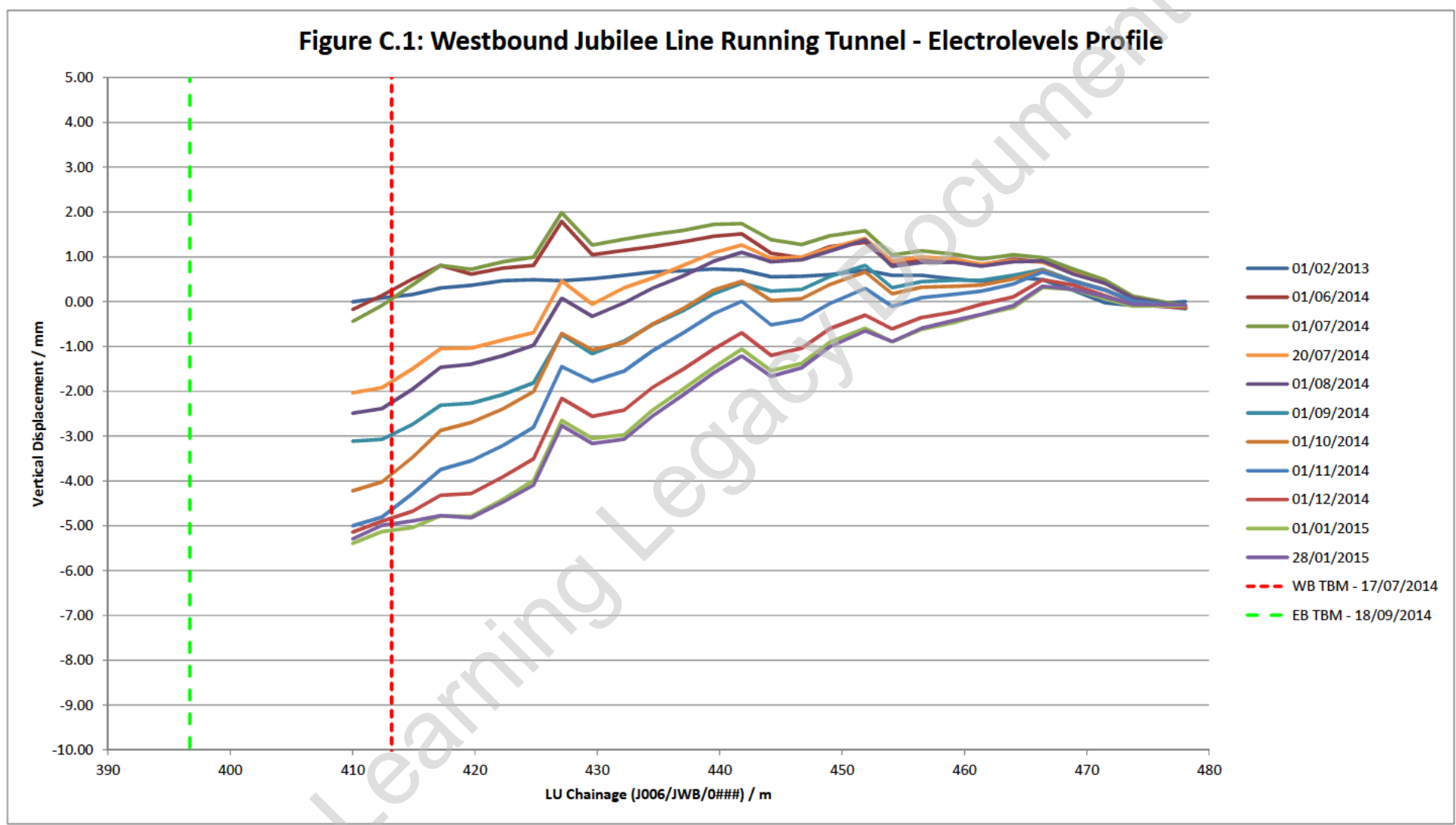
NORTH

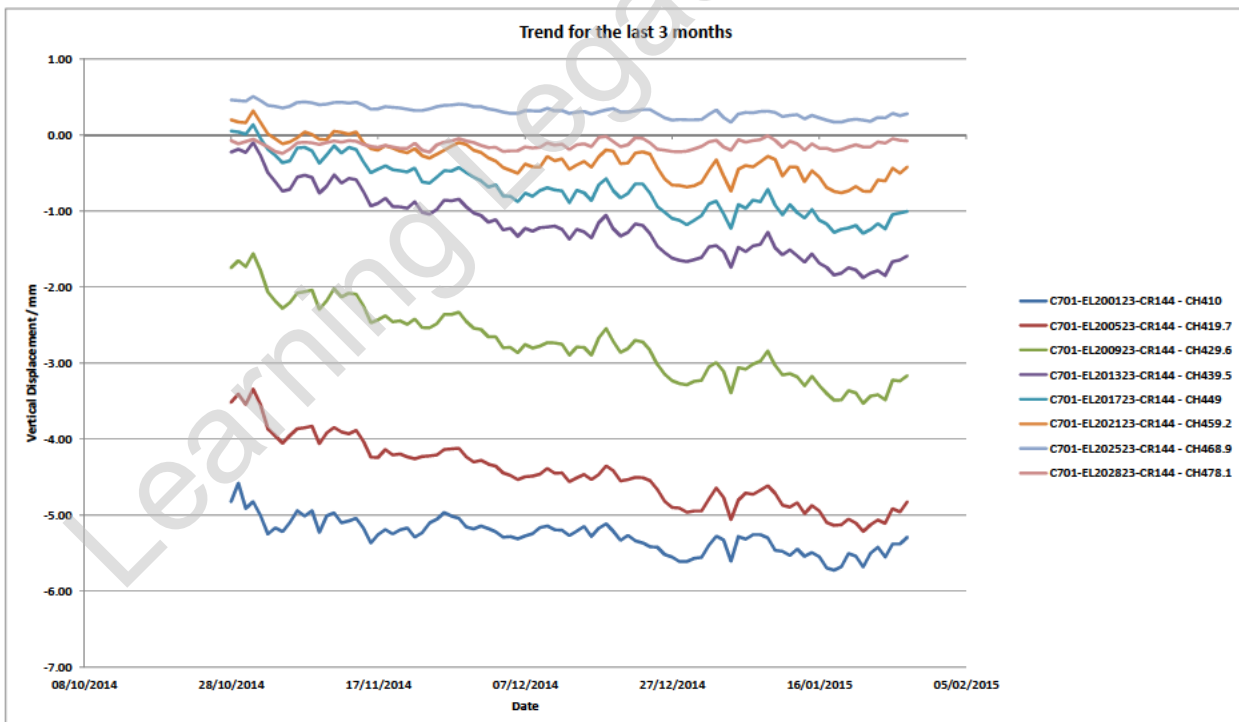
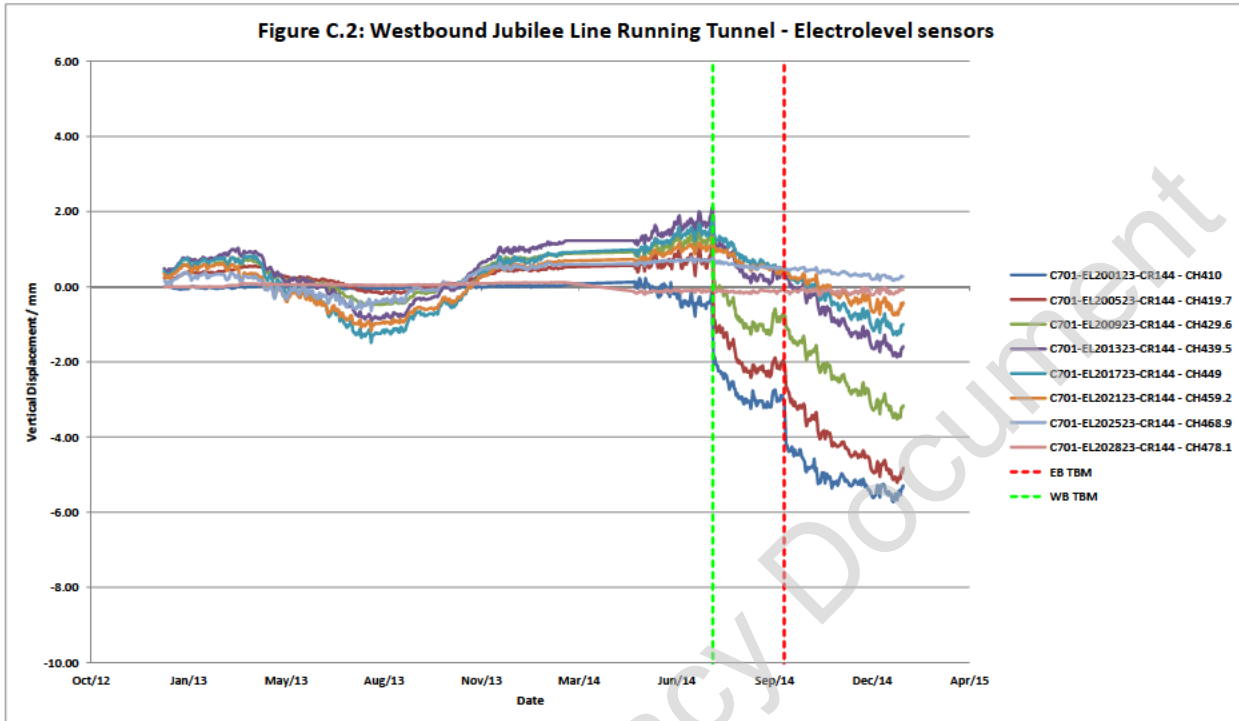
|                |          |  |                         |
|----------------|----------|--|-------------------------|
| <b>itmsoil</b> |          | itmsoil<br>UCKFIELD EAST SUSSEX TN22 1QL<br>ENGLAND Tel: +44(0)1825 765044<br>Fax: +44(0)1825 761740 |                         |
| Drawn          | JJ       | Title C701 - Canning Town<br>Jubilee as-built ALL  |                         |
| Checked        | KM       | Paper  | Drawing No.             |
| Date           | 25-04-13 | A1   | C701-ITM-CANJUB_228_001 |
| Rev            | 01       | Job Number   | 228                     |
| Scale          | NTS      | Sheet  | 01                      |

## **APPENDIX C**

Learning Legacy Document

Figure C.1: Westbound Jubilee Line Running Tunnel - Electrolevels Profile





**Figure C.3: Eastbound Jubilee Line Running Tunnel - Electrolevels Profile**

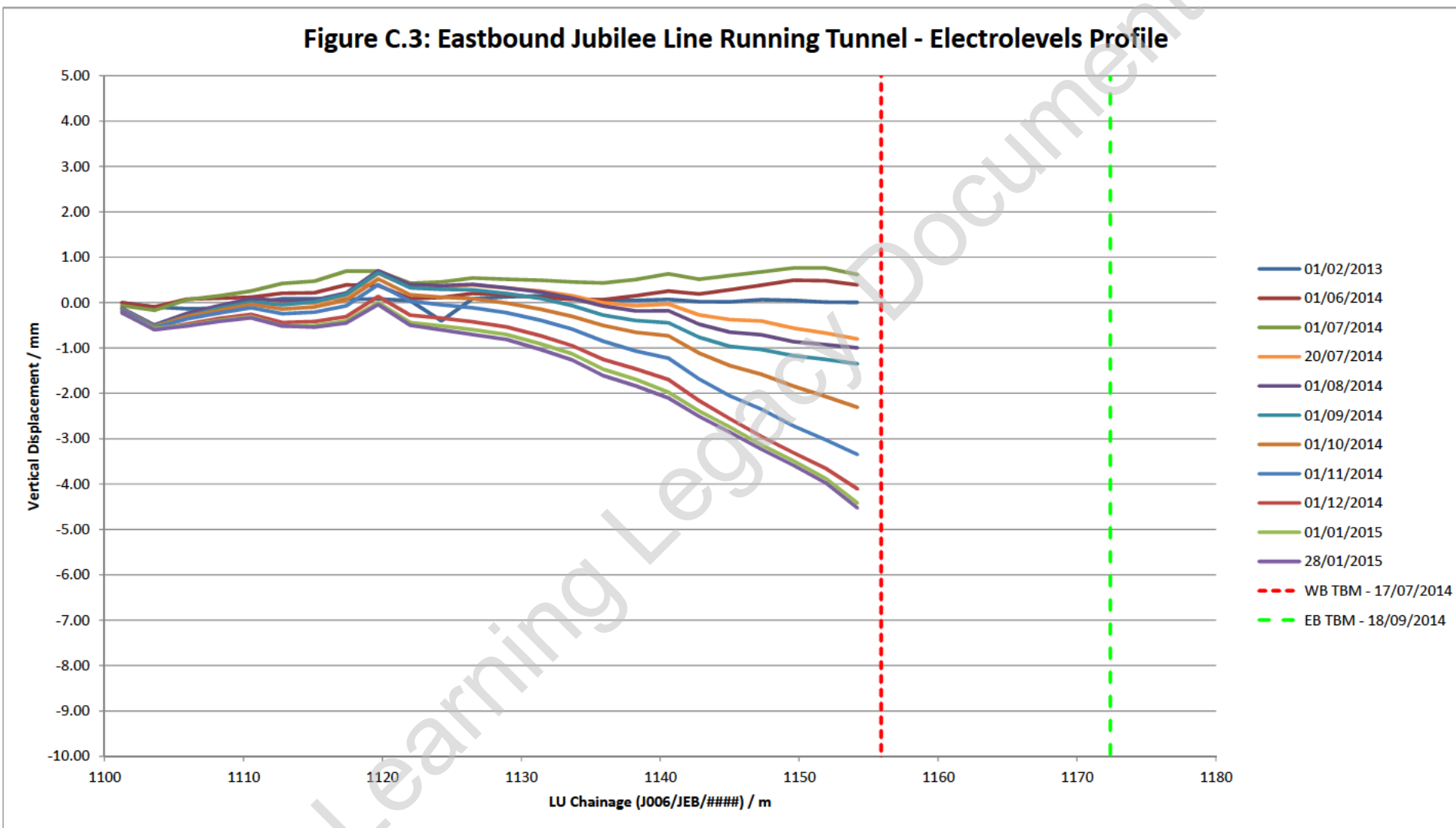
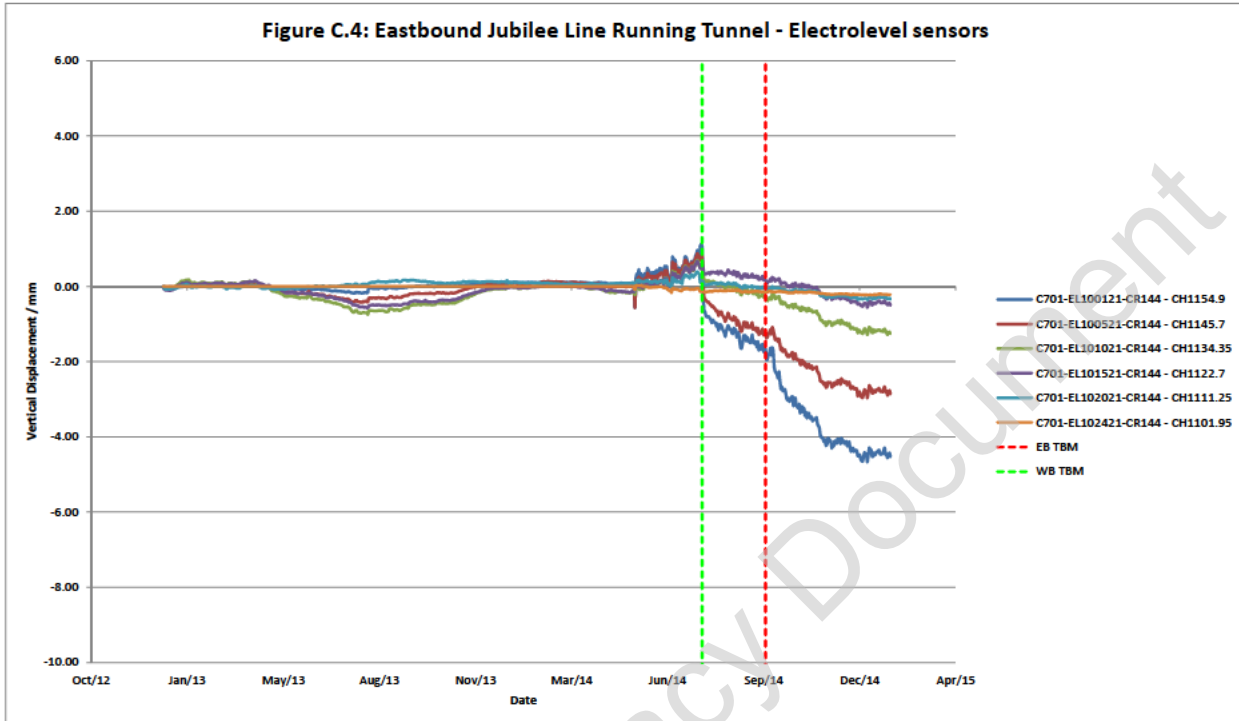
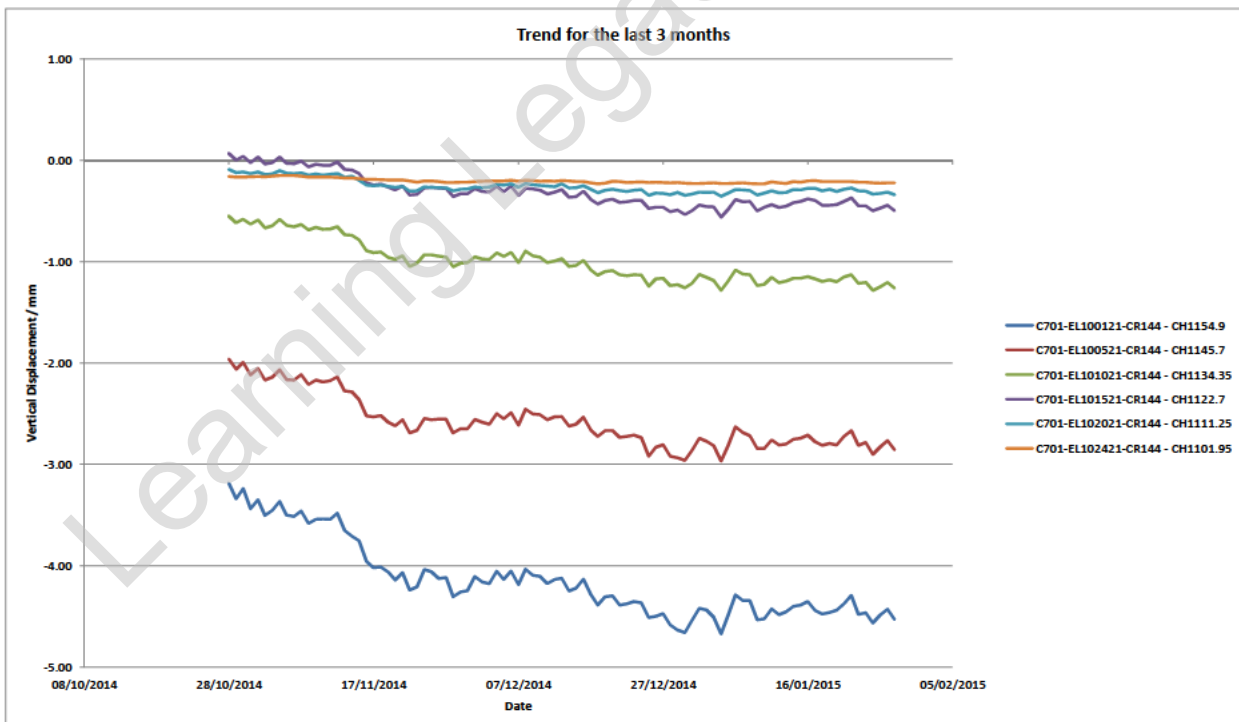
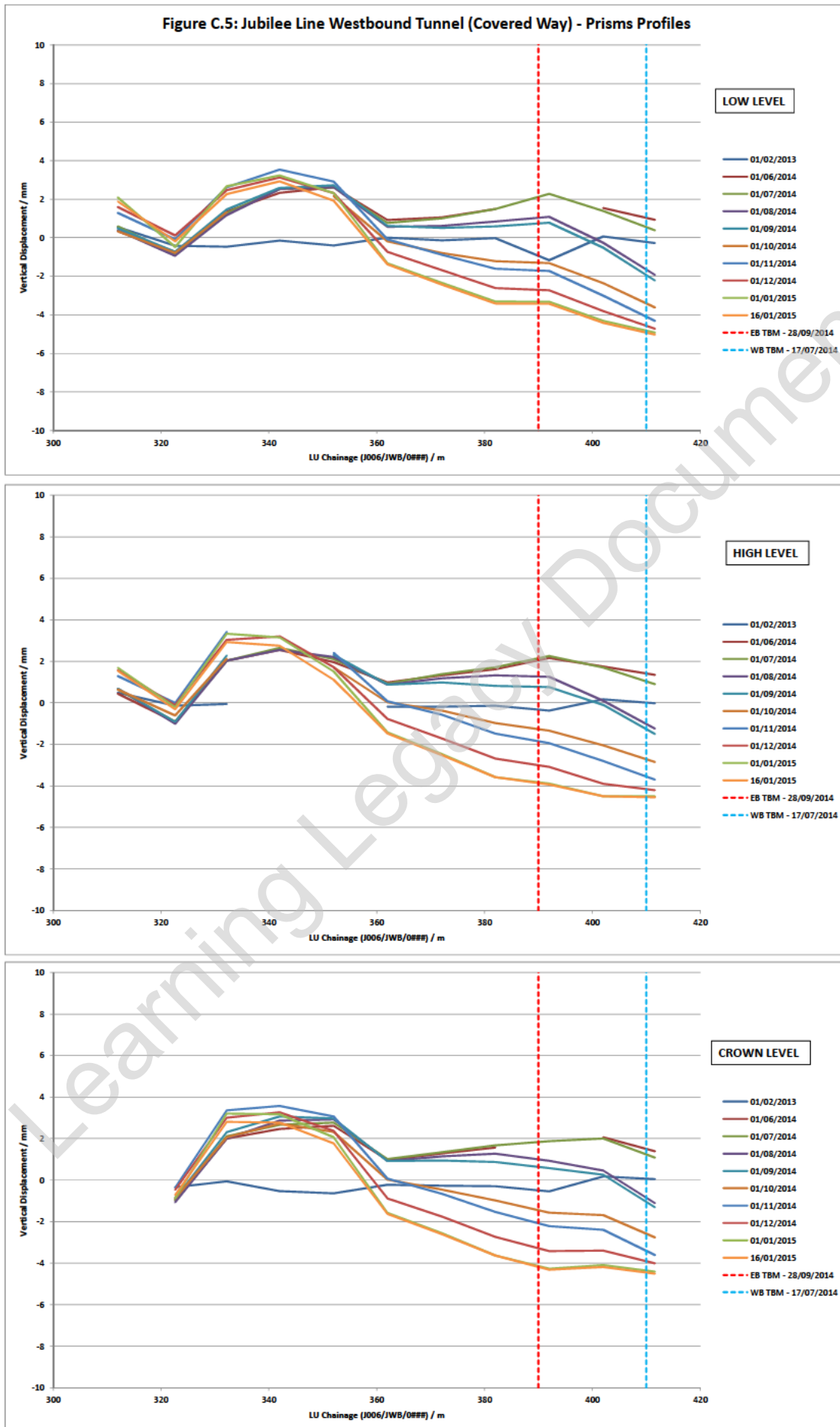


Figure C.4: Eastbound Jubilee Line Running Tunnel - Electrolevel sensors



Trend for the last 3 months







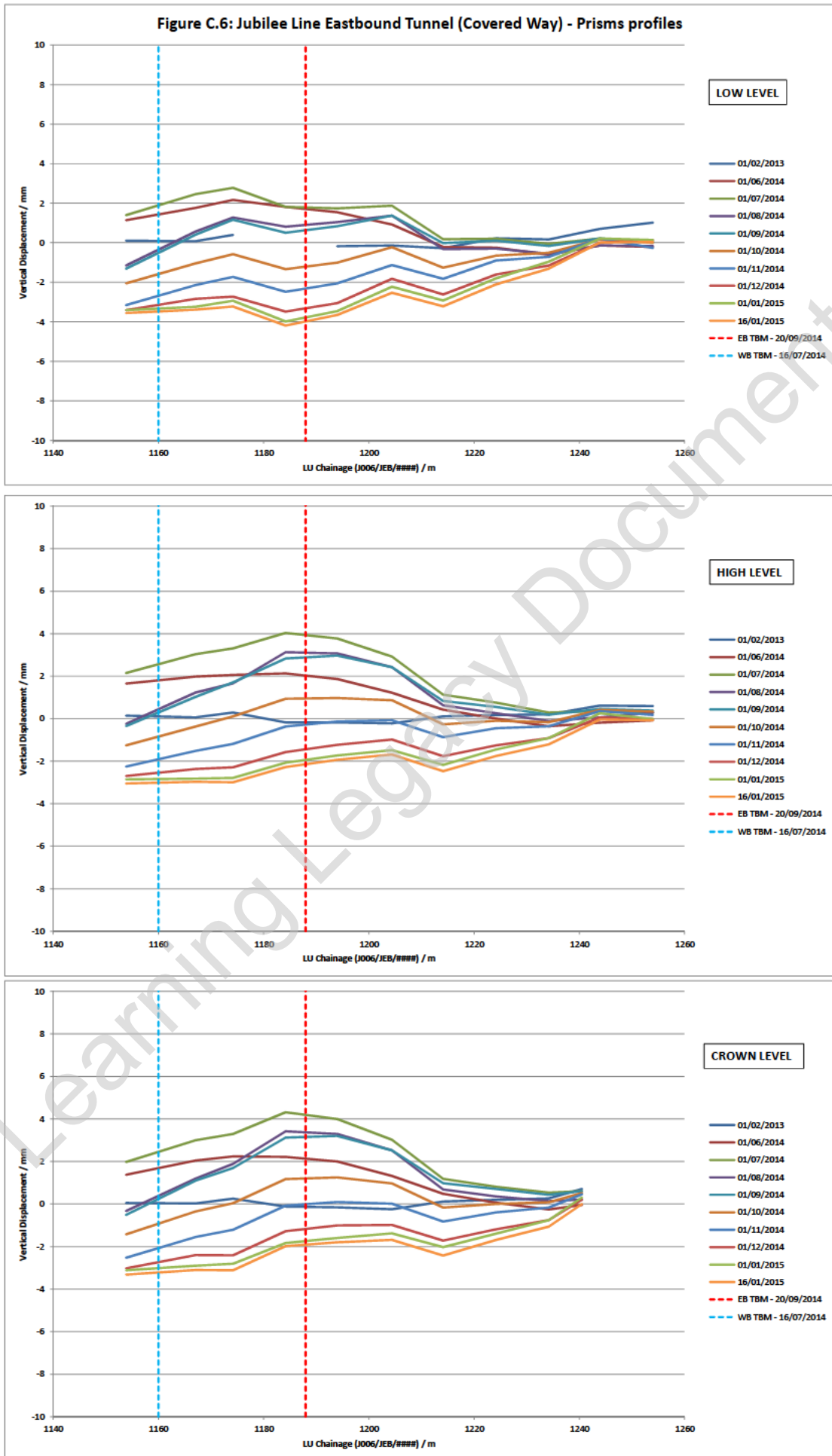
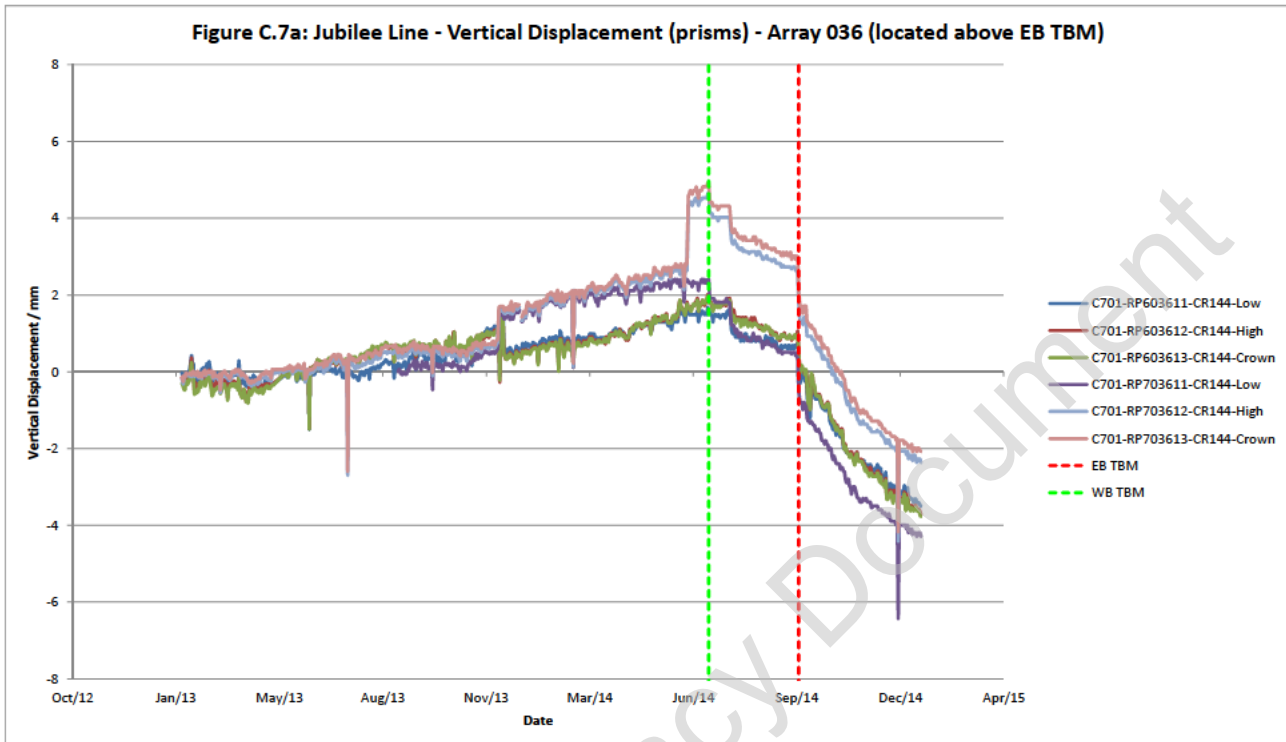


Figure C.7a: Jubilee Line - Vertical Displacement (prisms) - Array 036 (located above EB TBM)



Trend for the last 3 months

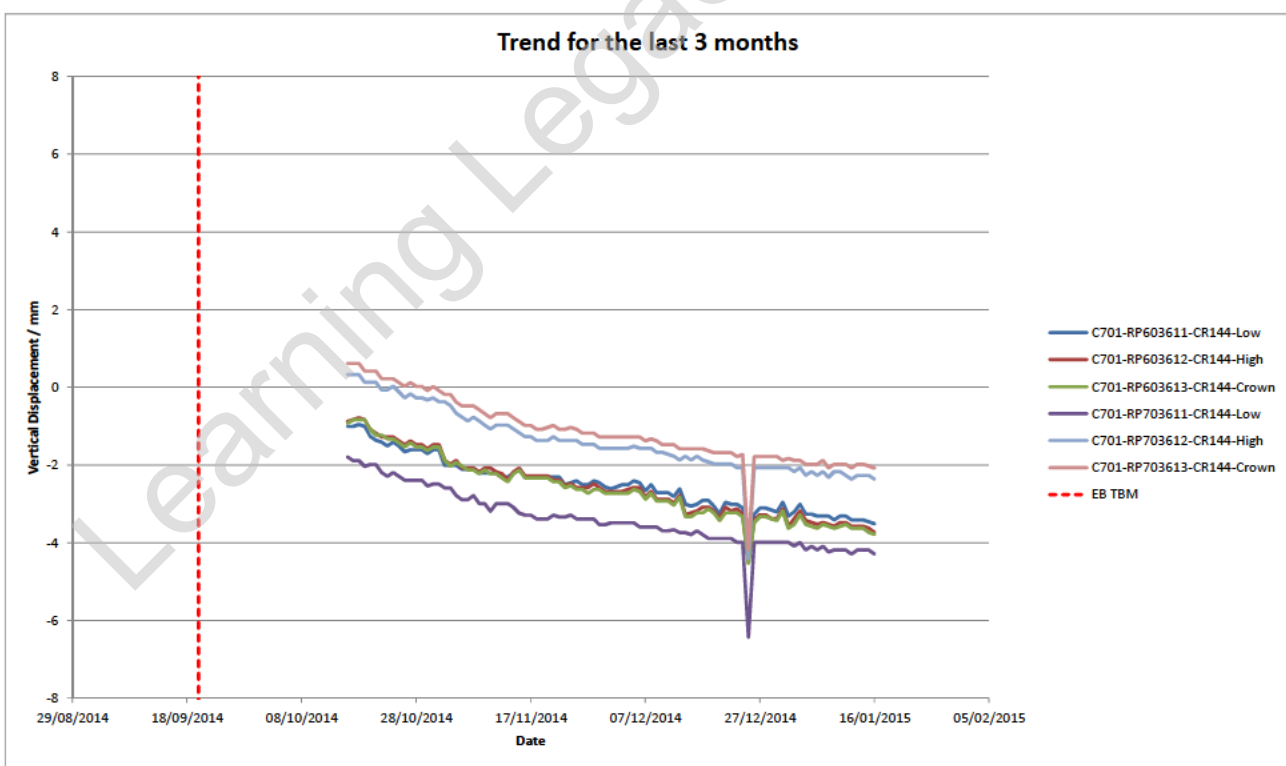
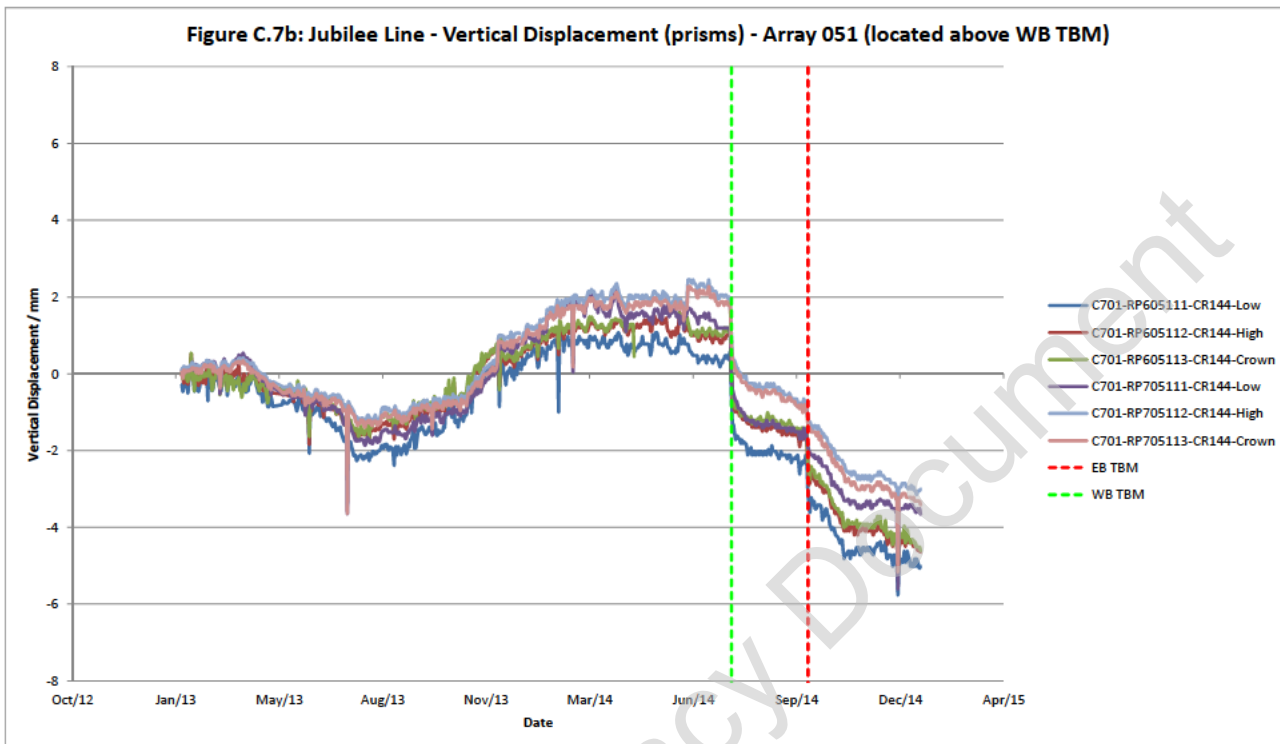


Figure C.7b: Jubilee Line - Vertical Displacement (prisms) - Array 051 (located above WB TBM)



Trend for the last 3 Months

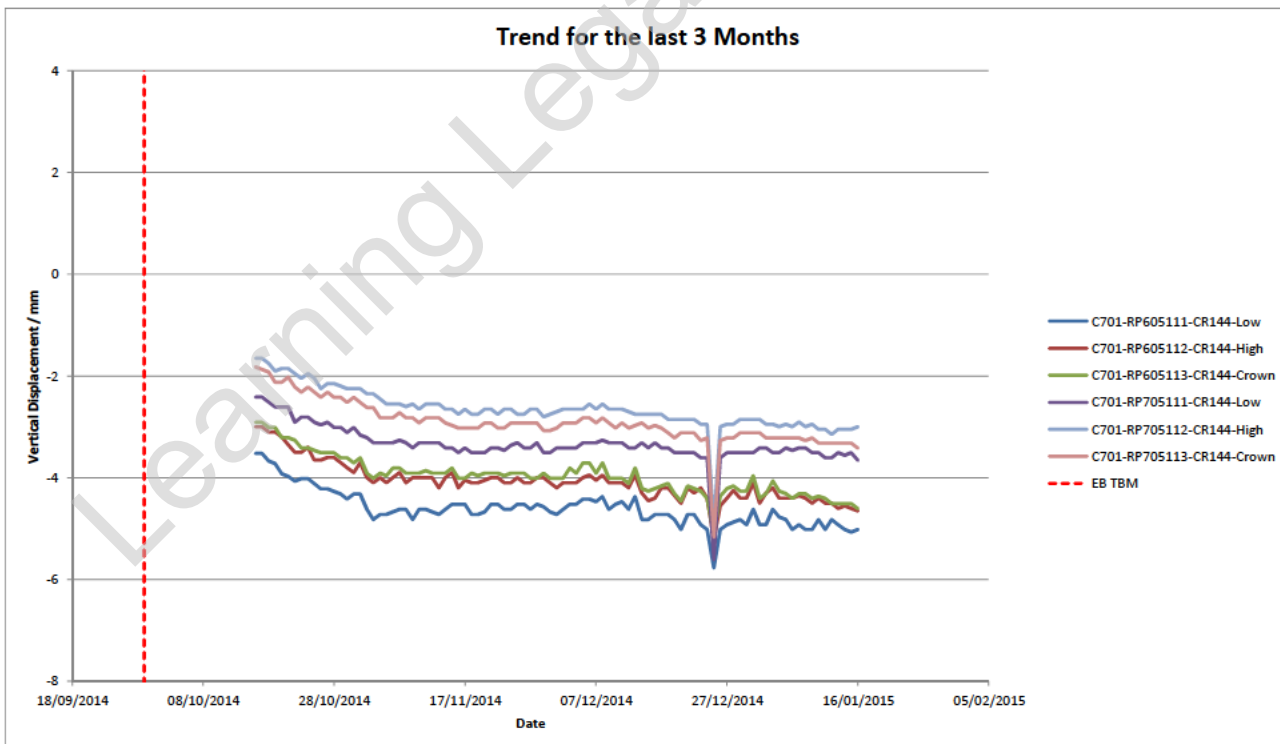
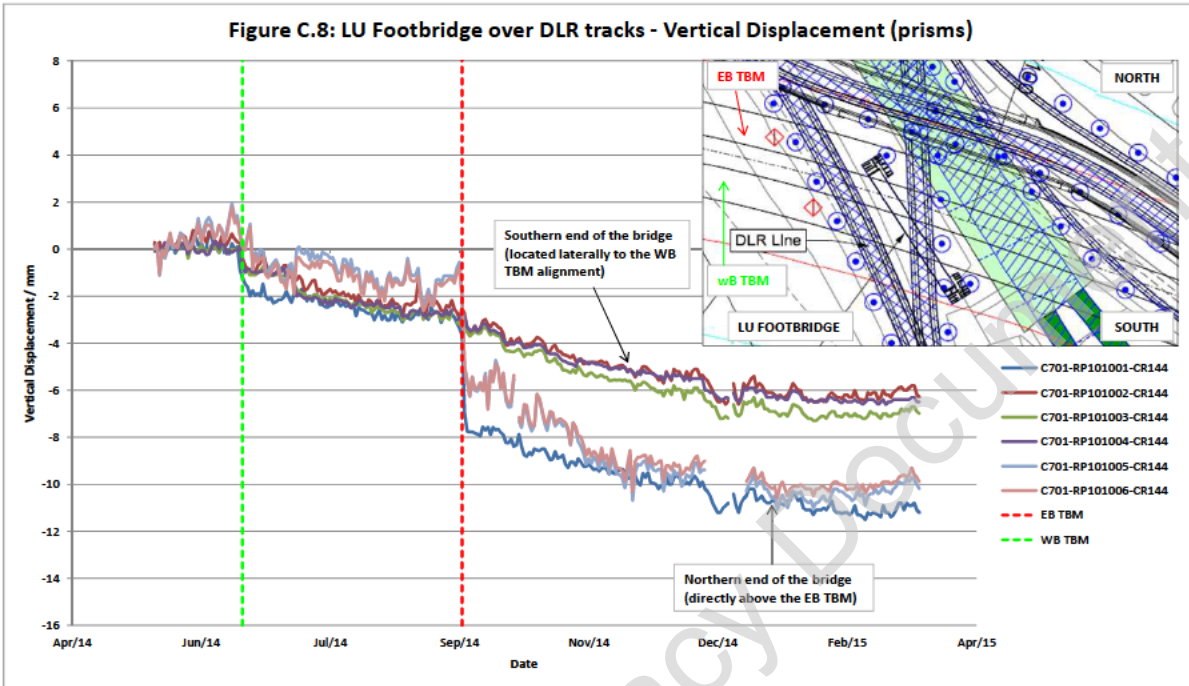
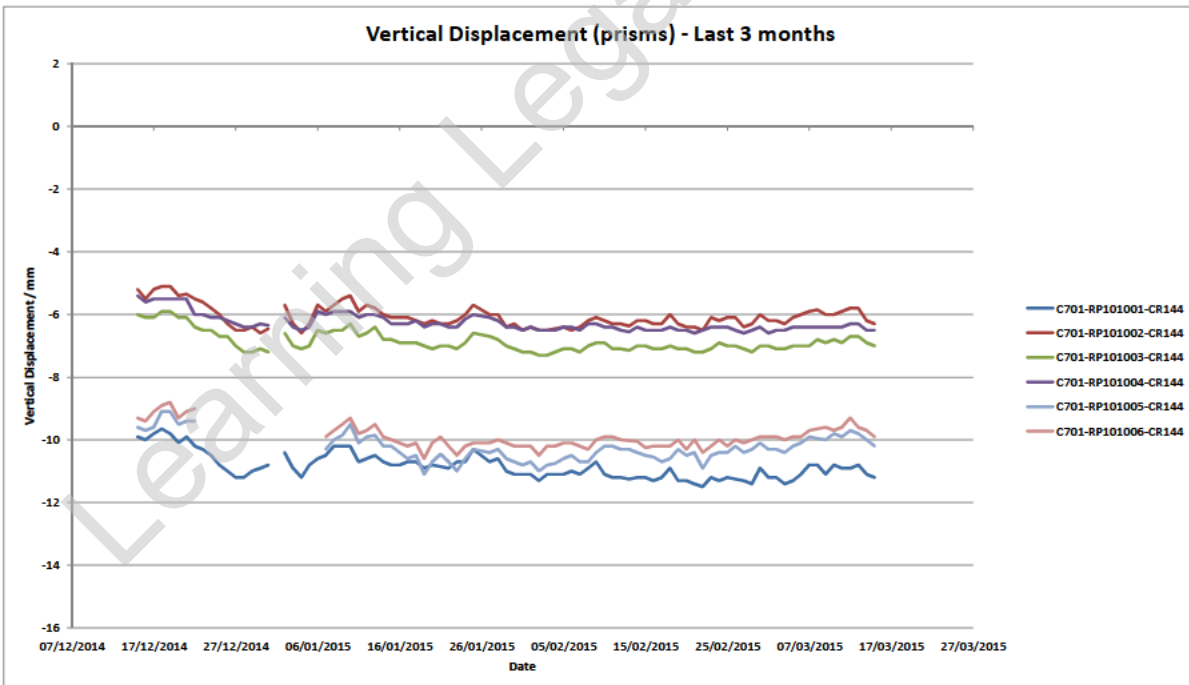


Figure C.8: LU Footbridge over DLR tracks - Vertical Displacement (prisms)



Vertical Displacement (prisms) - Last 3 months



Learning Legacy Document

**APPENDIX B:**  
**LEVELLING MARKS**

## TABLE OF CONTENT

1. LEVELLING MARKS LOCATED ON THE FOUR RAILS

Learning Legacy Document

1. LEVELLING MARKS LOCATED ON THE FOUR RAILS

This appendix includes coordinates for all the levelling marks located on the four rails LU tracks.

| SENSOR TYPE    | SENSOR ID     | SENSOR LOCATION-GPS READING (m) |            |                    |
|----------------|---------------|---------------------------------|------------|--------------------|
|                |               | Easting X                       | Northing Y | Elevation Z (mATD) |
| Levelling mark | C701-LT028001 | 89931.753                       | 35545.888  | 102.493            |
| Levelling mark | C701-LT028002 | 89932.498                       | 35544.047  | 102.434            |
| Levelling mark | C701-LT028003 | 89933.244                       | 35542.129  | 102.373            |
| Levelling mark | C701-LT028004 | 89933.993                       | 35540.287  | 102.312            |
| Levelling mark | C701-LT028005 | 89934.695                       | 35538.462  | 102.253            |
| Levelling mark | C701-LT028006 | 89935.443                       | 35536.586  | 102.192            |
| Levelling mark | C701-LT028007 | 89936.214                       | 35534.645  | 102.130            |
| Levelling mark | C701-LT028008 | 89936.930                       | 35532.828  | 102.072            |
| Levelling mark | C701-LT028009 | 89937.663                       | 35531.000  | 102.013            |
| Levelling mark | C701-LT028010 | 89938.402                       | 35529.142  | 101.953            |
| Levelling mark | C701-LT028011 | 89939.154                       | 35527.236  | 101.892            |
| Levelling mark | C701-LT028012 | 89939.872                       | 35525.431  | 101.834            |
| Levelling mark | C701-LT028013 | 89940.608                       | 35523.562  | 101.773            |
| Levelling mark | C701-LT028014 | 89941.322                       | 35521.749  | 101.716            |
| Levelling mark | C701-LT028015 | 89942.105                       | 35519.809  | 101.654            |
| Levelling mark | C701-LT028016 | 89942.829                       | 35517.976  | 101.595            |
| Levelling mark | C701-LT028017 | 89943.596                       | 35516.046  | 101.532            |
| Levelling mark | C701-LT028018 | 89944.313                       | 35514.227  | 101.473            |
| Levelling mark | C701-LT028019 | 89945.021                       | 35512.444  | 101.417            |
| Levelling mark | C701-LT028020 | 89945.767                       | 35510.564  | 101.357            |
| Levelling mark | C701-LT028021 | 89946.514                       | 35508.691  | 101.297            |
| Levelling mark | C701-LT028022 | 89947.259                       | 35506.815  | 101.238            |
| Levelling mark | C701-LT028023 | 89947.996                       | 35504.949  | 101.178            |
| Levelling mark | C701-LT028024 | 89948.727                       | 35503.097  | 101.118            |
| Levelling mark | C701-LT028025 | 89949.439                       | 35501.301  | 101.061            |
| Levelling mark | C701-LT028026 | 89950.223                       | 35499.324  | 100.998            |
| Levelling mark | C701-LT028027 | 89950.960                       | 35497.508  | 100.940            |
| Levelling mark | C701-LT028028 | 89951.668                       | 35495.656  | 100.880            |
| Levelling mark | C701-LT028029 | 89952.428                       | 35493.827  | 100.817            |
| Levelling mark | C701-LT028030 | 89953.139                       | 35492.011  | 100.757            |
| Levelling mark | C701-LT028031 | 89953.907                       | 35490.087  | 100.695            |
| Levelling mark | C701-LT028032 | 89954.666                       | 35488.163  | 100.635            |
| Levelling mark | C701-LT028033 | 89955.386                       | 35486.327  | 100.577            |
| Levelling mark | C701-LT028034 | 89956.099                       | 35484.535  | 100.519            |
| Levelling mark | C701-LT028035 | 89956.841                       | 35482.683  | 100.459            |
| Levelling mark | C701-LT028036 | 89957.596                       | 35480.786  | 100.399            |
| Levelling mark | C701-LT028037 | 89958.328                       | 35478.908  | 100.339            |
| Levelling mark | C701-LT028038 | 89959.061                       | 35477.066  | 100.280            |
| Levelling mark | C701-LT028039 | 89959.765                       | 35475.272  | 100.224            |
| Levelling mark | C701-LT028040 | 89960.530                       | 35473.366  | 100.164            |
| Levelling mark | C701-LT028041 | 89961.290                       | 35471.484  | 100.103            |
| Levelling mark | C701-LT028042 | 89962.044                       | 35469.570  | 100.041            |
| Levelling mark | C701-LT028043 | 89962.759                       | 35467.776  | 99.982             |

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|----------------|---------------|-----------|-----------|---------|
| Levelling mark | C701-LT028044 | 89963.474 | 35465.944 | 99.923  |
| Levelling mark | C701-LT028045 | 89964.213 | 35464.095 | 99.863  |
| Levelling mark | C701-LT028046 | 89964.936 | 35462.252 | 99.804  |
| Levelling mark | C701-LT028047 | 89965.705 | 35460.322 | 99.742  |
| Levelling mark | C701-LT028048 | 89966.433 | 35458.477 | 99.683  |
| Levelling mark | C701-LT028049 | 89967.147 | 35456.660 | 99.625  |
| Levelling mark | C701-LT028050 | 89967.910 | 35454.780 | 99.565  |
| Levelling mark | C701-LT028051 | 89968.635 | 35452.944 | 99.506  |
| Levelling mark | C701-LT028052 | 89969.372 | 35451.078 | 99.446  |
| Levelling mark | C701-LT028053 | 89970.111 | 35449.232 | 99.386  |
| Levelling mark | C701-LT028054 | 89970.821 | 35447.423 | 99.328  |
| Levelling mark | C701-LT028055 | 89971.570 | 35445.535 | 99.266  |
| Levelling mark | C701-LT028056 | 89972.300 | 35443.676 | 99.205  |
| Levelling mark | C701-LT028057 | 89973.045 | 35441.810 | 99.146  |
| Levelling mark | C701-LT028058 | 89973.799 | 35439.921 | 99.084  |
| Levelling mark | C701-LT028059 | 89974.525 | 35438.103 | 99.025  |
| Levelling mark | C701-LT028060 | 89975.263 | 35436.233 | 98.965  |
| Levelling mark | C701-LT028061 | 89976.027 | 35434.325 | 98.902  |
| Levelling mark | C701-LT028062 | 89976.746 | 35432.495 | 98.843  |
| Levelling mark | C701-LT028063 | 89977.488 | 35430.626 | 98.783  |
| Levelling mark | C701-LT028064 | 89978.201 | 35428.806 | 98.726  |
| Levelling mark | C701-LT028065 | 89978.975 | 35426.882 | 98.663  |
| Levelling mark | C701-LT028066 | 89979.702 | 35425.026 | 98.603  |
| Levelling mark | C701-LT028067 | 89980.427 | 35423.185 | 98.544  |
| Levelling mark | C701-LT028068 | 89981.164 | 35421.332 | 98.485  |
| Levelling mark | C701-LT028069 | 89981.907 | 35419.477 | 98.425  |
| Levelling mark | C701-LT028070 | 89982.636 | 35417.617 | 98.366  |
| Levelling mark | C701-LT028071 | 89983.377 | 35415.743 | 98.308  |
| Levelling mark | C701-LT028072 | 89984.115 | 35413.892 | 98.251  |
| Levelling mark | C701-LT028073 | 89984.860 | 35412.022 | 98.192  |
| Levelling mark | C701-LT028074 | 89985.610 | 35410.140 | 98.134  |
| Levelling mark | C701-LT028075 | 89986.347 | 35408.302 | 98.077  |
| Levelling mark | C701-LT028076 | 89987.095 | 35406.438 | 98.020  |
| Levelling mark | C701-LT028077 | 89987.841 | 35404.575 | 97.961  |
| Levelling mark | C701-LT028078 | 89988.596 | 35402.716 | 97.900  |
| Levelling mark | C701-LT028079 | 89989.344 | 35400.859 | 97.841  |
| Levelling mark | C701-LT028080 | 89990.099 | 35399.023 | 97.783  |
| Levelling mark | C701-LT028081 | 89990.855 | 35397.179 | 97.725  |
| Levelling mark | C701-LT028082 | 89991.629 | 35395.295 | 97.665  |
| Levelling mark | C701-LT028083 | 89992.385 | 35393.459 | 97.607  |
| Levelling mark | C701-LT028084 | 89993.166 | 35391.604 | 97.547  |
| Levelling mark | C701-LT028085 | 89993.941 | 35389.757 | 97.487  |
| Levelling mark | C701-LT028086 | 89994.728 | 35387.912 | 97.428  |
| Levelling mark | C701-LT028087 | 89995.515 | 35386.064 | 97.368  |
| Levelling mark | C701-LT028088 | 89996.298 | 35384.236 | 97.311  |
| Levelling mark | C701-LT028089 | 89997.095 | 35382.403 | 97.254  |
| Levelling mark | C701-LT028090 | 89997.886 | 35380.556 | 97.199  |
| Levelling mark | C701-LT028091 | 89998.691 | 35378.721 | 97.143  |
| Levelling mark | C701-LT028201 | 89933.154 | 35546.425 | 102.492 |
| Levelling mark | C701-LT028202 | 89933.881 | 35544.605 | 102.433 |



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|----------------|---------------|-----------|-----------|---------|
| Levelling mark | C701-LT028203 | 89934.639 | 35542.692 | 102.372 |
| Levelling mark | C701-LT028204 | 89935.365 | 35540.864 | 102.312 |
| Levelling mark | C701-LT028205 | 89936.127 | 35538.946 | 102.250 |
| Levelling mark | C701-LT028206 | 89936.835 | 35537.156 | 102.193 |
| Levelling mark | C701-LT028207 | 89937.579 | 35535.280 | 102.132 |
| Levelling mark | C701-LT028208 | 89938.317 | 35533.411 | 102.072 |
| Levelling mark | C701-LT028209 | 89939.063 | 35531.563 | 102.013 |
| Levelling mark | C701-LT028210 | 89939.796 | 35529.676 | 101.952 |
| Levelling mark | C701-LT028211 | 89940.519 | 35527.853 | 101.894 |
| Levelling mark | C701-LT028212 | 89941.255 | 35526.003 | 101.834 |
| Levelling mark | C701-LT028213 | 89942.001 | 35524.149 | 101.773 |
| Levelling mark | C701-LT028214 | 89942.733 | 35522.278 | 101.714 |
| Levelling mark | C701-LT028215 | 89943.481 | 35520.407 | 101.653 |
| Levelling mark | C701-LT028216 | 89944.216 | 35518.542 | 101.594 |
| Levelling mark | C701-LT028217 | 89944.953 | 35516.662 | 101.534 |
| Levelling mark | C701-LT028218 | 89945.699 | 35514.812 | 101.474 |
| Levelling mark | C701-LT028219 | 89946.421 | 35512.984 | 101.416 |
| Levelling mark | C701-LT028220 | 89947.152 | 35511.127 | 101.357 |
| Levelling mark | C701-LT028221 | 89947.890 | 35509.274 | 101.298 |
| Levelling mark | C701-LT028222 | 89948.631 | 35507.422 | 101.239 |
| Levelling mark | C701-LT028223 | 89949.382 | 35505.558 | 101.180 |
| Levelling mark | C701-LT028224 | 89950.093 | 35503.711 | 101.120 |
| Levelling mark | C701-LT028225 | 89950.836 | 35501.849 | 101.061 |
| Levelling mark | C701-LT028226 | 89951.586 | 35499.976 | 101.001 |
| Levelling mark | C701-LT028227 | 89952.312 | 35498.133 | 100.941 |
| Levelling mark | C701-LT028228 | 89953.056 | 35496.262 | 100.881 |
| Levelling mark | C701-LT028229 | 89953.801 | 35494.404 | 100.819 |
| Levelling mark | C701-LT028230 | 89954.533 | 35492.556 | 100.758 |
| Levelling mark | C701-LT028231 | 89955.283 | 35490.661 | 100.697 |
| Levelling mark | C701-LT028232 | 89956.029 | 35488.766 | 100.637 |
| Levelling mark | C701-LT028233 | 89956.776 | 35486.896 | 100.578 |
| Levelling mark | C701-LT028234 | 89957.487 | 35485.101 | 100.519 |
| Levelling mark | C701-LT028235 | 89958.233 | 35483.223 | 100.459 |
| Levelling mark | C701-LT028236 | 89958.970 | 35481.368 | 100.401 |
| Levelling mark | C701-LT028237 | 89959.709 | 35479.497 | 100.340 |
| Levelling mark | C701-LT028238 | 89960.444 | 35477.661 | 100.281 |
| Levelling mark | C701-LT028239 | 89961.167 | 35475.832 | 100.224 |
| Levelling mark | C701-LT028240 | 89961.916 | 35473.938 | 100.165 |
| Levelling mark | C701-LT028241 | 89962.647 | 35472.079 | 100.105 |
| Levelling mark | C701-LT028242 | 89963.401 | 35470.174 | 100.043 |
| Levelling mark | C701-LT028243 | 89964.141 | 35468.351 | 99.983  |
| Levelling mark | C701-LT028244 | 89964.854 | 35466.513 | 99.924  |
| Levelling mark | C701-LT028245 | 89965.581 | 35464.672 | 99.864  |
| Levelling mark | C701-LT028246 | 89966.343 | 35462.763 | 99.803  |
| Levelling mark | C701-LT028247 | 89967.079 | 35460.915 | 99.743  |
| Levelling mark | C701-LT028248 | 89967.816 | 35459.067 | 99.684  |
| Levelling mark | C701-LT028249 | 89968.550 | 35457.238 | 99.625  |
| Levelling mark | C701-LT028250 | 89969.268 | 35455.395 | 99.566  |
| Levelling mark | C701-LT028251 | 89970.014 | 35453.542 | 99.507  |
| Levelling mark | C701-LT028252 | 89970.765 | 35451.650 | 99.445  |

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|----------------|---------------|-----------|-----------|---------|
| Levelling mark | C701-LT028253 | 89971.490 | 35449.785 | 99.386  |
| Levelling mark | C701-LT028254 | 89972.227 | 35447.958 | 99.326  |
| Levelling mark | C701-LT028255 | 89972.968 | 35446.102 | 99.266  |
| Levelling mark | C701-LT028256 | 89973.709 | 35444.218 | 99.204  |
| Levelling mark | C701-LT028257 | 89974.456 | 35442.352 | 99.145  |
| Levelling mark | C701-LT028258 | 89975.178 | 35440.494 | 99.085  |
| Levelling mark | C701-LT028259 | 89975.928 | 35438.650 | 99.024  |
| Levelling mark | C701-LT028260 | 89976.639 | 35436.803 | 98.964  |
| Levelling mark | C701-LT028261 | 89977.406 | 35434.902 | 98.902  |
| Levelling mark | C701-LT028262 | 89978.149 | 35433.032 | 98.842  |
| Levelling mark | C701-LT028263 | 89978.872 | 35431.178 | 98.783  |
| Levelling mark | C701-LT028264 | 89979.608 | 35429.356 | 98.725  |
| Levelling mark | C701-LT028265 | 89980.352 | 35427.480 | 98.663  |
| Levelling mark | C701-LT028266 | 89981.093 | 35425.583 | 98.601  |
| Levelling mark | C701-LT028267 | 89981.829 | 35423.718 | 98.542  |
| Levelling mark | C701-LT028268 | 89982.558 | 35421.900 | 98.483  |
| Levelling mark | C701-LT028269 | 89983.301 | 35420.036 | 98.424  |
| Levelling mark | C701-LT028270 | 89984.026 | 35418.200 | 98.364  |
| Levelling mark | C701-LT028271 | 89984.765 | 35416.355 | 98.303  |
| Levelling mark | C701-LT028272 | 89985.506 | 35414.476 | 98.240  |
| Levelling mark | C701-LT028273 | 89986.245 | 35412.613 | 98.178  |
| Levelling mark | C701-LT028274 | 89986.985 | 35410.752 | 98.117  |
| Levelling mark | C701-LT028275 | 89987.715 | 35408.925 | 98.056  |
| Levelling mark | C701-LT028276 | 89988.458 | 35407.046 | 97.993  |
| Levelling mark | C701-LT028277 | 89989.205 | 35405.205 | 97.931  |
| Levelling mark | C701-LT028278 | 89989.958 | 35403.351 | 97.866  |
| Levelling mark | C701-LT028279 | 89990.723 | 35401.486 | 97.802  |
| Levelling mark | C701-LT028280 | 89991.472 | 35399.646 | 97.740  |
| Levelling mark | C701-LT028281 | 89992.232 | 35397.775 | 97.679  |
| Levelling mark | C701-LT028282 | 89993.003 | 35395.915 | 97.617  |
| Levelling mark | C701-LT028283 | 89993.773 | 35394.074 | 97.556  |
| Levelling mark | C701-LT028284 | 89994.526 | 35392.256 | 97.497  |
| Levelling mark | C701-LT028285 | 89995.316 | 35390.376 | 97.437  |
| Levelling mark | C701-LT028286 | 89996.095 | 35388.551 | 97.377  |
| Levelling mark | C701-LT028287 | 89996.876 | 35386.713 | 97.318  |
| Levelling mark | C701-LT028288 | 89997.662 | 35384.873 | 97.260  |
| Levelling mark | C701-LT028289 | 89998.461 | 35383.032 | 97.203  |
| Levelling mark | C701-LT028290 | 89999.260 | 35381.175 | 97.147  |
| Levelling mark | C701-LT028291 | 90000.072 | 35379.345 | 97.092  |
| Levelling mark | C701-LT028601 | 89936.770 | 35547.454 | 102.004 |
| Levelling mark | C701-LT028602 | 89937.514 | 35545.591 | 101.946 |
| Levelling mark | C701-LT028603 | 89938.236 | 35543.751 | 101.886 |
| Levelling mark | C701-LT028604 | 89938.988 | 35541.869 | 101.825 |
| Levelling mark | C701-LT028605 | 89939.716 | 35540.043 | 101.764 |
| Levelling mark | C701-LT028606 | 89940.436 | 35538.207 | 101.708 |
| Levelling mark | C701-LT028607 | 89941.177 | 35536.345 | 101.647 |
| Levelling mark | C701-LT028608 | 89941.921 | 35534.511 | 101.587 |
| Levelling mark | C701-LT028609 | 89942.636 | 35532.671 | 101.531 |
| Levelling mark | C701-LT028610 | 89943.387 | 35530.784 | 101.469 |
| Levelling mark | C701-LT028611 | 89944.110 | 35528.964 | 101.410 |

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| Levelling mark | C701-LT028612 | 89944.848 | 35527.050 | 101.349 |
| Levelling mark | C701-LT028613 | 89945.585 | 35525.245 | 101.290 |
| Levelling mark | C701-LT028614 | 89946.330 | 35523.395 | 101.230 |
| Levelling mark | C701-LT028615 | 89947.072 | 35521.540 | 101.170 |
| Levelling mark | C701-LT028616 | 89947.798 | 35519.693 | 101.110 |
| Levelling mark | C701-LT028617 | 89948.567 | 35517.802 | 101.052 |
| Levelling mark | C701-LT028618 | 89949.269 | 35515.975 | 100.991 |
| Levelling mark | C701-LT028619 | 89950.004 | 35514.121 | 100.931 |
| Levelling mark | C701-LT028620 | 89950.749 | 35512.249 | 100.872 |
| Levelling mark | C701-LT028621 | 89951.473 | 35510.422 | 100.814 |
| Levelling mark | C701-LT028622 | 89952.245 | 35508.532 | 100.754 |
| Levelling mark | C701-LT028623 | 89952.961 | 35506.693 | 100.692 |
| Levelling mark | C701-LT028624 | 89953.687 | 35504.864 | 100.634 |
| Levelling mark | C701-LT028625 | 89954.419 | 35503.013 | 100.575 |
| Levelling mark | C701-LT028626 | 89955.156 | 35501.139 | 100.513 |
| Levelling mark | C701-LT028627 | 89955.896 | 35499.301 | 100.451 |
| Levelling mark | C701-LT028628 | 89956.614 | 35497.485 | 100.391 |
| Levelling mark | C701-LT028629 | 89957.354 | 35495.637 | 100.328 |
| Levelling mark | C701-LT028630 | 89958.112 | 35493.722 | 100.266 |
| Levelling mark | C701-LT028631 | 89958.854 | 35491.901 | 100.204 |
| Levelling mark | C701-LT028632 | 89959.597 | 35490.019 | 100.140 |
| Levelling mark | C701-LT028633 | 89960.311 | 35488.218 | 100.081 |
| Levelling mark | C701-LT028634 | 89961.075 | 35486.327 | 100.017 |
| Levelling mark | C701-LT028635 | 89961.831 | 35484.454 | 99.955  |
| Levelling mark | C701-LT028636 | 89962.564 | 35482.652 | 99.895  |
| Levelling mark | C701-LT028637 | 89963.315 | 35480.815 | 99.834  |
| Levelling mark | C701-LT028638 | 89964.057 | 35478.982 | 99.771  |
| Levelling mark | C701-LT028639 | 89964.816 | 35477.147 | 99.710  |
| Levelling mark | C701-LT028640 | 89965.576 | 35475.281 | 99.650  |
| Levelling mark | C701-LT028641 | 89966.338 | 35473.447 | 99.586  |
| Levelling mark | C701-LT028642 | 89967.384 | 35471.681 | 99.524  |
| Levelling mark | C701-LT028643 | 89967.877 | 35469.775 | 99.461  |
| Levelling mark | C701-LT028644 | 89968.649 | 35467.950 | 99.401  |
| Levelling mark | C701-LT028645 | 89969.454 | 35466.087 | 99.335  |
| Levelling mark | C701-LT028646 | 89970.292 | 35464.139 | 99.271  |
| Levelling mark | C701-LT028647 | 89971.092 | 35462.303 | 99.208  |
| Levelling mark | C701-LT028648 | 89971.883 | 35460.475 | 99.144  |
| Levelling mark | C701-LT028649 | 89972.678 | 35458.674 | 99.082  |
| Levelling mark | C701-LT028650 | 89973.493 | 35456.831 | 99.023  |
| Levelling mark | C701-LT028651 | 89974.283 | 35455.083 | 98.961  |
| Levelling mark | C701-LT028652 | 89975.123 | 35453.270 | 98.901  |
| Levelling mark | C701-LT028653 | 89975.933 | 35451.477 | 98.840  |
| Levelling mark | C701-LT028654 | 89976.769 | 35449.679 | 98.782  |
| Levelling mark | C701-LT028655 | 89977.623 | 35447.856 | 98.719  |
| Levelling mark | C701-LT028656 | 89978.527 | 35445.939 | 98.660  |
| Levelling mark | C701-LT028657 | 89979.383 | 35444.170 | 98.602  |
| Levelling mark | C701-LT028658 | 89980.211 | 35442.404 | 98.541  |
| Levelling mark | C701-LT028659 | 89981.121 | 35440.566 | 98.478  |
| Levelling mark | C701-LT028660 | 89981.995 | 35438.785 | 98.417  |
| Levelling mark | C701-LT028661 | 89982.896 | 35436.987 | 98.359  |

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| Levelling mark | C701-LT028662 | 89983.799 | 35435.208 | 98.302  |
| Levelling mark | C701-LT028663 | 89984.707 | 35433.402 | 98.243  |
| Levelling mark | C701-LT028664 | 89985.614 | 35431.626 | 98.185  |
| Levelling mark | C701-LT028665 | 89986.519 | 35429.893 | 98.128  |
| Levelling mark | C701-LT028666 | 89987.381 | 35428.251 | 98.068  |
| Levelling mark | C701-LT028667 | 89988.373 | 35426.378 | 98.008  |
| Levelling mark | C701-LT028668 | 89989.300 | 35424.623 | 97.951  |
| Levelling mark | C701-LT028669 | 89990.234 | 35422.876 | 97.893  |
| Levelling mark | C701-LT028670 | 89991.196 | 35421.111 | 97.836  |
| Levelling mark | C701-LT028671 | 89992.147 | 35419.357 | 97.782  |
| Levelling mark | C701-LT028672 | 89993.093 | 35417.621 | 97.727  |
| Levelling mark | C701-LT028673 | 89994.074 | 35415.849 | 97.674  |
| Levelling mark | C701-LT028674 | 89995.046 | 35414.114 | 97.622  |
| Levelling mark | C701-LT028675 | 89995.985 | 35412.413 | 97.572  |
| Levelling mark | C701-LT028676 | 89996.965 | 35410.677 | 97.523  |
| Levelling mark | C701-LT028677 | 89997.949 | 35408.931 | 97.474  |
| Levelling mark | C701-LT028678 | 89998.945 | 35407.180 | 97.427  |
| Levelling mark | C701-LT028679 | 89999.939 | 35405.437 | 97.380  |
| Levelling mark | C701-LT028680 | 90000.928 | 35403.708 | 97.335  |
| Levelling mark | C701-LT028681 | 90001.915 | 35401.997 | 97.291  |
| Levelling mark | C701-LT028682 | 90002.915 | 35400.260 | 97.247  |
| Levelling mark | C701-LT028683 | 90003.908 | 35398.536 | 97.203  |
| Levelling mark | C701-LT028684 | 90004.912 | 35396.831 | 97.160  |
| Levelling mark | C701-LT028685 | 90005.917 | 35395.092 | 97.116  |
| Levelling mark | C701-LT028686 | 90006.909 | 35393.375 | 97.073  |
| Levelling mark | C701-LT028687 | 90007.929 | 35391.641 | 97.029  |
| Levelling mark | C701-LT028688 | 90008.936 | 35389.914 | 96.986  |
| Levelling mark | C701-LT028689 | 90009.957 | 35388.189 | 96.942  |
| Levelling mark | C701-LT028690 | 90010.944 | 35386.482 | 96.898  |
| Levelling mark | C701-LT028691 | 90011.959 | 35384.756 | 96.856  |
| Levelling mark | C701-LT028692 | 90012.963 | 35383.032 | 96.812  |
| Levelling mark | C701-LT028693 | 90013.969 | 35381.319 | 96.768  |
| Levelling mark | C701-LT028694 | 90014.981 | 35379.606 | 96.726  |
| Levelling mark | C701-LT028695 | 90015.972 | 35377.894 | 96.681  |
| Levelling mark | C701-LT028696 | 90016.977 | 35376.188 | 96.637  |
| Levelling mark | C701-LT028697 | 90017.983 | 35374.460 | 96.593  |
| Levelling mark | C701-LT028698 | 90019.000 | 35372.715 | 96.548  |
| Levelling mark | C701-LT028699 | 90019.969 | 35371.037 | 96.503  |
| Levelling mark | C701-LT028700 | 90020.983 | 35369.312 | 96.460  |
| Levelling mark | C701-LT028701 | 90021.982 | 35367.563 | 96.416  |
| Levelling mark | C701-LT028401 | 89938.178 | 35547.983 | 102.004 |
| Levelling mark | C701-LT028402 | 89938.907 | 35546.156 | 101.945 |
| Levelling mark | C701-LT028403 | 89939.638 | 35544.293 | 101.886 |
| Levelling mark | C701-LT028404 | 89940.378 | 35542.416 | 101.826 |
| Levelling mark | C701-LT028405 | 89941.132 | 35540.541 | 101.766 |
| Levelling mark | C701-LT028406 | 89941.820 | 35538.788 | 101.707 |
| Levelling mark | C701-LT028407 | 89942.566 | 35536.923 | 101.646 |
| Levelling mark | C701-LT028408 | 89943.329 | 35534.996 | 101.587 |
| Levelling mark | C701-LT028409 | 89944.023 | 35533.249 | 101.530 |
| Levelling mark | C701-LT028410 | 89944.788 | 35531.344 | 101.470 |

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|                |               |           |           |         |
|----------------|---------------|-----------|-----------|---------|
| Levelling mark | C701-LT028411 | 89945.497 | 35529.509 | 101.410 |
| Levelling mark | C701-LT028412 | 89946.256 | 35527.618 | 101.348 |
| Levelling mark | C701-LT028413 | 89946.979 | 35525.822 | 101.289 |
| Levelling mark | C701-LT028414 | 89947.716 | 35523.962 | 101.229 |
| Levelling mark | C701-LT028415 | 89948.474 | 35522.060 | 101.169 |
| Levelling mark | C701-LT028416 | 89949.201 | 35520.208 | 101.110 |
| Levelling mark | C701-LT028417 | 89949.949 | 35518.367 | 101.050 |
| Levelling mark | C701-LT028418 | 89950.671 | 35516.512 | 100.990 |
| Levelling mark | C701-LT028419 | 89951.423 | 35514.652 | 100.930 |
| Levelling mark | C701-LT028420 | 89952.144 | 35512.796 | 100.871 |
| Levelling mark | C701-LT028421 | 89952.894 | 35510.970 | 100.814 |
| Levelling mark | C701-LT028422 | 89953.609 | 35509.139 | 100.753 |
| Levelling mark | C701-LT028423 | 89954.381 | 35507.179 | 100.693 |
| Levelling mark | C701-LT028424 | 89955.087 | 35505.415 | 100.633 |
| Levelling mark | C701-LT028425 | 89955.816 | 35503.586 | 100.574 |
| Levelling mark | C701-LT028426 | 89956.556 | 35501.720 | 100.514 |
| Levelling mark | C701-LT028427 | 89957.302 | 35499.851 | 100.455 |
| Levelling mark | C701-LT028428 | 89958.009 | 35498.061 | 100.399 |
| Levelling mark | C701-LT028429 | 89958.772 | 35496.143 | 100.342 |
| Levelling mark | C701-LT028430 | 89959.520 | 35494.273 | 100.283 |
| Levelling mark | C701-LT028431 | 89960.245 | 35492.457 | 100.226 |
| Levelling mark | C701-LT028432 | 89960.998 | 35490.561 | 100.167 |
| Levelling mark | C701-LT028433 | 89961.716 | 35488.770 | 100.112 |
| Levelling mark | C701-LT028434 | 89962.487 | 35486.861 | 100.054 |
| Levelling mark | C701-LT028435 | 89963.222 | 35485.008 | 99.996  |
| Levelling mark | C701-LT028436 | 89963.953 | 35483.208 | 99.940  |
| Levelling mark | C701-LT028437 | 89964.688 | 35481.424 | 99.882  |
| Levelling mark | C701-LT028438 | 89965.451 | 35479.531 | 99.826  |
| Levelling mark | C701-LT028439 | 89966.217 | 35477.716 | 99.769  |
| Levelling mark | C701-LT028440 | 89966.978 | 35475.877 | 99.713  |
| Levelling mark | C701-LT028441 | 89967.782 | 35473.956 | 99.657  |
| Levelling mark | C701-LT028442 | 89968.504 | 35472.138 | 99.598  |
| Levelling mark | C701-LT028443 | 89969.296 | 35470.306 | 99.539  |
| Levelling mark | C701-LT028444 | 89970.029 | 35468.582 | 99.480  |
| Levelling mark | C701-LT028445 | 89970.846 | 35466.644 | 99.422  |
| Levelling mark | C701-LT028446 | 89971.660 | 35464.749 | 99.361  |
| Levelling mark | C701-LT028447 | 89972.444 | 35462.942 | 99.303  |
| Levelling mark | C701-LT028448 | 89973.286 | 35461.053 | 99.245  |
| Levelling mark | C701-LT028449 | 89974.078 | 35459.211 | 99.188  |
| Levelling mark | C701-LT028450 | 89974.869 | 35457.472 | 99.131  |
| Levelling mark | C701-LT028451 | 89975.691 | 35455.639 | 99.076  |
| Levelling mark | C701-LT028452 | 89976.495 | 35453.842 | 99.020  |
| Levelling mark | C701-LT028453 | 89977.324 | 35452.055 | 98.963  |
| Levelling mark | C701-LT028454 | 89978.124 | 35450.330 | 98.904  |
| Levelling mark | C701-LT028455 | 89978.989 | 35448.499 | 98.842  |
| Levelling mark | C701-LT028456 | 89979.889 | 35446.576 | 98.779  |
| Levelling mark | C701-LT028457 | 89980.734 | 35444.828 | 98.721  |
| Levelling mark | C701-LT028458 | 89981.573 | 35443.075 | 98.662  |
| Levelling mark | C701-LT028459 | 89982.485 | 35441.227 | 98.600  |
| Levelling mark | C701-LT028460 | 89983.368 | 35439.412 | 98.539  |

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|                |               |           |           |        |
|----------------|---------------|-----------|-----------|--------|
| Levelling mark | C701-LT028461 | 89984.217 | 35437.722 | 98.479 |
| Levelling mark | C701-LT028462 | 89985.117 | 35435.943 | 98.420 |
| Levelling mark | C701-LT028463 | 89986.036 | 35434.110 | 98.363 |
| Levelling mark | C701-LT028464 | 89986.919 | 35432.372 | 98.304 |
| Levelling mark | C701-LT028465 | 89987.833 | 35430.646 | 98.242 |
| Levelling mark | C701-LT028466 | 89988.774 | 35428.838 | 98.181 |
| Levelling mark | C701-LT028467 | 89989.711 | 35427.046 | 98.114 |
| Levelling mark | C701-LT028468 | 89990.645 | 35425.291 | 98.054 |
| Levelling mark | C701-LT028469 | 89991.577 | 35423.562 | 97.993 |
| Levelling mark | C701-LT028470 | 89992.518 | 35421.814 | 97.933 |
| Levelling mark | C701-LT028471 | 89993.474 | 35420.059 | 97.872 |
| Levelling mark | C701-LT028472 | 89994.418 | 35418.337 | 97.813 |
| Levelling mark | C701-LT028473 | 89995.387 | 35416.596 | 97.754 |
| Levelling mark | C701-LT028474 | 89996.349 | 35414.851 | 97.699 |
| Levelling mark | C701-LT028475 | 89997.319 | 35413.123 | 97.646 |
| Levelling mark | C701-LT028476 | 89998.285 | 35411.385 | 97.593 |
| Levelling mark | C701-LT028477 | 89999.268 | 35409.639 | 97.539 |
| Levelling mark | C701-LT028478 | 90000.258 | 35407.918 | 97.487 |
| Levelling mark | C701-LT028479 | 90001.257 | 35406.173 | 97.436 |
| Levelling mark | C701-LT028480 | 90002.238 | 35404.452 | 97.386 |
| Levelling mark | C701-LT028481 | 90003.218 | 35402.711 | 97.338 |
| Levelling mark | C701-LT028482 | 90004.227 | 35400.987 | 97.290 |
| Levelling mark | C701-LT028483 | 90005.213 | 35399.286 | 97.241 |
| Levelling mark | C701-LT028484 | 90006.220 | 35397.563 | 97.193 |
| Levelling mark | C701-LT028485 | 90007.226 | 35395.842 | 97.145 |
| Levelling mark | C701-LT028486 | 90008.217 | 35394.126 | 97.097 |
| Levelling mark | C701-LT028487 | 90009.210 | 35392.411 | 97.048 |
| Levelling mark | C701-LT028488 | 90010.220 | 35390.700 | 96.999 |
| Levelling mark | C701-LT028489 | 90011.220 | 35388.985 | 96.951 |
| Levelling mark | C701-LT028490 | 90012.228 | 35387.266 | 96.903 |
| Levelling mark | C701-LT028491 | 90013.248 | 35385.547 | 96.856 |
| Levelling mark | C701-LT028492 | 90014.251 | 35383.825 | 96.807 |
| Levelling mark | C701-LT028493 | 90015.254 | 35382.124 | 96.760 |
| Levelling mark | C701-LT028494 | 90016.245 | 35380.425 | 96.712 |
| Levelling mark | C701-LT028495 | 90017.257 | 35378.706 | 96.663 |
| Levelling mark | C701-LT028496 | 90018.259 | 35376.973 | 96.615 |
| Levelling mark | C701-LT028497 | 90019.264 | 35375.247 | 96.566 |
| Levelling mark | C701-LT028498 | 90020.272 | 35373.532 | 96.517 |
| Levelling mark | C701-LT028499 | 90021.285 | 35371.789 | 96.470 |
| Levelling mark | C701-LT028500 | 90022.263 | 35370.082 | 96.421 |
| Levelling mark | C701-LT028501 | 90023.270 | 35368.354 | 96.372 |