



Woolwich Station Modelling Report

RIBA Stage D

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1 Introduction

This report presents the Legion modelling of pedestrian flows at Woolwich. The dynamic modelling was used to determine any passenger management and station operational requirements. Legion versions EP4 and EP5 were used for this modelling.

The CAD drawings are from Scheme Design 3 (SD3) RIBA D of Woolwich station.

Assessments have been undertaken for the AM Peak period (07:00 to 10:00 hours) and PM Peak period (16:00 to 19:00 hours). These were tested at 2026 AM and PM Peak and 2026 plus 28%.

Passengers with Restricted Mobility (PRMs) using the lifts have also been modelled in this study. The data sources, assumptions, passenger routing options and results of the analysis are summarised in this report.

The results of this Legion modelling study are in the form of cumulative passenger density plots which show Fruin Levels of Service, and two-dimensional videos showing passenger movements within the station.

Table 1: Summary Table of Scenarios

| Model | Scenarios |
|-------|-------------------|
| AM | 2026 2026 +28% |
| PM | 2026 2026 +28% |

2 Model Development

Station Layout

The model was built with reference to a previous model produced by Crossrail.

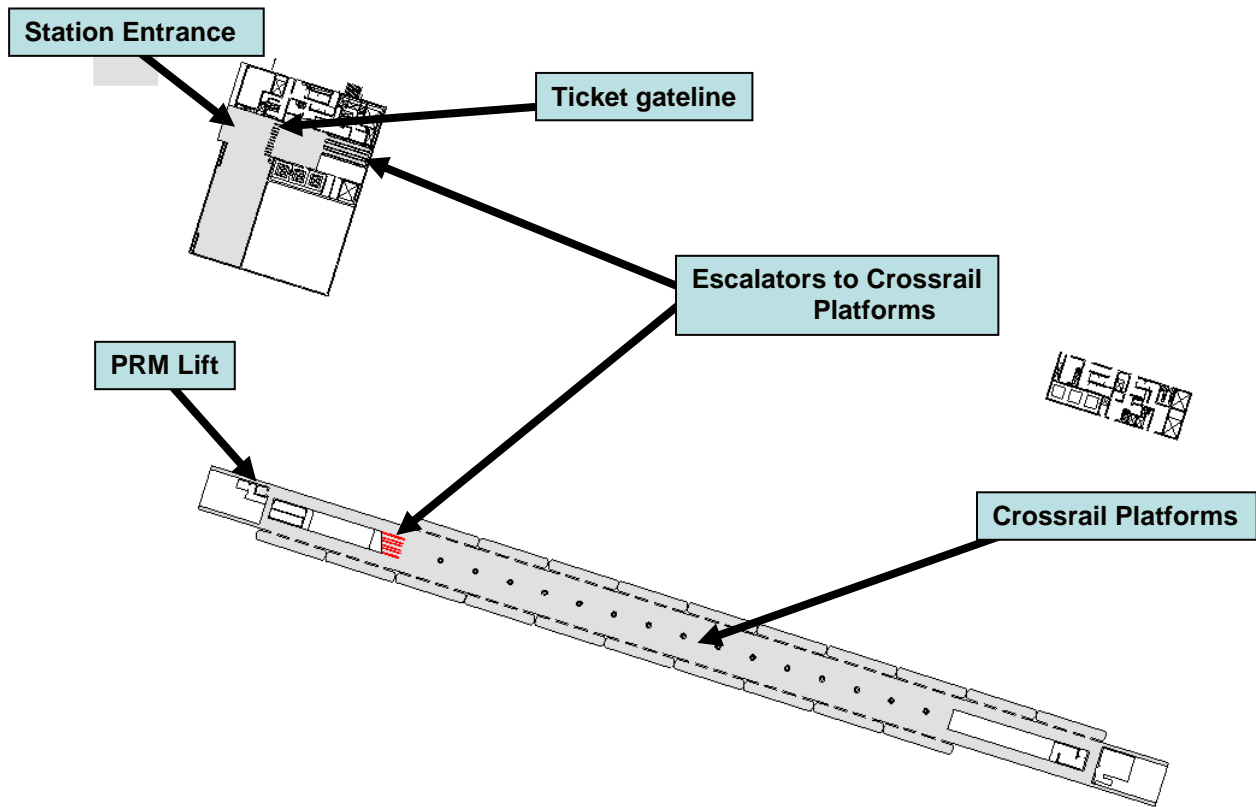
The station layout consists of a station box with two platforms for the eastbound and westbound direction of Crossrail. The ticket hall is above the western end of the Crossrail platform and consists of nine automatic ticket gates, plus two additional wide aisle gates for Persons of Reduced Mobility (PRM).

Access to the Crossrail platforms is by a bank of three escalators (one in 'up', two in 'down' direction in the AM peak and two in 'up', one in 'down' direction in the PM peak). The station is also served by a lift, from the ticket hall to the Crossrail platforms.

Entry to the station is by a western entrance which gives access to Woolwich Town Centre via a crossing on Plumstead Road.

At platform level, the proportionate splits have been estimated on a carriage by carriage basis. This involved making a decision on which carriages passengers are likely to use based on the proximity of a particular carriage to the escalators. The bank of escalators forms the only platform egress point which means that passengers are likely to favour carriages that stop in this area.

Illustration 1: Woolwich Station Layout



2.1 Passenger Demand

Table 4: 2026 +28%, 3 hour AM Peak Demand

| 2026 +28% with Crossrail - AM Peak Period Demand at Woolwich | | | | |
|--|---------------------------|-------------------------|-------------------------|--------------|
| WOH153RuAM | WOOLWICH STATION ENTRANCE | WOOLWICH CROSSRAIL (EB) | WOOLWICH CROSSRAIL (WB) | TOTAL |
| WOOLWICH STATION Entrance | - | 0 | 11456 | 11456 |
| WOOLWICH CROSSRAIL (EB) | 2688 | - | - | 2688 |
| WOOLWICH CROSSRAIL (WB) | 64 | - | - | 64 |
| TOTAL | 2752 | 0 | 11456 | 14208 |

Table 5: 2026 +28%, 3 hour PM Peak Demand

| 2026 +28% with Crossrail - PM Peak Period Demand at Woolwich | | | | |
|--|---------------------------|-------------------------|-------------------------|--------------|
| WOH153RuPM | WOOLWICH STATION ENTRANCE | WOOLWICH CROSSRAIL (EB) | WOOLWICH CROSSRAIL (WB) | TOTAL |
| WOOLWICH STATION Entrance | - | 64 | 2688 | 2752 |
| WOOLWICH CROSSRAIL (EB) | 11456 | - | - | 11456 |
| WOOLWICH CROSSRAIL (WB) | 0 | - | - | 0 |
| TOTAL | 11456 | 64 | 2688 | 14208 |

2.2 Entity Description

Table 3: Entity Description

| Entity Name | Description | Colour |
|----------------|---|---------------|
| Crossrail (EB) | Crossrail eastbound going to Abbey Wood | Blue |
| Crossrail (WB) | Crossrail westbound going to Paddington | Red |
| Entrance | Alighters exiting at Woolwich | Bright yellow |

2.3 Train Assumptions

Table 7: Destination Distribution for Boarding Passengers – Crossrail Trains

| Eastbound Train Boarders | |
|--------------------------|------|
| Abbey Wood | 100% |
| Westbound Train Boarders | |
| Paddington | 100% |

It is assumed that all passengers will board the first Crossrail train. No passengers are expected to board eastbound services which only run to Abbey Wood.

Table 8: Origin Distribution for Alighting Passengers – Crossrail Trains

| Eastbound Train Boarders | |
|--------------------------|------|
| Abbey Wood | 100% |

| Westbound Train Boarders | |
|--------------------------|------|
| Paddington | 100% |

1. Crossrail rolling stock was assumed to have three doors per carriage. Each train carriage was assumed to be approximately 20m in length.
2. For Crossrail, a dwell time of 45 seconds was assumed on all services. 10 seconds was assumed to be required for door opening and closing and therefore 35 seconds of effective door open time was modelled.

Table 12: Length and Frequency of Trains

| Length of Crossrail Trains | 10 Car | 12 Car |
|--|--------|--------|
| Train Frequency (trains per hour) | | |
| Crossrail EB | 12 | 12 |
| Crossrail WB | 12 | 12 |

2.4 Passenger Arrival Profile

Table 13: 2026 AM Peak Arrival Profile

| Woolwich Station Arrival Profiles - AM Peak | | | | | | | | | | | | |
|---|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| | 07:00 | 07:15 | 07:30 | 07:45 | 08:00 | 08:15 | 08:30 | 08:45 | 09:00 | 09:15 | 09:30 | 09:45 |
| Crossrail (WB) | 8% | 9% | 9% | 9% | 8% | 9% | 9% | 8% | 8% | 8% | 8% | 7% |
| Crossrail (EB) | 6% | 8% | 9% | 9% | 8% | 8% | 9% | 9% | 9% | 9% | 9% | 8% |
| Entrances | 7% | 7% | 8% | 9% | 11% | 12% | 11% | 10% | 8% | 7% | 5% | 4% |

Table 14: 2026 PM Peak Arrival Profile

| Woolwich Station Arrival Profiles - PM Peak | | | | | | | | | | | | |
|---|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| | 16:00 | 16:15 | 16:30 | 16:45 | 17:00 | 17:15 | 17:30 | 17:45 | 18:00 | 18:15 | 18:30 | 18:45 |
| Crossrail WB | 6% | 7% | 7% | 7% | 8% | 9% | 10% | 10% | 10% | 10% | 9% | 8% |
| Crossrail EB | 4% | 5% | 6% | 7% | 7% | 9% | 10% | 10% | 10% | 11% | 11% | 10% |
| Entrance | 7% | 7% | 8% | 9% | 9% | 10% | 9% | 9% | 9% | 9% | 8% | 6% |

2.5 Platform Alighting Profile

Table 15: Platform Alighting Profile for 10 and 12 car train

| Train Carriage | 10 Car Train | | 12 Car Train | |
|-------------------|--------------|-------------|--------------|-------------|
| | EB Platform | WB Platform | EB Platform | WB Platform |
| Car 1 | 4% | 19% | 2.5% | 14.2% |
| Car 2 | 4% | 19% | 2.5% | 14.2% |
| Car 3 | 4% | 19% | 2.5% | 14.2% |
| Car 4 | 4% | 19% | 2.5% | 14.2% |
| Car 5 | 4% | 19% | 2.5% | 14.2% |
| Car 6 | 19% | 4% | 2.5% | 14.2% |
| Car 7 | 19% | 4% | 14.2% | 2.5% |
| Car 8 | 19% | 4% | 14.2% | 2.5% |
| Car 9 | 19% | 4% | 14.2% | 2.5% |
| Car 10 | 19% | 4% | 14.2% | 2.5% |
| Car 11 | n/a | n/a | 14.2% | 2.5% |
| Car 12 | n/a | n/a | 14.2% | 2.5% |

2.6 Train Boarding Profile

Table 16: Platform Boarding Profile for 10 and 12 car train

| Train Carriage | 10 Car Train | | 12 Car Train | |
|-------------------|--------------|-------------|--------------|-------------|
| | EB Platform | WB Platform | EB Platform | WB Platform |
| Car 1 | 4% | 8% | 2.5% | 14.2% |
| Car 2 | 5% | 14% | 2.5% | 14.2% |
| Car 3 | 5% | 18% | 2.5% | 14.2% |
| Car 4 | 5% | 18% | 2.5% | 14.2% |

| | | | | |
|---------------|-----|-----|-------|-------|
| Car 5 | 8% | 15% | 2.5% | 14.2% |
| Car 6 | 15% | 8% | 2.5% | 14.2% |
| Car 7 | 18% | 5% | 14.2% | 2.5% |
| Car 8 | 18% | 5% | 14.2% | 2.5% |
| Car 9 | 14% | 5% | 14.2% | 2.5% |
| Car 10 | 8% | 4% | 14.2% | 2.5% |
| Car 11 | n/a | n/a | 14.2% | 2.5% |
| Car 12 | n/a | n/a | 14.2% | 2.5% |

2.7 Station Operation Configuration

Table 19: Station Operation Configuration

| | AM | PM |
|------------------------|---|---|
| Escalators | 1 Up 2 Down | 2 Up 1 Down |
| Stairs | - | - |
| Passageways | - | - |
| Ticket Gates | 6 Inbound, 3 Outbound, + 2 WAGs one in each direction | 2 Inbound, 7 Outbound, + 2 WAGs one in each direction |
| Ticket Window/ Machine | 2 Multi-fare 2 Oyster | 2 Multi-fare 2 Oyster |

2.8 Passengers with Restricted Mobility (PRM)

Passengers with Restricted Mobility (PRM) were modelled in line with the latest LUL and CLRL guidance. The five different categories of PRMs and the proportions modelled are shown in Table 20. PRM types A, B, D and E were directed to the lifts and wide-aisle gates and PRM type C were directed to travel using the stairs and UTS gates. This is the most onerous assumption for lift usage. In reality, majority of PRM Ds (passengers with large luggage) and Es (adults with young children) are more likely to use escalators and stairs within the station.

PRMs are assigned to the waiting areas along the EB and WB platforms using the same distribution as able bodied passengers.

Table 20: PRM Proportions

| Type | Description | Diameter | Speed | % |
|----------|---------------------------|----------|----------|-------|
| Standard | UK Commuter | 0.332m | 1.53 m/s | 96.29 |
| A | Wheelchair User | 0.933m | 0.59 m/s | 0.01 |
| B | Disabled/Elderly Impaired | 0.359m | 0.80 m/s | 0.92 |
| C | Medium Luggage | 0.707m | 1.53 m/s | 2.02 |
| D | Large Luggage | 0.846m | 1.32 m/s | 0.41 |
| E | Adults with Children | 0.932 | 1.37 m/s | 0.35 |

All the lifts in the station are assumed to be operating on a fixed cycle time. The cycle times for lifts are derived based on the following data (Source: TfL BCDM):

Table 21: Lift Cycle Time Data

| Lift Cycle Time Data | |
|----------------------|------------|
| Lift Speed | 1.4 m/s |
| Dwell Time per Floor | 40 seconds |

2.9 Routing Assumptions

The escalator distributions have been proportioned to reflect what is thought to be realistic behaviour during normal operation. During the AM peak has all (100%) passengers going 'up' on one escalator. There is a 50:50 distribution between the two down escalators. This is reversed in the PM peak when there are two up escalators.

3 Legion Modelling Outputs

All the areas of the Crossrail station were assessed for queuing, stairway and walkway Fruin Levels of Service.

Cumulative Mean Density (CMD) plots based on Fruin's Levels of Service for walkways for the peak 15 minutes within the peak hour have been provided for each scenario. Where appropriate, this is backed up with queuing level of service plots.

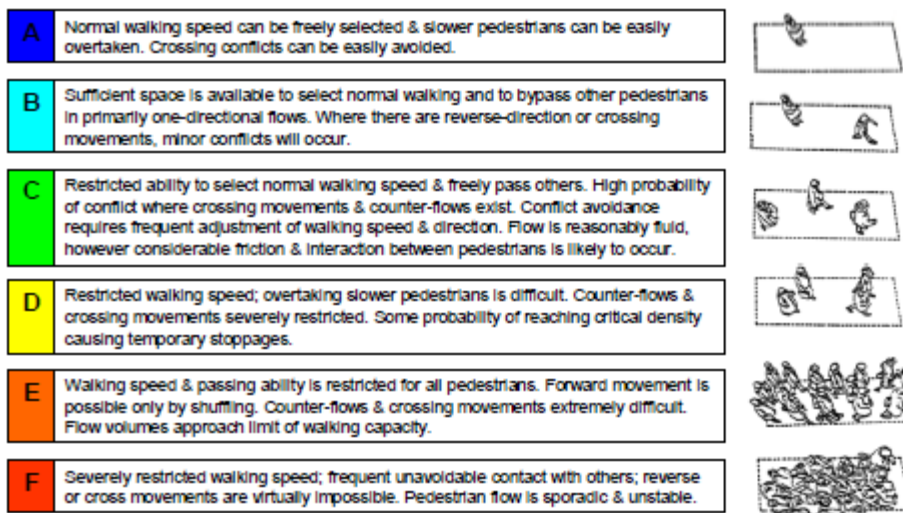
3.1 Levels of service (LoS)

Level of Service (LoS) is used in pedestrian planning to indicate densities of pedestrians per square metre and hence classify pedestrians' experience in terms of freedom of movement and comfort.

LoS A represents free-flow conditions whilst LoS F indicates a very congested situation associated with the breakdown in flow conditions with many stoppages (Pedestrian Planning and Design, John J. Fruin, 1987).

Figure 4 below shows the Walkways LoS A to F commonly used in pedestrian planning.

Level of Service (LoS) - Fruin standards for walkways



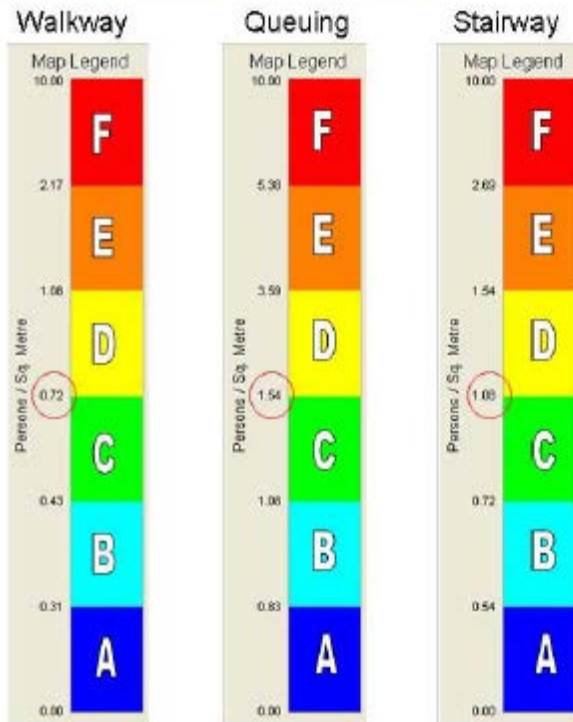
Source: Pedestrian Planning and Design, John J. Fruin, 1987

LEGION

The key for Fruin LoS for Walkways, Queuing and Stairways is shown in Figure 5. The areas of the station where passengers are willing to tolerate higher levels of service due to the nature of activity (queuing) are analysed using Fruin Queuing LoS.

Figure 5: Fruin Levels of Service (LOS)

Figure 5: Fruin Levels of Service (LOS)



3.2 CRL Acceptance Criteria for Legion Modelling

Table 4 below shows London Underground (LU)'s Level of Service measures to apply to the four categories of station operation in the station areas listed. Crossrail's Pedestrian Modelling Standard, Station Planning: Platforms, CR-STD-305, V6, states that,

"Under normal operation, platforms must be sized to offer a minimum Fruin Level of Service C at the busiest part of the platform. The platform must be sized:

- to provide both waiting areas/accumulation areas
- to provide circulation areas for passengers

The Platform Accumulation Area should be sized to perform at a maximum average density of 1.54 people per square metre. The Platform Circulation Area should be sized to a maximum average density of 0.72 people per square metre. Both the Accumulation Area and the Circulation Area are to be added together to determine the required platform width. It is acknowledged that Fruin Level of Service C performance standard may not be met for short periods of time. However it is required that platforms:

meet this level of service over the busiest 15 minute period of operation. This shall be demonstrated through the use of Legion Average Level of Service plots.

Similarly, in other locations where a mix of queuing and walking take place, a common sense approach should be adopted in the interpretation of Fruin results, relying heavily on the observed performance of the space in question during simulation".

Table 4: LU's - SPSG Planning Criteria and Levels of Service

| Station Area | Normal LoS | Operation | Quantitative Measure |
|-------------------------------|------------------------------------|-----------|-----------------------------------|
| Ticket Hall / Open Concourses | Queuing | LoS B | 1.0m ² per person |
| | Queuing for Ticket Hall facilities | LoS C | 0.8m ² per person |
| Passageways: | | | |
| One-way | Walkway LoS D | | 50 passengers /minute/metre width |
| Two-way | Walkway LoS C | | 40 passengers /minute/metre width |
| Stairways | | | |
| One-way | Stairway LoS D | | 35 passengers /minute/metre width |
| Two-way | Stairway LoS C | | 28 passengers /minute/metre width |
| Platforms | Queuing LoS C | | 0.8m ² per person |

(Source: SPSG, LUL, November 2005)

4 Results

The Results of the Legion modelling for Custom House station are included below. The following plots are Cumulative Mean Density plots using Walkways levels of service unless stated.

4.1 AM Peak (07:00 – 10:00)

The following plots show the density for the 08:30 – 08:45 period in the 2026 Base model.

Figure 1: AM Ticket Hall Level

Queuing CMD

(08:15-08:30)

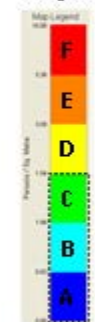
2026



+28%



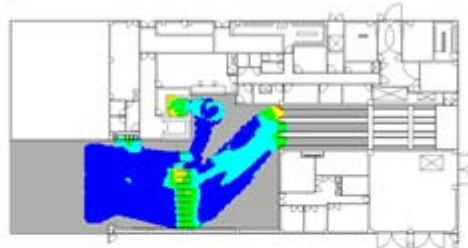
Queuing LoS



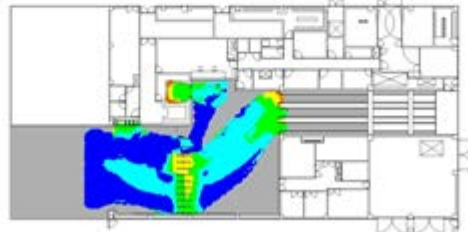
Walking CMD

(08:15-08:30)

2026



+28%



Walkway LOS

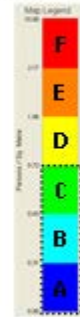


Figure 2: AM Platform Level

Queuing CMD

(08:15-08:30)

2026

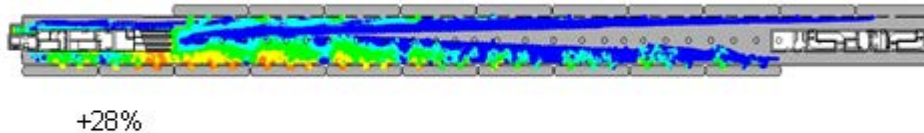
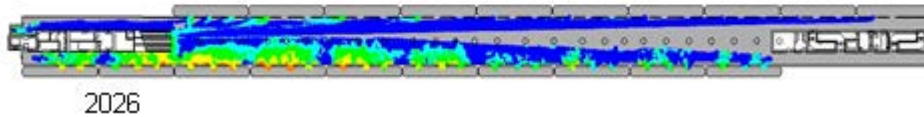


+28%



Walking CMD

(08:15-08:30)



4.2 AM Level of Service Summary

Overall the AM Peak operates well.

- The steady arrival of passengers at the station means that there is no gateline or escalator congestion.
- The eastbound platform is not busy; the only passengers on this platform are alighting because no passengers are assumed to travel to Abbey Wood. The eastbound (EB) platform is LoS A across its whole length
- The westbound platform has some waiting around the platform edge doors particularly towards the western end around the escalators. However there remains a lot of circulation space available on the platform. It is mostly LoS A.
- The westbound platform will clear with each train departure. There are no left behind passengers.

4.3 PM Peak (16:00 – 19:00)

Figure 3: PM Ticket Hall Level

Queuing CMD

(18:15 -18:30)

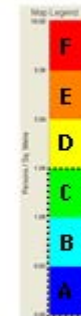
2026



+28%



Queuing LOS



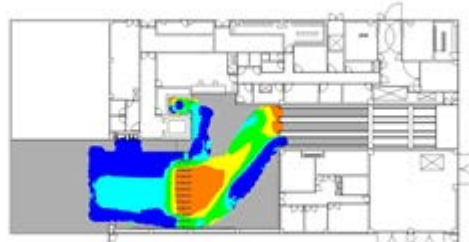
Walking CMD

(18:15 -18:30)

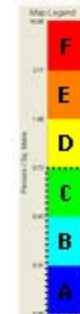
2026



+28%

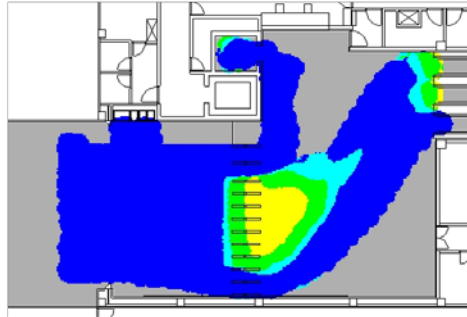


Walkway LOS

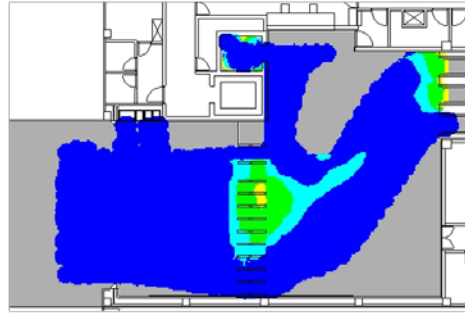


Queuing CMD

(18:15 -18:30)



Only PRMs using WAG (+28%)

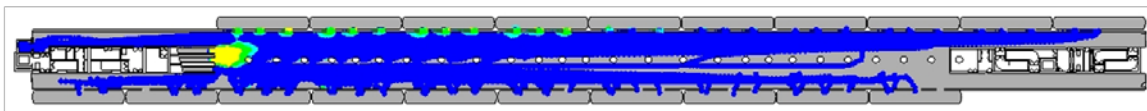


All types using WAG (+28%)

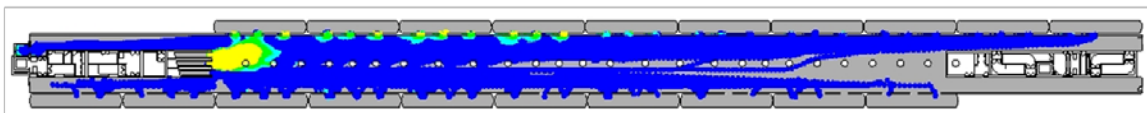
Figure 4: PM Platform Level

Queuing CMD

(18:15 -18:30)

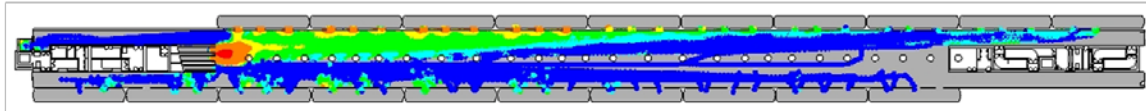


2026

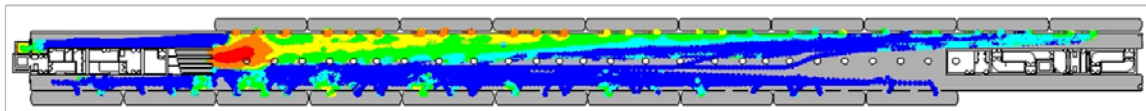


+28%

Walking CMD (18:15 -18:30)



2026



+28%

Platform level

4.4 PM Level of Service Summary

The PM Peak operates with some crowding at the escalators from the platforms. However this crowding is of short duration and follows the arrival of eastbound trains.

- The eastbound platform is busy with arriving passengers but the only area of congestion is around the up escalators.
- The westbound (WB) platform is LoS A across its whole length
- There are no arriving passengers on the westbound platform (from Abbey Wood). The westbound platform has departing passengers only.
- The arrival of heavily loaded trains from central London every five minutes creates uneven loading on the escalators. There will be some delay of over a minute to passengers as they wait for the escalators. The platform will comfortably clear before the next train.
- The gateline shows as being congested if the WAGs are not used by all passengers. However if the WAGs are used by all passengers (as is usually the case) the extra capacity ensures that there is almost no queuing at the gateline.

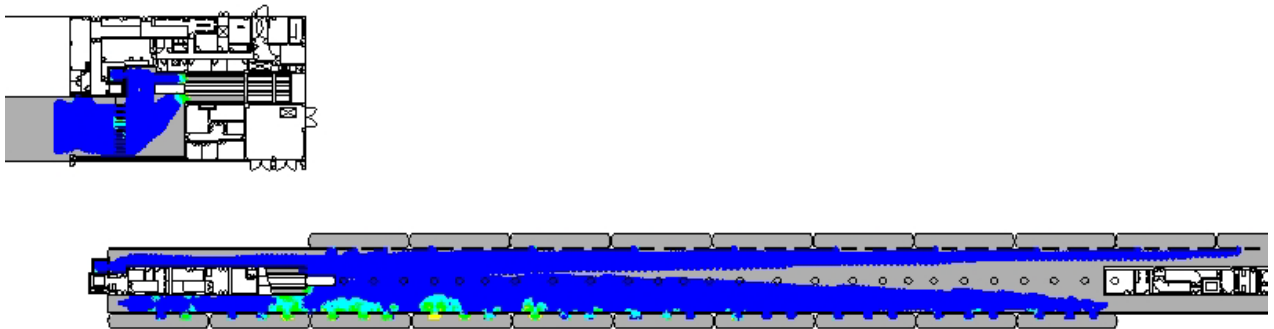
4.5 PRM Analysis

The PRM lift is at the western end of the platform beyond the escalators. This location means that it is on the desire line, being in the same direction for passengers as the escalators. There is also no additional walk distance for PRMs. Modelling indicates that there are no concerns around access for People with Restricted Mobility (PRMs) within the station

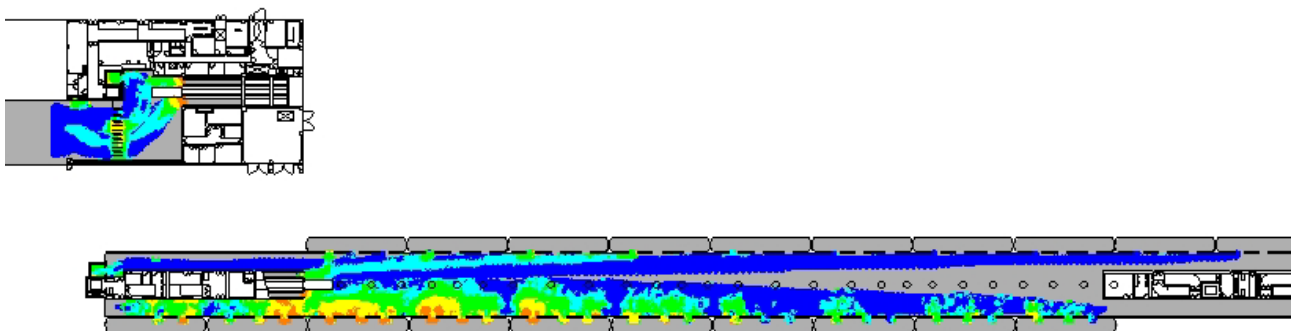
4.6 Escalator closed Analysis

The impact of having one escalator closed for maintenance is also modelled. In addition to the escalator being closed there is a hoarded work area of 6 metres at the bottom and top of the closed escalator. The demand is 2026 +28% so represents the worst case.

Figure 5: AM 2026 +28% CMD of whole station with central escalator closed



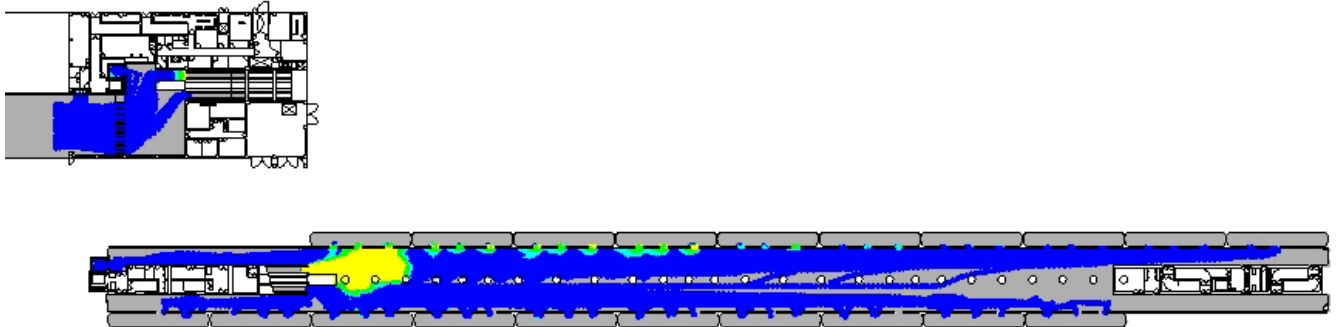
AM 2026 +28% CMD (queuing) 08:15 – 08:30



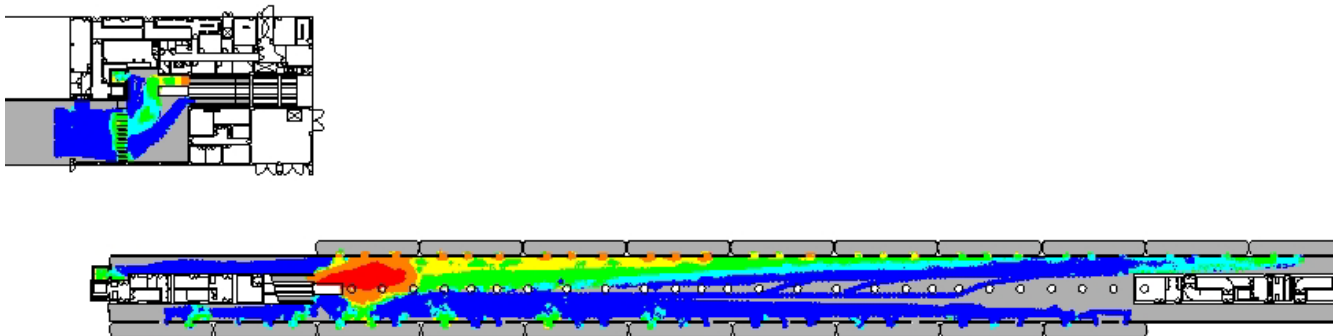
AM 2026 +28% CMD (walkway) 08:15 – 08:30

During the AM peak with one escalator out there is no additional crowding. This is due to the assumed even arrival of passengers the each five minute headway. This arrival profile is associated with the “turn-up and go” service provided by Crossrail. This shows that the station could be operated with only two escalators in the AM peak even at 2026 +28% demand.

Figure 6: PM 2026 +28% CMD of whole station with central escalator closed



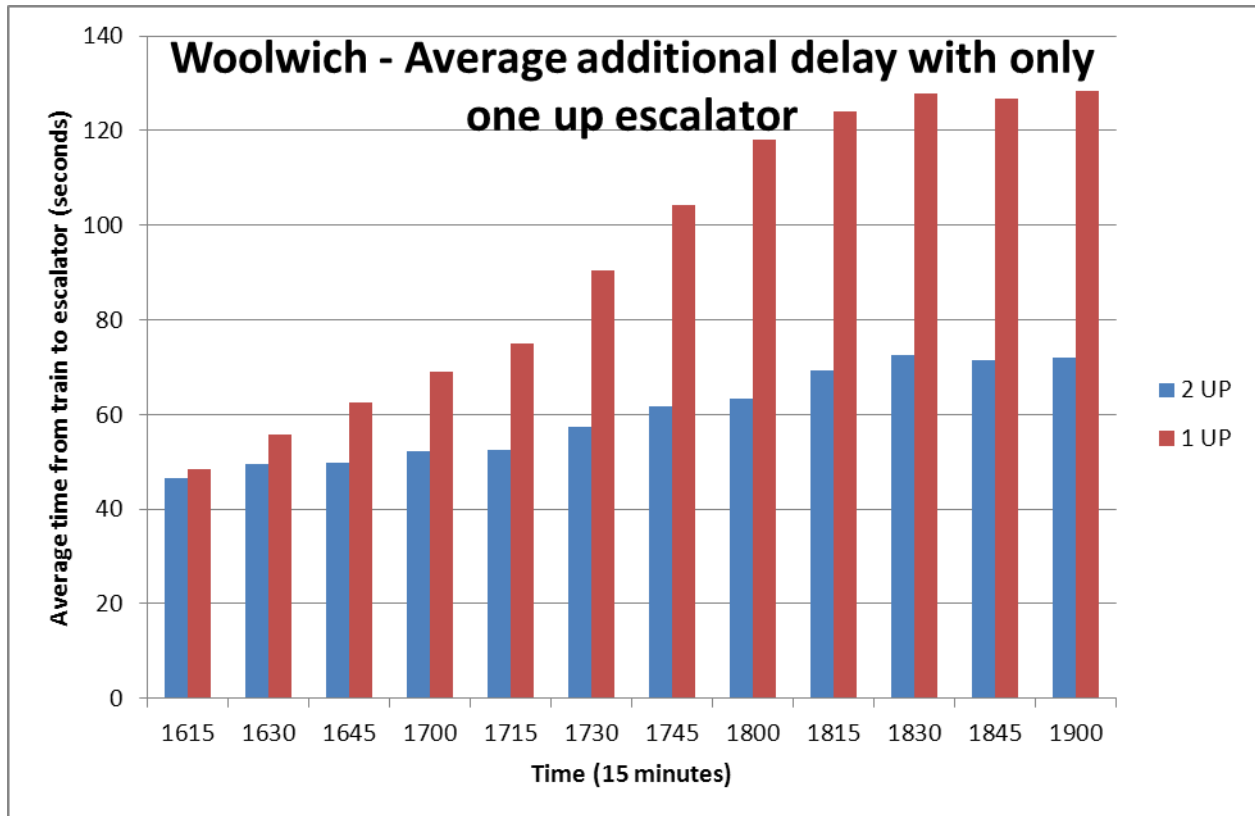
PM 2026 +28% CMD (queuing) 18:15 – 18:30



PM 2026 +28% CMD (walkway) 18:15 – 18:30

In the PM peak there is congestion at the foot of the up escalator following the arrival of heavily loaded eastbound trains. This is exacerbated by having one escalator closed. The carriages close to the escalators are assumed to be more heavily loaded and crowding on the platform will slow alighting passengers extending dwell times.

Figure 7: Delay to alighting passengers with central escalator closed



The chart shows that in 2026 +28% in free-flow conditions the average time taken per passenger to go from train to the foot of the escalator is about 50 seconds. It should be noted that the platform is 200m long so some passengers will have an uncongested walk of over two minutes to reach the escalator bank.

With two escalators the average time reaches a maximum of about 70 seconds and with only one escalator the average maximum time increases to 130 seconds.

The average additional delay to passengers exiting the station in the PM peak is one minute. This delay would be greater for some passengers and the queuing passengers would need good passenger information and management. However the platform would clear before the next train so that crowding would not be a safety issue – it would just cause a long wait.

The possibility of using the escape stairs would be unlikely to save time over waiting in the queue. However it is possible that the escape stairs and lift could be used for passengers entering the station during the PM peak.

5 Conclusions

Woolwich station operates well in the AM peak with large areas of Level of Service A and no crowding issues. There is no crowding at the escalators or the gateline. This is assisted by the steady arrival of passengers from Woolwich. At the platform level passengers will all board the first westbound train. There are no left behind passengers and each westbound train will clear the platform. The one escalator out modelling shows that assuming even arrival of passengers at the station only two of the three escalators would be required during the AM peak.

The PM peak is the most stressful test of station capacity. The arrival of heavily loaded trains at 5 minute intervals creates a surge of passengers that will cause temporary queuing at the escalators and gateline. This queuing is of an average duration of 20 seconds at 2026 +28% demand. At platform level there is only crowding around the escalators and the westbound platform is mostly Level of Service A.

It should be noted that demand assumes that there will be no passengers boarding Abbey Wood bound trains or alighting from Abbey Wood trains. The station complies with SPSG Level of Service requirements.

With one escalator closed there will be a lengthy queue at the foot of the remaining escalator during the PM peak. The maximum average wait in this queue (which is actually a slow moving shuffle) would be about 80 seconds.

Locations of Files

Drawings:- M: :\South East \Woolwich\Drawing 2011\Woolwich West End.pdf and M:\Woolwich\Drawing 2011\Woolwich East End.pdf

Data files - M: :\South East \Woolwich\Legion Model 2009\Data Files

Modelling files - M:\South East\Woolwich\Legion Model 2009\Model files

AM Data

M: :\South East \Woolwich\Legion Model 2009\Data Files\AM Profiles\[AM Profiles_2026 +28% (Woolwich).xls]Demand AM

PM data

M: :\South East \Woolwich\Legion Model 2009\Data Files\PM Profiles\[PM Supply Types_2026 +28% (Woolwich).xls]ST- Demand PM

Reference Documents

Crossrail's Pedestrian Modelling Guidelines (CR/QMS/OPS/GN/0010)
Crossrail's Pedestrian Modelling Standard, Station Planning: Platforms (CR-STD-305, V6)
LUL Standard 1-371 – Station Planning

