SILVERTOWN TUNNEL

Managing Uncertainty in Forecasting

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MAYOR OF LONDON

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1 INTRODUCTION

1.1.1 The issue of uncertainty has been a topic of considerable discussion through the examination of the Silvertown Tunnel DCO application, particularly in relation to the modelling of Scheme impacts.

1.1.2 The Examining Authority, Interested Parties, and the Applicant itself have acknowledged the importance of identifying, and considering the implications of, uncertainty. The potential for uncertainties in one area of the Scheme's assessment to flow onward into other aspects of the assessment has been specifically noted.

1.1.3 The ExA indicated that uncertainty should be interpreted as encompassing but not limited to:

i. uncertainty in model inputs at each stage of the model system, including measurement error and background demographic and economic growth scenarios;

ii. specification error;

iii. error in model parameters; and

iv. scope and scale of propagation of uncertainty between model stages and links to environmental tools (noise and air quality).

1.1.4 This note addresses these issues by providing a comprehensive account of the key sources of uncertainty in each aspect of the Applicant's quantified assessment, as well as the steps that have been taken to reduce or address forecasting uncertainty. The note also draws attention to the scope to manage the impacts of uncertainty once the Scheme is operational.

1.1.5 The note first describes the modelling underpinning forecasts of the Scheme's effects on travel behaviour and traffic. The note then considers the sources of uncertainty in relation to the translation of traffic model outputs to the inputs to environmental modelling, and then in the production of the Scheme's environmental modelling forecasts themselves. Finally, the note discusses the scope to manage the outturn impacts of uncertainty (as opposed to managing the potential for uncertainty within forecasts). In line with the ExA's action point, uncertainty is considered both numerically, where possible, and in qualitative terms, where not.

1.1.6 As this note will demonstrate, the Applicant has given extensive and detailed consideration to the potential for uncertainty in its forecasts, and has followed recognised guidance and best practice in order to minimise this potential and to ensure that the implications of this uncertainty are fully understood.

1.1.7 Additionally, the Applicant considers that while uncertainty is a feature of all forecasting, the Silvertown Tunnel scheme would be able to adapt more effectively to a wider range of outturn scenarios than most other comparable major schemes; indeed the Scheme has been actively developed in such a way as to ensure precisely this ability to adapt.

2 TRANSPORT MODELLING

2.1 Models Used

2.1.1 The transport models that have been used to assess the strategic transport impacts of the Silvertown Tunnel are the London Regional Demand Model (LoRDM), the River Crossings Highway Assignment Model (RXHAM) and the public transport assignment model (Railplan). These models are discussed in more detail within the response to FWQ TT1 (REP1-174).

2.1.2 These models provide data that is used to assess the traffic and economic impact of the scheme. The traffic model data is also converted for use in the environmental models.

2.1.3 The transport models used have been developed to be consistent with the Department for Transport's WebTAG best practice guidance and, as stated in the Applicant's response to FWQ TT4 (REP1-174), independent audit has confirmed that the models are in line with the WebTAG guidance and fit for the purpose of assessing the Silvertown scheme.

2.1.4 The models include future year forecasts for the Reference Case and the Assessed Case. These represent TfL's best estimate of future traffic conditions with and without the Scheme as required by WebTAG and the assumptions adopted have been accepted by most Interested Parties, including the host boroughs and most of the affected local authorities as noted in their Local Impact Reports.

2.2 Best practice in treatment of uncertainty

2.2.1 WebTAG guidance recognises that all forecasts have uncertainty associated with them and that it is essential to acknowledge and consider its impact on Scheme performance.

2.2.2 The applicant has followed this approach with this document summarising the key assumptions and uncertainties, covering the forecast inputs, the model parameters and scheme specification. A series of sensitivity tests and / or alternative scenarios were then designed to understand the impact of these uncertainties on the robustness of the forecasts.

3 APPROACH UNDERTAKEN TO ADDRESSING UNCERTAINTY IN TRANSPORT MODELLING

3.1.1 The approach taken by TfL to address uncertainty has been threefold:

- Minimise uncertainty
- Undertake sensitivity tests
- Scheme design – adjustments to the user charge and mitigation to meet the Scheme's objectives.

3.2 Minimise Uncertainty

3.2.1 Firstly, the Applicant has actively sought to minimise uncertainty wherever possible. This was done throughout the modelling process for example by:

- following WebTAG guidance in model development. The independent audit confirmed that WebTAG best practice has been followed (see response to FWQ TT4, REP1-174);
- basing the models on an extensive set of observed data. Data collected includes counts at over 1,200 locations and journey time data across 60 routes (FWQ TT1, Appendix A, table 10-12 REP1-174);
- ensuring that the model is well converged and validates well in the study area and that the study area itself is large enough to cover all potential diversion routes (see answer to FWQ TT6, REP1-174);
- collecting local evidence on values of time through stated preference exercises to determine whether there was strong enough evidence to vary the WebTAG value of time;
- basing forecast growth on GLA estimates of future growth in population and employment that have been subject to an Examination in Public, consulting local authorities on these assumptions, and undertaking a detailed review of likely future developments (independent audit of the models by SDG confirmed that the growth assumptions adopted were appropriate); and
- comparing the modelled elasticity response to the user charge against international studies of user charging schemes to ensure that the model responded in line with these benchmarks.

3.3 Undertake sensitivity tests

3.3.1 Secondly, TfL has carried out a range of sensitivity tests to address the impact on model results of key inputs that are subject to the greatest levels of uncertainty. This is to understand any additional impacts associated with the Scheme above those considered in the assessed case and the extent to which they require mitigation. This analysis also involves consideration of mitigation (where required) through changes to the level of charge or through the mitigation strategy.

3.3.2 The Applicant assessed uncertainties as described in the next section which led to the identification of sensitivity tests to establish the Scheme's performance under a range of different assumptions in three key areas to account for uncertainty:

- population and employment growth
- values of time
- car ownership and costs of travelling by car

3.3.3 The assumptions adopted for these tests were designed to provide an envelope which incorporates the most 'extreme' outcomes for the scheme in terms of traffic impacts and economics.

3.3.4 For example, adopting all of the assumptions that could result in higher levels of traffic in one scenario and vice versa enabled consideration of the extent to which the Scheme's performance would vary in such an 'extreme' scenario. Additionally, the Applicant considered the extent to which the Scheme's user charge be used to counteract any undesirable traffic impacts resulting from these different assumptions. Table 1 shows the specification of each sensitivity test.

Table 1: Sensitivity test specification

ID	Scenario Name	Population and Employment	Value of Time	Car Ownership	Car travel costs
S1	**Assessed Case**	Central	WebTAG	Central	Central
S2	**Assessed Case + VoT Uplift**	Central	London Uplift	Central	Central
S3	**High Growth**	High	WebTAG	High	Low
S4	**High Growth +**	High	London Uplift	High	Low

	VoT Uplift				
S5	**Low Growth**	Low	WebTAG	Low	High
S6	**Assessed Case + DfT VoT update**	Central	VOT update (not yet adopted by DfT)	Central	Central

3.3.5 Figure 1 and Figure 2 show the results of these sensitivity tests in terms of changes in two-way river crossing demand flows against their respective reference cases. In Figure 1 and Figure 2, the charges applied in all scenarios are the same – ie they are the Assessed Case user charges.

3.3.6 The data presented in Figure 3 and Figure 4 demonstrates the beneficial impact of adjusting the user charges. In each of the scenarios represented, indicative user charges have been set at a level which is broadly reflective of what might be required to mitigate any additional (or reduced levels) traffic impacts beyond those seen in the Assessed Case. The charts again present river crossing flows against the relevant reference case. It should be noted that test S6 has not been run with charges indicative of a mitigated level and so is only shown in figures 1 and 2, ie. not in figures 3 and 4.

3.3.7 Changes in charge levels adopted to mitigate traffic impacts are between -20% and +50% in the peak in the most extreme scenarios (equating to a reduction of £0.60 and an increase of £1.50 respectively) and -10% and +20% in the off-peak and counter peak directions in the most extreme scenarios (equating to a reduction of £0.30 and an increase of £0.60 respectively).

Figure 1: 2021 Sensitivity Test AM Peak Crossing Flow Changes with Asssessed Case Charges

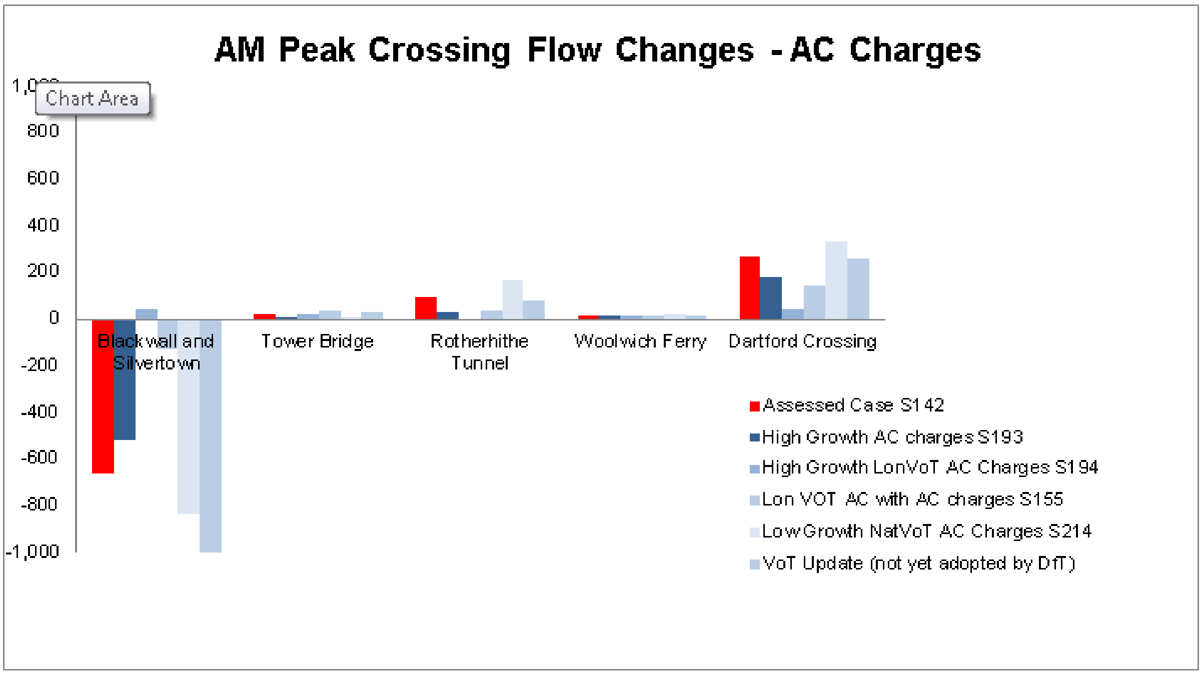


Figure 2: 2021 Sensitivity Test PM Peak Crossing Flow Changes with Asssessed Case Charges

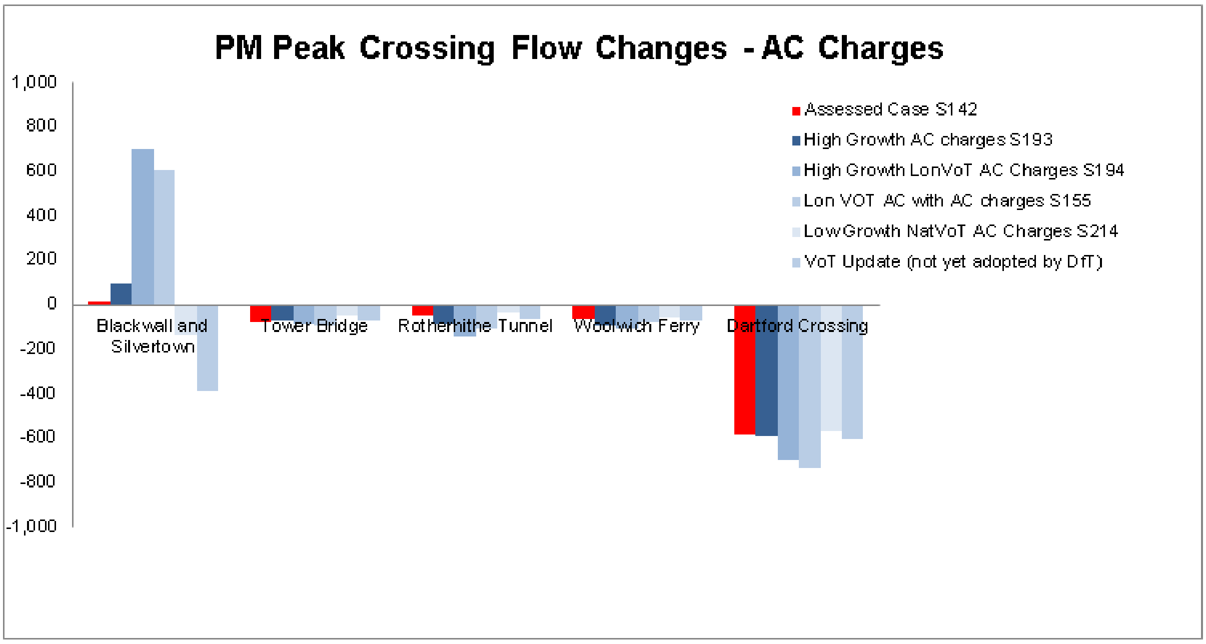


Figure 3: 2021 Sensitivity Test AM Peak Crossing Flow Changes with Adjusted Charges

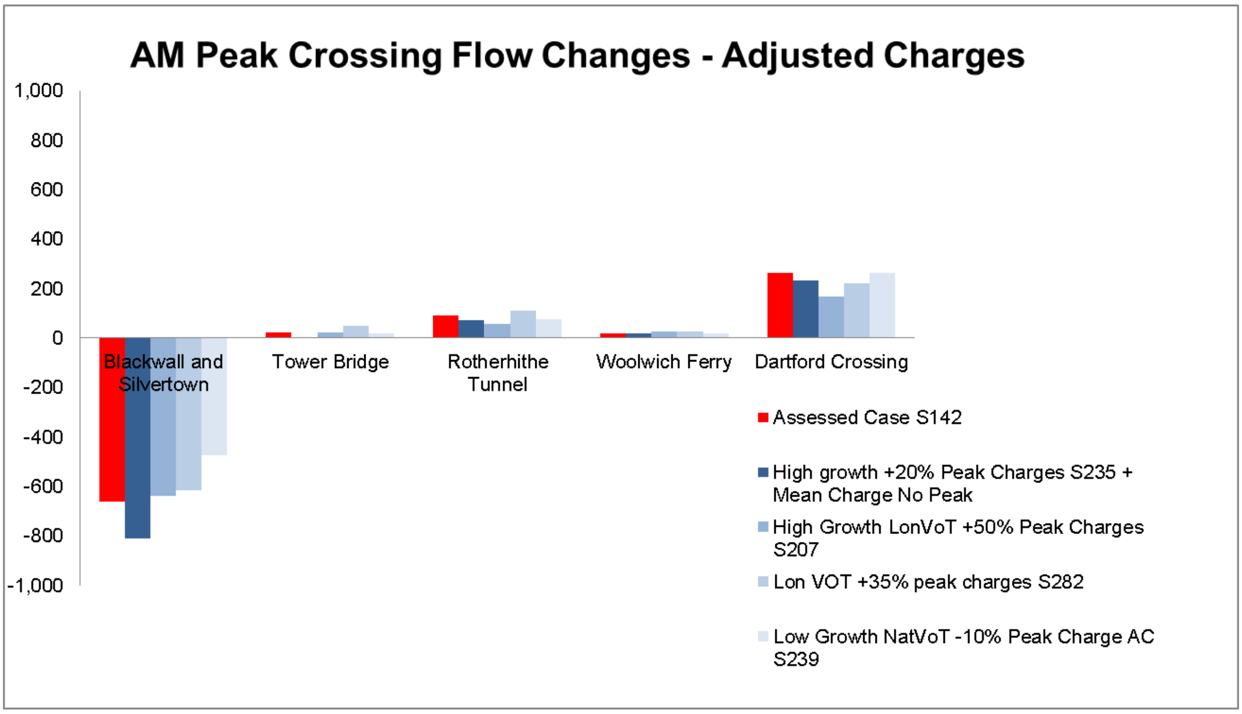
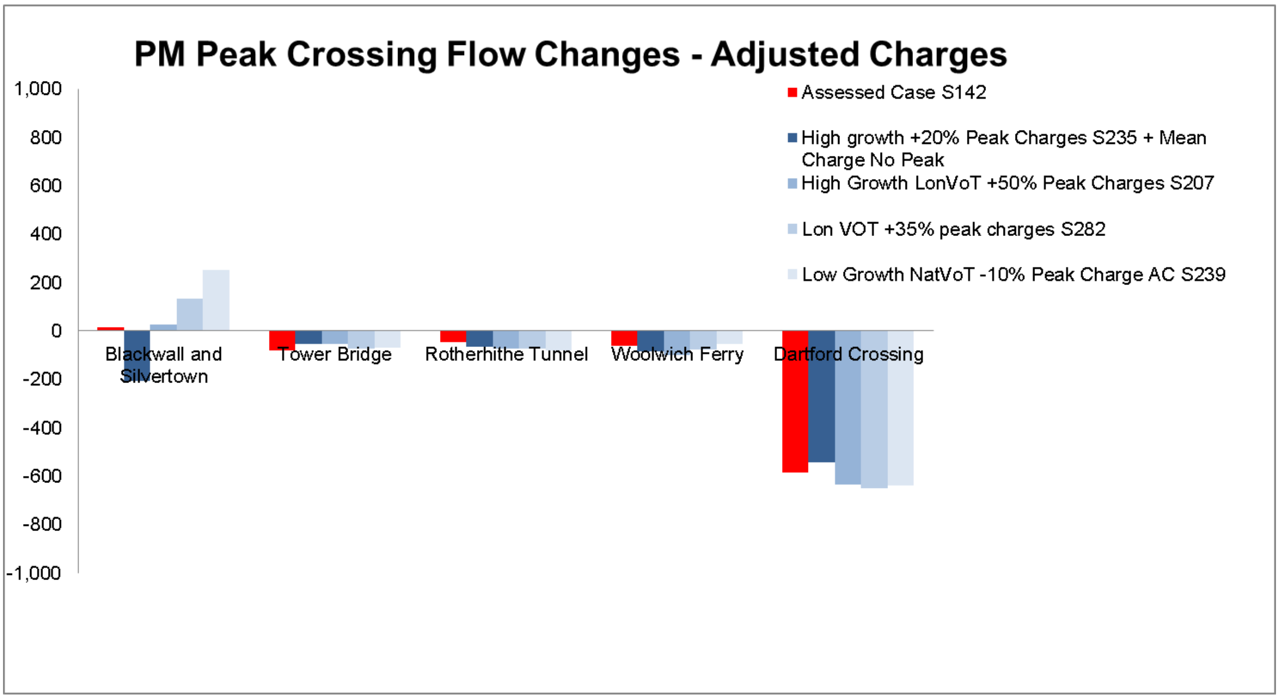


Figure 4: 2021 Sensitivity Test PM Peak Crossing Flow Changes with Adjusted Charges



3.3.8 This analysis provides confidence that uncertainty in the scheme inputs can be effectively mitigated by adjusting the charges as flow changes at all the key crossings are reduced to levels close to those seen in the assessed case.

3.3.9 While it can be seen that by changing the charge, the effects of the Scheme can be brought very substantially into line with those in the Assessed Case in a wide variety of circumstances it should be noted that charges have only been selected on an intuitive basis at this stage, and have not yet been fully optimised by iteratively changing charges until Assessed Case flows result. Nevertheless the tests demonstrate that charging can control the flows on the crossings and hence network wide traffic impacts. The greatest increase seen at Blackwall and Silvertown Tunnel across the adjusted charge scenarios in any peak period is less than 3% of total flow, providing further confidence that uncertainty is unlikely to lead to significant unmittigable impacts.

3.4 Scheme design – adjustments to the user charge and mitigation

3.4.1 Thirdly, remaining uncertainty that either cannot be quantified or reasonably assessed through sensitivity testing by adjusting model assumptions has been addressed through the design of the scheme.

3.4.2 Most importantly, the ability to adjust the user charge provides TfL with a very powerful means of altering the Scheme’s effects, should circumstances differ from those it has forecasted. TfL has the power to alter the user charges from those assumed in the Assessed Case, both ahead of Scheme opening (as part of the refreshed assessment to which it has committed) and / or once the Scheme is operational, if monitoring of road traffic and environmental conditions suggests that they are materially different from those forecast in the Assessed Case.

4 AREAS OF UNCERTAINTY IN TRANSPORT MODELLING

4.1.1 This section presents the uncertainty log which contains a list of the areas of uncertainty within the Scheme's transport modelling, with quantitative and qualitative description of the impact on outputs together with mitigating action that has been taken.

4.1.2 The discussion is split into inputs, specification error and parameter error as requested by the ExA with further discussion at the end of the section on how the impact on overall outputs can be considered. Figures 1 – 4 (above) present an overview of the impact on flows at all East London crossings of each of the sensitivity tests mentioned in the text below This provides evidence for reference in the discussion below. It should be noted that the RAG status mentioned below is according to the following key.

Key

(Green)	Sensitivity test carried out, with model outputs showing either that no mitigation is required or that charging can mitigate the impact
(Amber)	Impact not modelled but estimated to be of a magnitude that can be mitigated by TIMS or charging policy revision
(Red)	Uncertainty that could result in unmitigable negative impact if the risk materialises

4.2 Base Year Input uncertainty

4.2.1 There are a wide range of base year inputs to the model, the uncertainty in these is discussed below.

4.2.2 **Count Data:** WebTAG advises that count error may be up to +/- 5% for individual automatic traffic counts (ATCs) and +/- 10% for individual manual traffic counts (MCCs). However, as these are expected to follow a normal distribution it is likely that there would be as many over-estimates as under-estimates resulting in a very narrow overall range of uncertainty across corridors and the network as a whole. Therefore, any uncertainty in the overall count data is likely to be much lower than the magnitude of any individual count error.

4.2.3 **RAG Status:** **AMBER** (localised implications capable of mitigation through Transport Impacts Mitigation Strategy, strategic implications capable of mitigation through Charging Policy)

- **Journey Time Data**: An investigation completed by TfL showed that journey time data derived from Trafficmaster GPS can be an under or over estimate of true journey time by up to 8 seconds per km. Although this compares favourably to the Moving Car Observer (MCO) data which is traditionally used, it still results in uncertainty. As with count data, any errors on individual route times are likely to effectively balance out.

4.2.4 **RAG Status:** AMBER (localised implications capable of mitigation through Transport Impacts Mitigation Strategy, strategic implications capable of mitigation through Charging Policy)

- **Base Year Trip Patterns:** Trip patterns are derived from RSI data combined with development uplifts and a synthetic trip distribution model (as described in FWQ TT1, Appendix A REP1-174). Validation of modelled trip patterns against mobile phone data (presented in 'RSI Data and Matrix Development', REP2-057) show that current patterns are well represented. However, uncertainty still exists in trip patterns, especially at a more disaggregate level. This has been mitigated through the consideration of Low and High development scenario sensitivity tests and independent audit of the model. Remaining uncertainty is not expected to lead to a systematic under or over estimation of trip patterns.

4.2.5 **RAG Status:** AMBER (localised implications capable of mitigation through Transport Impacts Mitigation Strategy, strategic implications capable of mitigation through Charging Policy)

- **Value of Time:** The core scenario (Assessed Case) uses WebTAG values of time. It is accepted, however, that inevitably some uncertainty exists. Test S2 (table 1) was carried out with uplifted VoTs (approximately 30% for out of work time purposes and 40% for in work time and goods vehicles). This showed that with revised charges flow changes from reference case on all crossings could be brought back to broadly Assessed Case levels on all crossings. A lower VoT was not tested as this would lead to greater charge sensitivity meaning that lowering the charge would be effective in bringing back flows to Assessed Case levels.

4.2.6 The DfT has communicated its intention to update VOTs for appraisal and modelling although these have not yet been adopted. These VOTs have been run as a sensitivity test and showed that while the balance of car traffic between business and non-business users changes, the overall flows were not significantly impacted and any change in traffic flow could be mitigated with revised charges. A note on the impact of these VOTs will be provided at D4.

4.2.7 **RAG Status: GREEN** (mitigation demonstrated through sensitivity test)

4.3 Forecast Years Input uncertainty

4.3.1 Areas of uncertainty in future year modelling inputs are presented below:

- **Population and Employment Growth:** The core scenario is based on the Greater London Authority Further Alterations to the London Plan (FALP – March 2015). This is further discussed in the Growth Assumptions Note (REP2-056). The assumptions were agreed with the host boroughs and additional sensitivity tests undertaken. Scenario S3 and S4 with high growth assume full build-out of all GLA opportunity areas and the low growth test (S5) assumes that FALP projections are missed by the same magnitude they are exceeded in the high growth scenario. Tests with adjusted charges showed that charging policy can mitigate this uncertainty.

4.3.2 **RAG Status: GREEN** (mitigation demonstrated through sensitivity test)

- **Network Assumptions:** Network assumptions are not varied across sensitivity tests. All committed and funded infrastructure with available plans is included and the list of schemes was agreed with the Boroughs on multiple occasions (e.g. Nov 2014 and Feb 2015). No schemes judged to materially change the scheme impacts has come forward since this time. The Applicant will update its assessment prior to scheme opening to mitigate any unaccounted for impacts that materialise from this uncertainty.

4.3.3 **RAG Status:** AMBER (Can be mitigated by Transport Impacts Mitigation Strategy and Charging Strategy)

- **GDP growth/ VoT:** GDP growth uncertainty impacts assumptions on the growth in Values of Time which increase in line with estimates of GDP/Capita as per WebTAG. Test S4 with high development growth and high value of time was seen as a suitable proxy for higher GDP, with test S5 assuming Low Growth acting as a suitable proxy for lower

GDP growth. Tests with adjusted charges showed that the charging policy can mitigate this uncertainty.

4.3.4 **RAG Status: GREEN** (mitigation demonstrated through sensitivity test)

- **Car Ownership:** The Assessed Case assumes a reduction in the rate of car ownership per head of the population over time. Therefore sensitivity tests S3 and S5 were carried out with higher and even lower car ownership rates (respectively) assumed into the future. Tests with adjusted charges showed that charging policy can mitigate this uncertainty.

4.3.5 **RAG Status: GREEN** (mitigation demonstrated through sensitivity test)

- **Parking Costs:** The assessed case assumes parking cost increases at around 30% above GDP growth . Sensitivity test S3 (High Growth) assumed GDP growth only (i.e. lower growth than assessed case) and test S5 (Low Growth) assumed increases at around 60% greater than GDP. Tests with adjusted charges showed that charging policy can mitigate this uncertainty.

4.3.6 **RAG Status: GREEN** (mitigation demonstrated through sensitivity test)

- **Vehicle Operating Cost:** Assumptions into the future carry uncertainty due to fuel price assumptions and vehicle efficiency. Low and high values have been tested in sensitivity tests S3 and S5 as described above. Tests with adjusted charges showed that charging policy can mitigate this uncertainty.

4.3.7 **RAG Status: GREEN** (mitigation demonstrated through sensitivity test)

4.4 Specification Error

- **Vehicle charge exemptions:** Some vehicle charge exemptions are not represented in the modelling. Buses, taxis and coaches on fixed routes are modelled as exempt from charging but others are not. Such exemptions include users such as blue badge holders and emergency vehicles. These are estimated to account for between 7% and 9% of traffic, although data is limited, especially in terms of trip patterns associated with such users. The impact of this in terms of uncertainty in traffic impacts is estimated to be small. This is because only a small proportion of those users incorrectly assumed by the model to pay the charge will be deterred by the charge in any case. This is evidenced by the scheme effects in general which suggest that charging of the crossing deters around 22% of traffic. This can also be used as an indication of the percentage of exempt traffic likely to be deterred in the absence of any other evidence. Applying this proportion to the traffic would leave flows less than 2.5% in consideration which is likely to have a small impact on the scheme.

4.4.1 **RAG Status:** AMBER (Can be mitigated by Transport Impacts Mitigation Strategy and Charging Strategy)

4.4.2

- **Time of day and trip frequency:** Time of day choice and trip frequency responses are not modelled. This was discussed in the response to FWQ TT9 (REP-174) and is not expected to have a significant impact. Realism tests carried out and reported in Appendix B of the response to FWQ TT1 (REP1-174) showed that vehicle km response to changes in journey time, fuel cost and fares were in line with guideline values. While some uncertainty remains, this is likely to be small.

4.4.3 **RAG Status:** AMBER (localised implications capable of mitigation through Transport Impacts Mitigation Strategy, strategic implications capable of mitigation through Charging Policy)

4.5 Errors in Model Parameters

- **Convergence:** The demand and supply models converge to a standard above that suggested by WebTAG . For example, the assignment model has a % Gap (total % change in travel time across the network) of less than 0.01% (WebTAG target <0.1%) (see Appendix A of the response to FWQ TT1 (REP1-174), Table 10-1). Any uncertainty in results caused by this is thought to be very small and not in need of mitigation.

4.5.1 **RAG Status:** **GREEN** (No mitigation required)

- **Variable Demand Model Parameters:** Parameters for the demand model are calibrated based on local data from the London Travel Demand Survey (a rolling annual sample of 8,000 households). WebTAG suggests sensitivity tests with scaling parameters controlling part of the demand model response set at +25% are carried out. This test is envisaged for simpler incremental models but is not practical for absolute models such as those used in TfL's transport modelling. Given the demand response to the scheme in most cases does not exceed 20%, it is estimated that changes to the parameters would not lead to uncertainty in river crossing flows greater than +/- 5% (likely to be lower). Given that a range of sensitivities with varying assumptions have been carried out, it is unlikely that the direction of this error would be the same as that tested in each sensitivity test. With this in mind, the outturn impact above that considered in the envelope of tests carried out is likely to be significantly lower than 5%.

4.5.2 **RAG Status: GREEN** (No mitigation required)

- **Charge Response:** This is discussed in the Model Responsiveness note (REP2-051). Although the response is within benchmark ranges, it is accepted that some uncertainty exists as to the true impact of the charge. Sensitivity testing has shown that flows can be controlled back to Assessed Case levels through changes in the charge level. Therefore if the charge response (despite being plausible and supported by benchmark study values) is different to that anticipated, changes to the charge can be used to manage actual traffic flows and any environmental effects. Further, behavioural studies (Appendix D, REP2-055) carried out also support the conclusion that the charge can be used to manage traffic levels on the crossing.

4.5.3 **RAG Status:** AMBER (Charging Policy can be used to mitigate)

4.6 Propagation of Uncertainty

4.6.1 Propagation of modelling uncertainty could take place between model stages and also between the transport models and air quality, noise and economic assessments.

Propagation of uncertainty between model stages

4.6.2 It should be noted that the Silvertown Models operate as a single integrated and iterative suite of models. Figure 5 below (reproduced from the response to FWQ TT1, REP1-174) shows how demand and costs are passed between the demand and assignment elements of the modelling suite. The aim of this WebTAG compliant and iterative structure is to achieve a state of equilibrium which is progressively better at each iteration and meets the WebTAG criteria on demand model convergence. As a result, any imbalances between the various elements of the modelling suite which can lead to uncertainty are minimised in the final assignment.

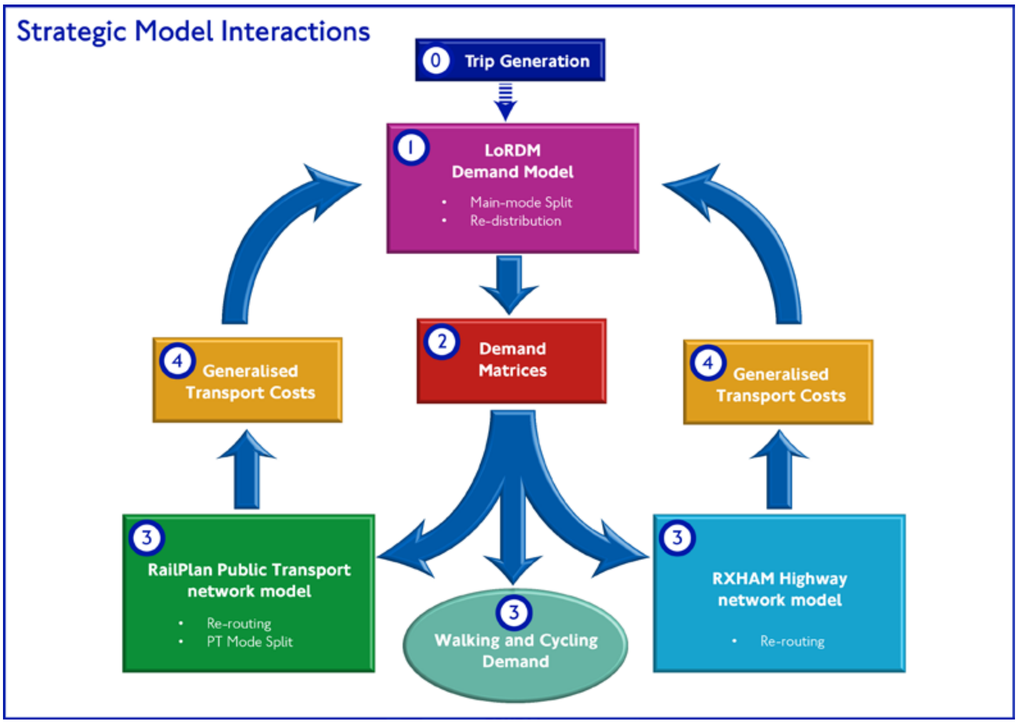


Figure 5: Strategic Model Intearctions reproduced from response to FWQ TT1 (REP1-174)

4.6.3 It should also be noted that many of the potential sources of uncertainty listed in this section would on average have the effect of cancelling themselves out and it would be highly unlikely that all uncertainities would work in the same direction.

4.6.4 In addition the model errors and therefore any propogation of the errors have been minimised:

- through use of a modelling approach based on London's long established, widely used and widely accepted strategic modelling framework
- by incoprporating extensive and high quality data such as traffic counts and the London Travel Demand Survey;
- by ensuring that the Silvertown Modelling Suite has been developed in line with WebTAG best practice and has been subjected to a very thorough independent audit which found that the model was fit for the purpose of assessing the Silvertown Scheme.
- By undertaking a range of sensitivity tests to examine the sensitivity of the model to key inputs.

- Through the application of a user charge and TIMS. Unlike most schemes that are brought forward the Silvertown Scheme has a user charge that enables Scheme objectives to be met in a variety of different scenarios. The sensitivity testing has found that, through the variation of the user charge, traffic flow outcomes very similar to the Assessed Case can be delivered.

Propogation between the transport models and other assessments

4.6.5 Any uncertainty in the modelling will propagate to the air quality, noise and economic assessments. However, TfL has designed the scheme such that it will look to mitigate any impact beyond that forecast through the TIMS and changes to charging levels. Further, the Economic Assessment Report (APP-101) demonstrates that the case for the scheme remains robust in different scenarios.

4.6.6 Conversions of the traffic data for use in other assessments is considered in the following sections.

5 CONVERSION OF TRANSPORT MODEL OUTPUTS TO ENVIRONMENT MODEL INPUTS

5.1.1 The transport models represent conditions in three periods – the AM Peak Hour, the Interpeak Average Hour, and the PM Peak Hour. This enables an appreciation of the transport impacts of the Scheme at the busiest times and in conditions outside the peak periods, which are the most useful measures of the Scheme's transport performance.

5.1.2 Environmental assessments are typically concerned not with peak and off-peak conditions, but with the total effect of a scheme over longer periods, reflecting the cumulative impact of emissions of environmental pollutants on air quality and the effect of noise over the periods when it has most impact on receptors.

5.1.3 Therefore a process is required to convert the outputs of transport models to suitable inputs to the environmental models.

5.1.4 This chapter sets out the data used to support this conversion, the process followed, and considers the accuracy and tolerances in the conversion process and the external validation which has taken place.

5.1.5 It should be noted that more information on the data and process was previously provided in Appendix 6D of the ES (APP-052), and additionally in responses to Action Points 8 and 9 arising from the Traffic and Transport ISH on 7 December 2016 [REP2-063], and Response to FWQ TT.22 Appendix H -Traffic Data used for Noise and Air Quality Assessments (REP1-174.

5.2 Data used for converting traffic model outputs for environmental assessment

5.2.1 The survey count data used for the calculations of the expansion factors consisted of the following:

- Hourly Manual Classified Counts (MCCs) undertaken for five days (19th to 23rd November 2012) for 118 sites for the period (06:00-22:00hrs).
- 24 Hour Automatic Traffic Counts (ATCs) for 9 sites for a period of one year (2012)

5.3 Conversion process/mechanism used in converting traffic model output to AADT/AAWT for AQ/Noise assessment

Process/Mechanism used

5.3.1 The process used follows WebTAG guidance M1.2, factoring traffic data (section 3.3.38-3.3.41) and develops separate 'expansion' factors for different time periods. These, and the sources of data for each, are set out in the table below. Figures 4.4-4.6 of Appendix D of the ES (REP1-151) provide a flowchart of the processes and are also appended to this document (Appendix A).

5.3.2 The traffic model provides three hourly flows - the morning peak hour (0800-0900), an average interpeak hour (1000-1600) and an evening peak hour (1700-1800). To derive the estimates needed for noise analysis (18-hour Annual Average Weekday Traffic or AAWT) and for air quality (24-hour Annual Average Daily Traffic or AADT) factors need to be applied to the modelled hours. The table below and the flowcharts in the appendix show the process used.

Modelled hour	Time period for which modelled data is expanded	Count data source	Used for AADT?	Used for AAWT?	Comment
0800-0900	0600-1000	118 MCC	Yes	Yes	Factors am peak hour to am peak period 0600-1000
1000-1600 average hour	1000-1600	No data used, as average hour already, expansion factor is 6	Yes	Yes	Factors IP average hour to IP period 1000-1600
1700-1800	1600-1900	118 MCC	Yes	Yes	Factors pm peak hour to pm peak period 1600-1900
1000-1600 average hour	1900-2200	118 MCC	Yes	Yes	Factors IP average hour to charged post-pm peak period 1900-2200
1000-1600 interpeak average	2200-0000	9 ATC	No	Yes	Factors IP average hour to non-charged period 2200-000 for AAWT only
1000-1600. Note that an uncharged model run was used for this period.	2200-0600 (uncharged)	9 ATC	Yes	No	Factors an uncharged IP average hour to non-charged period 2200-000 for AADT only

Table 2: Conersion Process

5.3.3 Using the method mentioned above, expansion factors were used on the different model hours and combined to derive

- A 24 hour count estimate (November average, based on traffic model)
- An 18 hour weekday count estimate (November average, based on traffic model).

5.3.4 These estimates were then factored using ATC data, to give a 24-hour estimate (whole year) for AADT and 18-hour estimate (whole year) for AAWT.

5.3.5 To expand the flow data for the entire traffic model, advanced database tools (Macros/VBA code) were used to make sure the process of converting the data for the whole model was accurate. Checks have been undertaken to make sure there are no errors in the analysis.

Data specifications and values

5.3.6 The guidance advises (M1.2 – section 3.3.26-3.3.28) that a single day MCC count and two-week ATC count data is required to develop expansion factors. It states that a 95% confidence interval for traffic counts should be assumed but if the data is collected for a longer period (MCC for two days), the confidence interval will be narrower than that mentioned in the guidance.

5.3.7 The values used in the factoring are quoted in the Appendix to this response.

5.4 Accuracy and tolerances in the conversion process and external validation

5.4.1 As with all traffic data and factoring, there are some uncertainties arising from each data source. These uncertainties can be due to:

- Variations at each manual traffic count site
- Variations at ATC sites
- Variation between flow profiles on different links – the process factors all modelled links up by the same average factor. This will mean the estimate at some locations will be higher and some lower than actual, but the average outcome will be appropriate.

5.4.2 There has been no detailed quantitative assessment of these uncertainties by the Applicant, and we are not aware of any such requirement in current guidance. We believe that the method and the process used for this project has minimised these uncertainties, through (i) following the accepted WebTAG guidelines for the method, (ii) using a more extensive set of count data than recommended in the guidance. (iii) use of multiple counts, which as noted above, will further reduce uncertainty.

5.4.3 WebTAG Unit M1.2: Data sources and surveys, gives guidance on the traffic count data specifications, accuracy and tolerances required for use for various assessment purposes.

5.4.4 In respect of variability at count sites, section 3.3.32, provides some 95% confidence limits, which are 5% for ATC counts and 10% for MCC counts. However, the data used for the assessment was much more extensive than that assumed in this note – 5 days of MCC compared to 1 in the WebTAG assumption, and a year of ATC data compared to the required 2 weeks. Given this, the 95% confidence limits will be much lower than those quoted in WebTAG, and in the case of the ATC data should be extremely low.

5.4.5 It is also worth noting that the MCC count data set is very extensive, covering the strategic network across the model area to capture the flow pattern; the use of 118 sites is unusually high and will further reduce uncertainty.

5.4.6 There has been no external validation of the factoring process, as the only data against which the factors could be validated was the count data which was used to derive the factors.

5.5 Summary

5.5.1 The process followed for deriving the expansion factors for calculating the AADT/AAWT has been carried out in accordance with industry best practice following the appropriate tools. While the applicant acknowledges that there is some degree of uncertainty in the results, the data and the method/process used has minimised these uncertainties.

6 AIR QUALITY MODELLING UNCERTAINTY

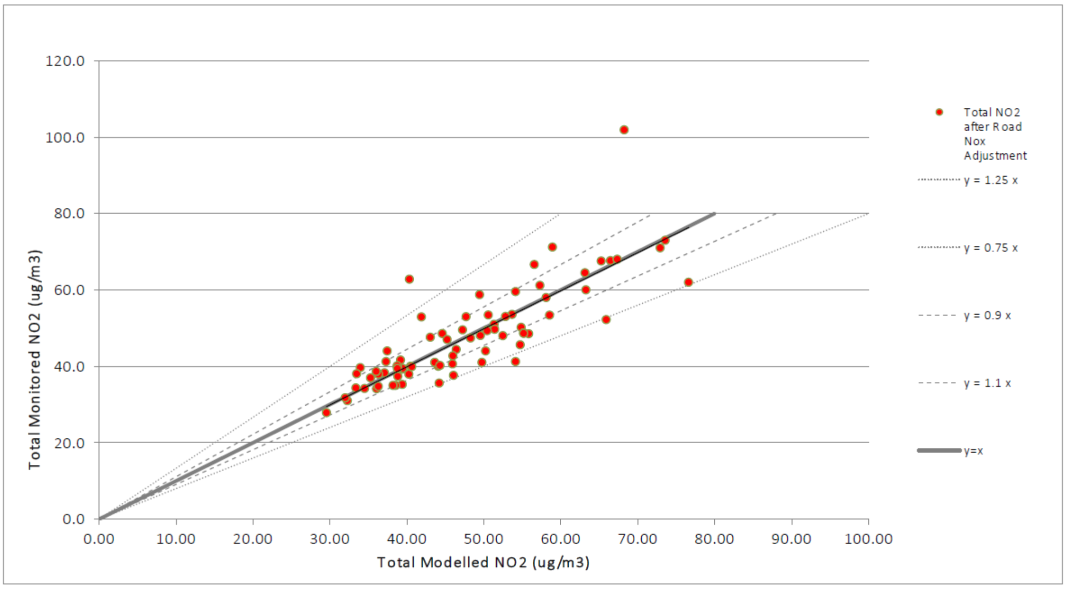
6.1 Overall Uncertainty

6.1.1 This chapter addresses uncertainties in relation to nitrogen dioxide (NO2) concentrations and the linked nitrogen oxides concentrations. It does not deal with particulate matter as there are no exceedances of the assessment criteria within the study area (objectives and limit values) (see the updates air quality and health assessment (REP2-041)).

6.1.2 The modelling follows commonly accepted approaches and takes account of the relevant guidance, in particular the guidance set out in the DMRB and its associated IANs and the guidance issued by Defra, as described in the ES Chapter 6 (AS-022).

6.1.3 The key to understanding the overall uncertainty in the modelling of pollutant concentrations at receptors across the study area is the plot of measured concentrations at 77 sites against the modelled concentrations at these locations. This is presented in the updated Appendix 6.B Model Verification that forms part of 8.33 Updated Air Quality and Health Assessment (REP2-041). Figure 4-3 from page 24 of the Appendix (pdf page 103 of REP2-041) is reproduced here.

Figure 6 Total Monitored versus Modelled NO2 concentrations in 2012 [a] (Figure 4-3 from Appendix 6.B in REP2-041).



6.1.4 The modelled results have been adjusted by applying verification factors as discussed later in this chapter.

6.1.5 Figure 1 includes the 1:1 line (perfect agreement) and lines reflecting ±10% and ±25%. The Figure shows that the majority of results lie within the ±10% lines, with virtually all lying within ±25%. The regression through the data points fits the 1:1 line so there is no overall bias in the modelling.

6.1.6 The statistics accompanying this plot are set out in Table 2, which reproduces Table 4.4 in the updated Appendix 6.B Model Verification that forms part of 8.33 Updated Air Quality and Health Assessment (REP2-041) (on pdf page 107 of REP2-041). These are the key statistics accepted widely in the air quality modelling community.

Table 3: Air Quality Model Performance Statistics (Table 4.4 from Appendix 6.B in REP2-041)

Parameter	No Adjustment	NO_x Contribution Adjustment (8 zones)
Root Mean Square Error (RMSE)	11.5	7.0
Fractional Bias	0.2	0.0
Correlation Coefficient	0.76	0.83

6.1.7 The statistics show that after applying the verification factors (the last column), the residual Root Mean Square Error in model predictions of annual means of NO2 concentrations is reduced to 7.0 µg/m3, with no overall bias and an increased correlation coefficient of 0.83.

6.1.8 The experience of the Applicant's consultants is that the results in the Figure and Table demonstrate that the modelling outcome is robust. The process of verifiying the model has been undertaken in accordance with the most appropriate advice (i.e. LAQM.TG(16)). .

6.2 Sources of Uncertainty for Air Quality Modelling

6.2.1 It is recognised by the Applicant that air quality modelling has a number of sources of uncertainty, including, but not limited to:

6.2.2 For individual links:

- the traffic flow on the link in terms of:
    - the AADT flow;
    - the distribution of the flow by time of day;
    - the speeds of the vehicles;
    - the engine load (acceleration etc.);

    - the mix of vehicles types (cars, buses etc.); and
    - the Euro class of the vehicles on that link,

- all of which may deviate from the default values used, which are based on a much larger data set;
- the geometry of the road, including the number of lanes and any gradients;
- the presence of local factors disturbing typical flows over the link, e.g. bus stops, pedestrian crossings etc.;
- the fraction of NO2 in vehicle NOx emissions for the emissions on that link; and
- the model limitations in terms of its ability to model dispersion within complex urban environments.

6.2.3 For the overall model:

- the emission factors for the different classes of vehicle in the base year and in the future year;
- the use of meteorological conditions at London City Airport to represent conditions across the study area;
- the conversion from NOx to NO2 being properly represented in the NOx to NO2 tool (this conversion depends on atmospheric reactions that convert the nitric oxide (NO) within the nitrogen oxides emissions to NO2 and the balanced removal of NO2 by photochemical reactions driven by sunlight);
- the fraction of NO2 in vehicle NOx emissions used as a default for the study area; and
- the uncertainty in the monitoring data (these data being used to verify and adjust the model to remove bias).

6.2.4 The Applicant emphasises that it is not recognised practice to quantify these uncertainties and build an uncertainty model for assessment applications, which is more in the realm of research investigations. There is no requirement in any guidance to do this and the Applicant’s consultants are not aware of this ever having been done for assessments within the development control system.

6.3 Model Verification and Adjustment

6.3.1 The process of model verification is used to minimise model uncertainties and, by way of model adjustment, to ensure the overall results are presented without bias. Its application to the Silvertown Tunnel assessment is described in full in Appendix A in REP02-041 and has been outlined in this note.

6.3.2 The guidance is to compare the modelled road NOx concentrations with monitored road NOx concentrations (the latter derived after removing background concentrations). The first step, if the data show a large degree of scatter and/or evident bias, is to check that the modelling has been carried out appropriately, i.e. that the data have been input correctly, in particular that the distances and heights of the monitors have been properly represented.

6.3.3 Once these checks have been made, it may still be found that the modelled concentrations are being under-predicted, especially on more congested urban streets. A regression of the data through zero is used to find the best-fit relationship between the measured and modelled NOx values. The slope of the regression line gives the extent to which the model is under-predicting. The modelled NOx concentrations are then adjusted by this factor (which can be called a verification factor) to improve the performance of the model, in particular to remove bias. An additional step that can be applied to further improve the performance of the model is to establish whether there are different adjustment factors that can be applied to different road types or different geographical areas. This has been done in the case of the Silvertown Tunnel assessment, with eight areas being identified with different adjustment factors being appropriate to each (see Table 4-3 in the updated air quality and health assessment (REP2-041)).

6.4 Future Uncertainty in Projections

6.4.1 It should also be noted that future projections used to assess the Scheme impacts are consistent with, or go beyond, the requirements of the national networks national policy statement (NN NPS), and in particular paragraphs 5.7 – 5.9, which refers to the use of Defra projections for future air quality within an Environmental Statement. This is because undertaking the air quality assessment for the Scheme using the advice in DMRB, namely the use of the LTTE6 future projection curve from IAN 170/12v3, is more conservative than Defra projections for future air quality. The use of more conservative future projections, therefore, provides a precautionary approach, helping offset uncertainty in projections of future air quality. This has been further demonstrated in the the written summary for the

Traffic/Transport Modeeling ISH issued as part of the deadline 3 submissions (Document Refence: 8.60), relating to the information on why the applicant is of the opinion that following this guidance the assessment will still be more precautionary than increasing emissions from Euro 6 diesel cars as highlighted in the ClientEarth judgement.

6.5 Judgement of Significance

6.5.1 In addition to the information provided in relation to uncertainty it should also be noted that the guidance followed in determining the significance of the schemes impacts, Interim Advice Note (IAN) 174/13, recognises uncertainty in the modelling process and accounts for this in the judgement of significance. In section 2.3 of the IAN it states that;

6.5.2 "Air quality assessments are based on the most reasonable, robust and representative methodologies, taking advice from published guidance. The results are verified against monitoring data and can be used to inform a professional judgement.

6.5.3 However, whilst the modelled results are reasonable there is still some element of residual uncertainty, hereafter referred to as Measure of Uncertainty (MoU). This is due to inherent uncertainty in air quality monitoring, modelling and the traffic data used in the assessment.

6.5.4 The approach to describing the MoU in the IAN is based around Defra's published advice in TG(09) on the desirability of achieving 10% verification (between modelled and monitored concentrations) where concentrations are close to or above the air quality threshold."

6.5.5 As described in the previous sections the model has been verified and after applying verification adjustment factors the majority of the modelled concentrations are within 10% of the monitored concentrations.

6.5.6 The IAN requires changes in concentrations between the reference case and assessed case at receptors which exceed the Air Quality Strategy Objectives to be categorised as either imperceptible (if the changes are ≤0.4μg/m³), small (>0.4 to 2μg/m³), medium (>2 to 4μg/m³) or Large (>4μg/m³). The larger the change the more confidence there is in the outcome modelled. This is also why a significant impact can be triggered with a smaller number of receptors with large changes than small as there is more certainty of the impact.

6.6 Summary

6.6.1 The Applicant is satisfied that the modelling has been carried out in accordance with industry best practice, using appropriate tools and following appropriate guidance which, together with the use of assumptions (when necessary) that err towards being worst-case, are designed to provide a reasonable worst-case assessment of the impacts of the scheme. While there is residual uncertainty in the results, especially for individual receptors, the overall results of the modelling for the base year are designed to be presented without bias, while the assessed year results are designed to represent likely worst-case conditions. In addition, as demonstrated in the development of the guidance used to determine whether a road scheme leads to a significant impact (IAN174/13), uncertainty in the tools used in the assessment process was factored into the advice and has been followed in the Applicant's assessment.

7 UNCERTAINTY IN THE CALCULATION OF ROAD TRAFFIC NOISE

7.1.1 In the UK, since 1975, road traffic noise has been predicted using a method set out in a government publication “Calculation of Road Traffic Noise” (CRTN) which followed work at the National Physical Laboratory published in 1972. In 1976 results of a study of the accuracy of the prediction method were published, which gave an over-prediction of traffic noise of 0.6 dB(A) with a Root Mean Square (RMS) error of 2.5 dB(A). In 1987 following changes to the vehicle noise regulations a new study found that the overprediction had increased to approximately 0.7 dB(A) with an RMS error of 2.1 dB(A). CRTN was revised in 1988 to include a number of significant changes and a comparison of predicted and measured noise levels found a mean prediction error of +0.1 dB(A) with an RMS error of 1.9 dB(A). A study published in 2010 found a correlation coefficient (R^2) of 0.86-0.9 between predictions (as implemented using software packages) and measured levels. The software package used for the Silvertown Tunnel implementation of CRTN has been verified against the worked examples in the CRTN document and the largest error was 0.5 dB(A) for the example in Annex 8 of the CRTN, with the remaining 17 CRTN worked examples reporting errors of 0.0 dB (for example 0.05 dB in Annex 5).

7.1.2 These results apply to the prediction of absolute noise levels. A large part of the noise study for Silvertown Tunnel involves the calculation of noise changes, and many of the uncertainties associated with prediction of absolute levels cancel out when one prediction is subtracted from another to predict noise change. The underlying equation in the CRTN method, that overall noise level is proportional to 10 log10 (vehicle flow) is fundamental to the mathematics of the decibel scale.

7.1.3 A change in traffic flow of 26% is required to cause a 1 dB(A) increase in the LA10 index. At the speeds concerned, the maximum sensitivity to traffic speed is approximately 0.5 dB(A) between 20 km/h and 50 km/h and the number of heavy vehicles would have to increase by at least 50% to make more than a 1 dB(A) difference. At the distances concerned the error associated with distance effects is near zero, as is the effect of gradient. The performance of noise barriers is calculated using fundamental acoustical principles, and the physical constraints mean that the effect of noise barriers on overall noise predictions at Silvertown is small and their contribution to overall uncertainty is negligible.

7.1.4 Use of CRTN is required both by statutory provisions regarding Noise Insulation and the DMRB in the assessment of road schemes, and it has been the basis of decisions by the Secretary of State for all road schemes in the UK for the past 40 years.

8 RESPONDING TO FORECASTING UNCERTAINTY

8.1.1 Whereas the preceding sections of this note have largely focused on the identification and minimisation of uncertainty within forecasting processes, this section concerns the management of uncertainty in the operational life of the Silvertown Tunnel scheme itself.

8.1.2 The Applicant has expressly recognised throughout its development of the Scheme that uncertainty is a factor in all planning. Accordingly, it has designed the Silvertown Tunnel scheme to be adaptable to changing circumstances. It is also putting forward mechanisms to ensure that the Scheme's impacts are forecast as accurately as possible, comprehensively monitored, and mitigated as necessary (both prior to and following the opening of the Scheme). The Applicant's Update Note submitted at Deadline 3 idenitifed areas where the Applicant is considering further enhancing this approach.

8.2 User charging

8.2.1 The user charge is a fundamental component of the Scheme, which enables the delivery of very substantial time savings without inducing additional traffic demand. The key means of ensuring adaptability is the Scheme's user charge.

8.2.2 Because of its inherent flexibility, the user charge provides a means of rebalancing the Scheme's effects in a wide variety of outturn scenarios. The effectiveness of this rebalancing can be seen in the sensitivity analysis set out above in section 3.3. This would provide an ability to influence traffic levels not only for the management of transport impacts (e.g. congestion), but also to achieve the environmental outcomes forecast for the Scheme (e.g. air quality). This is a significant advantage of the Scheme over other consented road schemes and minimises the risk that the acknowledged uncertainties in modelling lead to environmental effects which are materially different from those assessed in the opening year.

8.2.3 The Applicant has set out in the Charging Policies and Procedures (REP1-123) its proposed approach to the management of the user charge. This explains that in setting and varying the user charges, the Applicant's overriding obligation would be the achievement of the Project Objectives.

8.3 Monitoring and mitigation

8.3.1 The Applicant is also committed to monitoring the effects of the Scheme and bringing forward any mitigation required – either ahead of opening, if refreshed assessment indicates this is necessary, or following opening in light of monitoring data. (This commitment will be set out clearly in a single document combining and replacing the Monitoring Strategy and Traffic Impacts Mitigation Strategy and will be submitted at Deadline 4.)

8.3.2 Together, these mechanisms provide reassurance that uncertainties affecting the scheme can be identified and addressed prior to and post Scheme opening.

9 CONCLUSIONS

9.1.1 Despite the Applicant's confidence in the robustness of its forecasts, all planning must consider uncertainty. This is particularly so for major schemes of strategic significance, which by their nature tend to be assessed many years before they are likely to become operational, using large amounts of data to support complex, multi-stage analyses.

9.1.2 As set out in this document, the Applicant has taken great care throughout the development and assessment of the Silvertown Tunnel scheme to minimise uncertainty by following best practice and recognised guidance. It has sought expert assurance and external audit, and aimed to ensure that sources of uncertainty are recognised, and its effects understood and either acknowledged or mitigated as far as possible.

9.1.3 In addition, the Silvertown Tunnel scheme has been designed with a deliberate intention to maximise its ability to deliver positive outcomes and meet the Project Objectives under a variety of outturn conditions. The key to this is the proposed adaptive approach to user charging, monitoring, and mitigation.

9.1.4 Through this approach, the Applicant has demonstrated that the key strategic sources of uncertainty in transport forecasting can be directly managed through changes to user charges, across the range of plausibly foreseeable scenarios.

9.1.5 As well as providing reassurance around the assessed traffic effects of the Scheme, this also provides additional confidence in key inputs to the analysis that has been undertaken of environmental impacts and of costs and benefits to users.

9.1.6 While uncertainties which exist at a more localised level (for example, those concerning traffic counts on individual links) are not amenable to assessment through sensitivity testing, the Applicant has demonstrated that these are not likely to systematically bias the outputs of its modelling. The Applicant is committed to monitor the effects of the Scheme and bring forward any mitigation required – either ahead of opening, if refreshed assessment indicates this is necessary, or following opening in light of monitoring data. (This commitment will be set out clearly in a single document combining and replacing the Monitoring Strategy and Traffic Impacts Mitigation Strategy presented for Deadline 4.)

9.1.7 As a result, while all planning is undertaken in the context of uncertainty, the Applicant considers that its forecasts for the Silvertown Tunnel scheme are robust and that the Scheme is sufficiently adaptable to ensure that it can achieve the Project Objectives in a variety of outturn conditions.

Appendix A. Conversion process/mechanism used in converting traffic model output to AADT/AAWT for AQ/Noise assessment (as per the Environmental Statement)

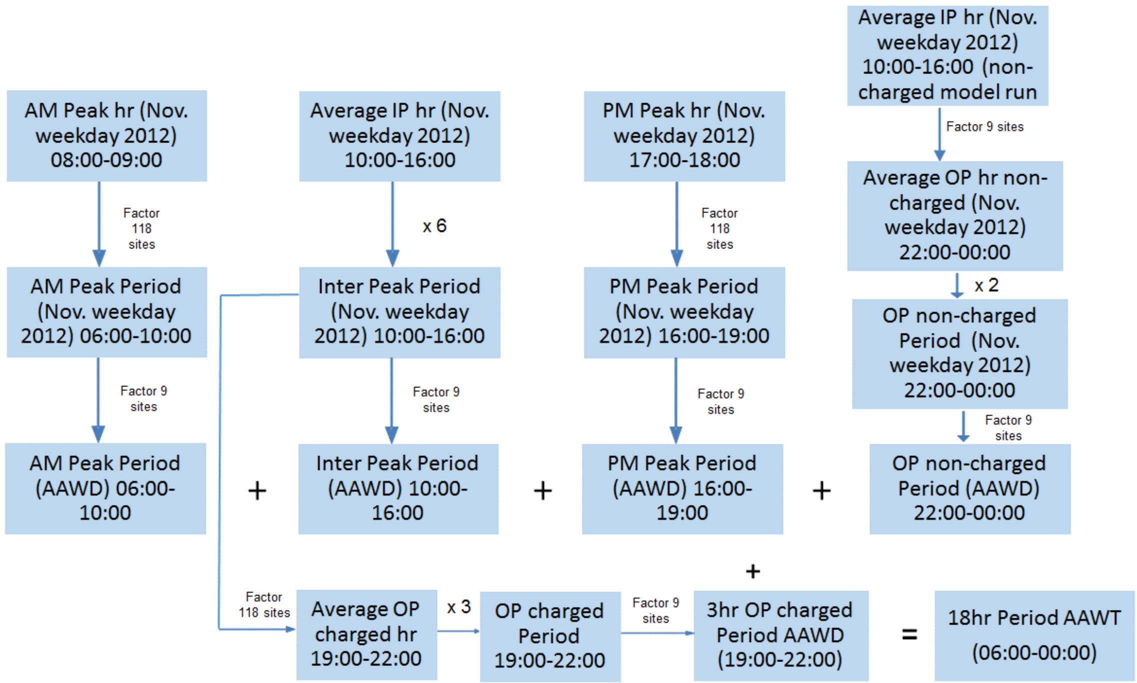


Figure 7: ES Appx 6.D Figure 4.4: Flow chart for AAWT

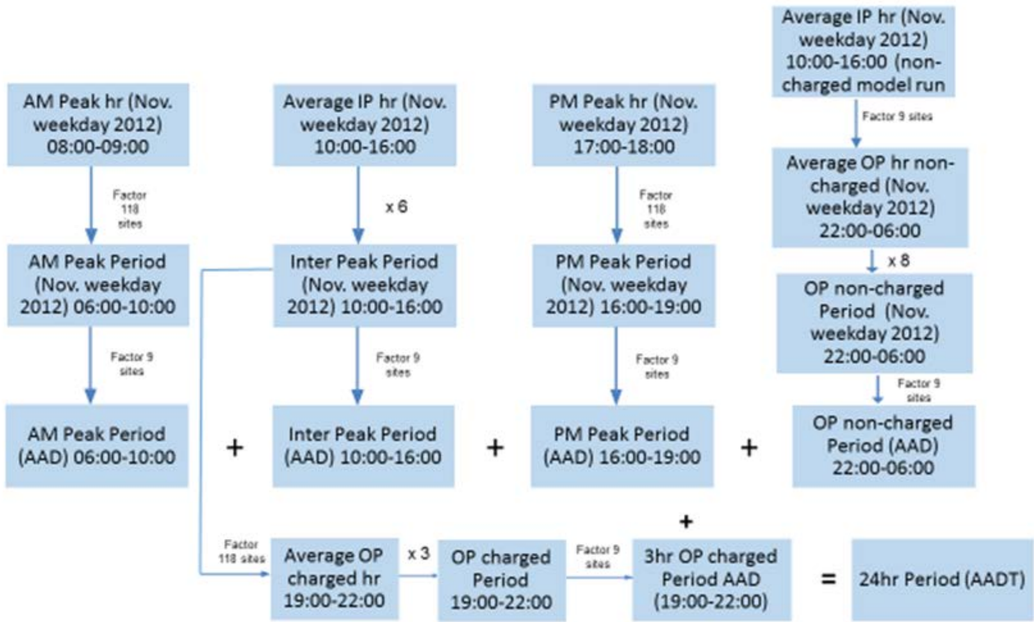


Figure 8: ES Appx 6.D Figure 4.5: Flow chart for AADT

Table 4: Peak Period Factors

	Morning (AM) Peak hour (08:00-09:00hrs) to four-hour AM Peak Period (06:00-10:00hrs)	Average Inter Peak (IP) hour (10:00 to 16:00hrs) to six-hour Inter Peak Period (10:00-16:00hrs)	Evening (PM) Peak hour (17:00-18:00hrs) to three-hour PM peak Period (16:00-19:00hrs)
Cars and LGVs	3.3315	6.0	2.8834
OGVs	3.8923	6.0	3.1360
All Vehicles	3.4087	6.0	2.8988

Table 5: Off Peak Period Factors

AADT	3hrs Off Peak charged period (19:00-22:00hrs)	8hrs Off Peak non-charged period (22:00-06:00hrs)
Cars and LGVs	2.3366	2.5221
OGVs	1.0467	1.6007
All Vehicles	2.2033	2.1519
AAWT	3hrs Off Peak charged period (19:00-22:00hrs)	2hrs Off Peak non-charged period (22:00-00:00hrs)
Cars and LGVs	2.3366	0.8422

OGVs	1.0467	0.3620
All Vehicles	2.2033	0.6832

The expansion factors to convert the November Weekday (24 Hours) to annual averages were:

- November Weekday (24 Hours) to Average Day Traffic Flow Factor (24 Hours) Cars and LGVs - 0.95812
- November Weekday (24 Hours) to Average Day Traffic Flow Factor (24 Hours) OGVs - 0.80384
- November Weekday (24 Hours) to Average Day Traffic Flow Factor (24 Hours) All Vehicles - 0.93289