

Thames Tideway Tunnel
Thames Water Utilities Limited



Application for Development Consent

Application Reference Number: WWO10001

Settlement Information Paper

Doc Ref: **7.21**

APFP Regulations 2009: Regulation **5(2)(q)**

Hard copy available in

Box **58** Folder **A**
January 2013

**Thames
Tideway Tunnel**



Creating a cleaner, healthier River Thames

This page is intentionally left blank

Thames Tideway Tunnel Settlement Information Paper

List of contents

	Page number
1 Executive summary	1
2 Asset protection process	3
2.1 Background	3
2.2 Approach to impact assessment works	3
2.3 Impact assessment works: Non-listed buildings	4
2.4 Impact assessment works: Flood defences	6
2.5 Impact assessment works: Utilities	7
2.6 Impact assessment works: Tunnels and bridges	7
2.7 Impact assessment works: In-river structures.....	8
3 Construction phase works	9
3.1 Protective measures.....	9
3.2 Monitoring.....	9
3.3 Building surveys	10
3.4 Infrastructure surveys	11
3.5 Repair works to buildings.....	11
4 Heritage considerations	13
4.1 Listed buildings.....	13
4.2 Listed bridges and tunnels.....	14
5 Settlement deeds for buildings.....	15
5.1 Settlement deed	15
Abbreviations.....	17
Bibliography.....	19
Glossary	21
Appendix A.....	23
Appendix B.....	24

This page is intentionally left blank

1 Executive summary

- 1.1.1 This paper explains the approach taken by Thames Water to the assessment, monitoring and mitigation measures to be implemented as part of the asset protection process being carried out for the Thames Tideway Tunnel Project (the 'Project').
- 1.1.2 Assessment works have been undertaken to determine the extent of predicted ground movements and the resulting impacts on existing infrastructure and buildings which may be caused by the construction of the Project. This is to confirm either that these impacts are acceptable or identify the need for mitigation works or special tunnelling measures. The assessments have been based on approaches proven on other major projects undertaken in London including the Jubilee Line Extension, Channel Tunnel Rail Link (High Speed 1) and currently the Crossrail project.
- 1.1.3 A risk-based, staged approach has been used to establish the predicted impact and identify whether any special protective measures would need to be implemented to allow the safe construction of the Project. This used conservative assumptions to identify whether assets would be at risk of negligible damage or less and then used progressively more sophisticated analyses to evaluate the impact on the remainder of the assets not within this risk of damage category.
- 1.1.4 The design of the Project has been developed to have very deep tunnels relative to other tunnelling projects, which would help to minimise the impact on existing infrastructure and buildings.
- 1.1.5 This paper explains the processes and procedures undertaken to date and also those to be used during construction to manage the interfaces with third party infrastructure and buildings as the works progress. This includes undertaking pre construction condition surveys and appropriate monitoring to provide the necessary assurance that the behaviour of the ground in response to the construction works is as predicted.
- 1.1.6 Detailed assessments were carried out on all listed buildings within the potential zone of influence of the Project. The risk of damage due to predicted ground movements as well as the heritage sensitivity, condition and structural form of the building were assessed. Intrusive mitigation measures would not be required or appropriate for any buildings.
- 1.1.7 Thames Water has developed a policy whereby owners can request the implementation of certain procedures the object of which is to monitor changes attributable to the Project with a view to assisting in any claim for statutory compensation. Thames Water will also offer in qualifying cases a deed to secure these commitments.

This page is intentionally left blank

2 Asset protection process

2.1 Background

- 2.1.1 The approach adopted for assessing the impacts of the construction works on third party infrastructure and buildings is based on extensive experience of undertaking excavation and tunnelling works within London. This includes recent major tunnelling projects such as the Jubilee Line Extension and the Channel Tunnel Rail Link (High Speed 1).
- 2.1.2 These projects established proven methods to assess the impacts of these ground movements on infrastructure and buildings which were verified by measurements of the resulting ground movements and the response of existing infrastructure and buildings. The same approaches are currently being used on the Crossrail project for the assessment of risk of damage to buildings.
- 2.1.3 The Project includes the construction of tunnels, shafts and other CSO interception works. These excavations would cause some ground movements within the vicinity of the works which may cause some impact on existing infrastructure and buildings depending on their location and proximity to the works.
- 2.1.4 The extent of the ground movements caused by the Project would depend on several factors including the size and depth of the construction works, existing soil conditions and the methods of construction. The response of the structure to these ground movements would be influenced by the type of structure, its condition, and its foundations.
- 2.1.5 The Project has implemented a rigorous asset protection process to support the design submitted with the application for development consent. The potential impacts have been predicted and the need for special protective measures identified.
- 2.1.6 The project has been designed to maximise the length of main tunnel drives and connections into them under the river. This minimises the number of interfaces with third party infrastructure and particularly with buildings. This is advantageous when compared to the railway projects mentioned above which are predominantly under land and include the construction of large station tunnels, cross passages, ventilation shafts and station concourses located within the city to enable passenger distribution.

2.2 Approach to impact assessment works

- 2.2.1 A risk-based, staged approach has been adopted to assess all third-party infrastructure and buildings that may be impacted by the ground movements arising from the construction of the Project.
- 2.2.2 Comprehensive ground investigations have been undertaken for the Project to provide detailed information about the ground conditions along the route of the Project. The information has been used in the design development and the assessment of the impacts on third party

infrastructure and buildings. It would also be used by contractors to develop construction methods to minimise impacts.

- 2.2.3 “Greenfield” settlement contours were generated for the Project based on proven empirical formulae to determine the predicted ground movements arising from construction accounting for both the assumed horizontal and vertical tunnel alignments and the location of the shafts. These are movements at the ground surface, calculated on the premise that the ground is a ‘green field’ (i.e. free of development) and are a conservative prediction.
- 2.2.4 A zone was identified within which the predicted ground movements would be 1mm or more. A five metre buffer zone, equivalent to the alignment adjustment allowed within the limit of deviation for the main tunnel, was added to the 1mm contour to provide an envelope for the potential zone of influence of the Project. The assets within this envelope and their owners were identified. This involved an extensive exercise which included searches of historical records and discussions with local authorities and other statutory bodies as well as the diligent enquiry exercise required by the Planning Act 2008 to identify those who may have a relevant claim.
- 2.2.5 All the known existing and proposed assets identified within the potential zone of influence of the Project were recorded along with a classification of the type of asset, including bridges; tunnels; flood defences, utilities and buildings (distinguishing those that are listed).
- 2.2.6 Assessment works were undertaken to establish the predicted impact of the Project on these assets. These assessments were used to identify any potential mitigation works and also to inform any monitoring requirements.

2.3 Impact assessment works: Non-listed buildings

- 2.3.1 All non-listed buildings within the potential zone of influence of the tunnels, shafts and associated works were classified according to the structural type of the building to establish an appropriate assessment method to be used. Principally the buildings are classed into:
- a. Class 1: Load bearing masonry buildings on shallow foundations.
 - b. Class 2: Framed buildings with masonry infill and possibly piled.
 - c. Class 3: Buildings not in ‘Class 1 or 2’, but subject to less than 10mm settlement and <1:500 gradient¹ and not considered to be ‘sensitive’ to ground movements.
 - d. Class 4: Buildings not in ‘Class 1 or 2’ and subject to more than 10mm settlement or >1:500 gradient or structures identified as being ‘sensitive’ to movement.
- 2.3.2 Following the assignment of the building class, the damage category for the buildings was assessed using a method appropriate to the type of building.

¹ Maximum gradient of predicted settlement trough at surface

- 2.3.3 Burland (1995) proposed a framework that defines potential damage based upon calculated tensile strains for a deep beam and relates this to approximate crack widths likely to occur and degrees of damage severity based upon ease of repair. This framework is shown in the table in Appendix A.
- 2.3.4 The classification system developed by Burland for load bearing masonry structures was used to assess Class 1 and Class 2 buildings. It also provides a useful framework to assign to Class 3 and Class 4 buildings.
- 2.3.5 Buildings in Class 3 were appraised following a review of available information about the building against the predicted ground movements to ascertain whether these were within the 'negligible' damage category, or otherwise they were assessed as a Class 4 building.
- 2.3.6 Class 4 buildings were subject to external visual surveys to determine factors such as the likely presence of basements and any designed movement joints in the facade of the building. Settlement diagrams were produced for each of the Class 4 buildings to assist with the process of determining damage category.
- 2.3.7 A damage category, as shown in Appendix A, was assigned based upon an appraisal of ground movements and review of the structural form of the building. Buildings assessed to have a damage category of greater than 2 – 'Slight', or those where further more detailed information was required to make an assessment were subject to further detailed assessment.
- 2.3.8 For the vast majority of buildings the assessment determined that they have a 'negligible' risk of damage due to the Project. Some buildings were assessed as having 'slight' or 'very slight' risk of damage. Only a few buildings were identified as having a potential 'moderate' risk of damage in accordance with either the Burland (1995) damage framework, or by structural assessment.
- 2.3.9 Following this assessment, a total of 46 non-listed buildings qualified for a more detailed assessment, either because they were felt to be particularly sensitive, or because of their proximity to shaft construction sites.
- 2.3.10 Following more detailed assessment, two of the 46 buildings were classified as being potentially subject to 'moderate' risk of damage. For one of these 'in tunnel' measures as described in Section 3.1.2 were identified as being sufficient to reduce the risk of damage to slight and these measures would be employed to mitigate this risk of damage.
- 2.3.11 The other 44 of the 46 buildings were classified as being potentially subject to 'slight' risk of damage or lower. Therefore this risk would be managed effectively using a suitable monitoring regime, refer to Section 3.2 for further details.
- 2.3.12 Details on other measures that would be implemented during the construction phase including building surveys and repair works are explained in Section 3.3 and 3.5.

2.4 Impact assessment works: Flood defences

- 2.4.1 Flood defence assets within the potential zone of influence of the Project, including river walls, embankments, slipways, steps, walls, outfalls and sluices, were categorised according to the following key parameters:
- a. Wall construction type and construction material,
 - b. River bed level in front of asset
 - c. Flood defence level and statutory defence level
 - d. Environment Agency Condition Grade
 - e. Other sensitivity to ground movement (e.g. listed structure)
 - f. Approximate founding level of asset
- 2.4.2 Visual inspections were carried out to supplement the existing record drawings and other details provided by the Environment Agency and others relating to the flood defence assets.
- 2.4.3 The initial stage of assessment involved assessing different river walls against a set of screening criteria to evaluate the impact of construction works. A number of assets were shown to be subject to negligible impact. For 69% of the flood defence assets along the route of the tunnel, it is predicted that the ground movements will have no impact on the global stability or serviceability of the structure.
- 2.4.4 Further assessment was carried out on the remaining 31% of assets where a greater impact was predicted. In addition to the impact on structures which are currently in very poor condition, increases in the stress in tie rods in tied structures was the only structurally significant issue identified in the assessment of the river walls that could result from ground movements along the route of the tunnel.
- 2.4.5 Flood defences in the vicinity of construction sites were subject to an assessment of construction-related impacts in addition to ground movement, including where applicable:
- a. Excavation in front of river walls
 - b. Excavation to rear of walls in vicinity of tie-rods
 - c. Additional surcharge loading immediately to the rear of the asset
 - d. Increased water differential for walls within temporary cofferdams
 - e. Scour due to modified fluvial flow
 - f. Additional surcharge loading set back from the rear of the asset
 - g. Dewatering as part of shaft construction
- 2.4.6 A similar approach was adopted for the impact of surface construction at the work sites in the vicinity of river walls. The initial stage of assessment involved assessing different river walls against a set of screening criteria to evaluate the impact of construction works. A number of assets were shown to be subject to negligible impact. Further asset-specific assessment was undertaken at some locations, and for approximately

40% of the structures assessed, it was concluded that some form of mitigation would be required.

- 2.4.7 Potential mitigation options for different flood defences were evaluated where these were considered a potential requirement, both for the river walls along the tunnel route and those affected by work at shaft construction sites. A generic list of possible mitigation strategies was developed, and the applicability of each was considered for each location. Considerations included site constraints and asset-related constraints.
- 2.4.8 In many cases it was considered that the risk to the flood defences could be mitigated using 'in tunnel' control measures as described in Section 3.1.2 or constraining construction activities so as to avoid the impacts. In other cases, predominantly associated with shaft site locations, temporary support, wall strengthening and/or wall replacement were considered as potential options. Confirmation of the need for such mitigation solutions, and their design, is subject to further investigations and development by the works contractor.

2.5 Impact assessment works: Utilities

- 2.5.1 In addition to diverting a number of utilities to accommodate the construction of the Project, assessments were carried out to determine the impact of the construction on other assets belonging to the utility companies. These assessments were carried out for sensitive utility assets within the potential zone of influence of the Project.
- 2.5.2 For water mains, sewers and gas mains the strains, joint rotation and pull out due to the predicted ground movements were assessed. These were compared to acceptance criteria that took account of the type of material, diameter and type of construction, which had been agreed with the appropriate asset owner.
- 2.5.3 More detailed assessments were then undertaken on the assets which failed the acceptance criteria to identify those that would require protective measures to be implemented prior to construction.
- 2.5.4 Potentially vulnerable electricity assets were identified in consultation with the owner and the acceptable limits of deformation which would not cause damage were agreed. The assessments showed that no adverse impact is predicted on these electricity assets.

2.6 Impact assessment works: Tunnels and bridges

- 2.6.1 All tunnels and bridges located within the potential zone of influence of the Project were identified and a detailed assessment of each was carried out in consultation with the asset owner where possible.
- 2.6.2 A visual inspection was undertaken where access was feasible for each asset to ascertain the existing structural condition. Owner inspection reports and existing record drawings where available were used to inform the numerical models of the bridges and tunnels which were developed to

enable the potential impact of the construction of the Project to be assessed.

- 2.6.3 The assessments indicated that with the exception of two assets no direct protective mitigation measures would be required. The two assets requiring substantial protective measures are existing Thames Water tunnels in west London, which will require a secondary lining to be installed prior to the Project crossing above.
- 2.6.4 Further assessments to take account of the Contractors' method of construction, condition and structural surveys would be undertaken where necessary on behalf of Thames Water prior to construction adjacent to these interfaces. The details of these surveys, monitoring and any necessary remedial works would be developed prior to construction in discussion with the asset owners.

2.7 Impact assessment works: In-river structures

- 2.7.1 Visual inspections were undertaken for 45 in-river structures within the zone of influence of the Project to obtain information; including materials and structural form, condition including existing defects, proximity of historic buildings or moored vessels and operational functions. These structures include wharves, piers, jetties, weirs and locks.
- 2.7.2 The impact of predicted ground movements on these structures was assessed and 13 structures were subject to less than 1mm vertical settlement. Six structures required further more detailed assessment.
- 2.7.3 Detailed assessment showed that three of the six structures would satisfactorily accommodate the predicted ground movements. However the Thames Water owned Middle Wharf Jetty would require mitigation due to predicted ground movements from the connection tunnel.
- 2.7.4 The existing jetty at Cremorne Wharf is in a condition which means that consideration would need to be given to whether any remediation measures would be needed prior to the start of construction, subject to its condition at that stage.
- 2.7.5 Detailed assessment of Three Mills Lock showed that any surcharge loading would need to be controlled in order to avoid creating an adverse impact on this structure.

3 Construction phase works

3.1 Protective measures

- 3.1.1 Construction specifications are being prepared for the Project to ensure that best practice is used to minimise the impact of the construction works on existing infrastructure and buildings. The depth of the tunnelling works assists with minimising the need for mitigation works.
- 3.1.2 The approach would be to employ ‘in tunnel’ measures to limit ground movements to acceptable levels where possible. These will include:
- a. specification of a minimum standard high performance tunnel boring machine (TBM) including high standards of management and construction
 - b. installation of instrumentation and monitoring to ensure the tunnel structures and ground movements behave as predicted
 - c. using measures such as increased face pressures for the TBM and staged excavation for open faced tunnels together with additional ground support
 - d. specification of high standards of workmanship and construction management for the construction works
 - e. preparation of design specifications to ensure the acceptability of the design.
- 3.1.3 Ground improvement methods may also be used, by ‘in tunnel’ measures or from the surface, to improve the engineering properties of the ground and reduce ground movements.
- 3.1.4 After these measures have been considered, where the risk of damage that exceeds damage category 2 remains, as defined in Section 2.3.3 and Appendix A, physical mitigation works may be required. These may take the form of special additional tunnelling measures or strengthening an existing structure, for example installing additional tie rods to strengthen a river wall.
- 3.1.5 These types of mitigation measures have been successfully used on other major projects which are comparable in scale and complexity of tunnelling and associated works to the Project. They have effectively mitigated adverse impacts on third party infrastructure and buildings.

3.2 Monitoring

- 3.2.1 Monitoring would be used to ensure the safe construction of the Project. The monitoring system would be designed to provide:
- a. confirmation that the ground movements are as predicted in the assessments of impacts on existing infrastructure and buildings
 - b. confirmation that the construction works are behaving as designed

- c. advanced warnings of any unacceptable trends in ground movement or other parameters before the trend becomes an issue.
- 3.2.2 Ground surface monitoring would be undertaken where feasible to confirm that ground movements are within the predicted levels. The specific requirements for monitoring any third party infrastructure and buildings will be determined from the assessment works carried out in agreement with the asset owner where appropriate. This includes bridges, tunnels, flood defence structures, in-river structures and utilities.
- 3.2.3 Baseline monitoring would be undertaken, where practicable and appropriate, to establish ground movements that are a result of seasonal variations or diurnal impacts due to tides and sunlight or the movement of rail infrastructure due to the morning and evening peak traffic and the night-time recovery. Baseline monitoring of specific infrastructure would be carried out with the agreement of the asset owners. The baseline monitoring would allow the residual movements as a result of construction of the works to be identified.
- 3.2.4 Monitoring would continue after the works until ground movements attributable to the Project have ceased or the rate of settlement is less than or equal to 2mm per annum. These criteria mean that the risk of any further ground movements arising from the construction of the Project are so small that they pose no risk of detrimental impact to third party infrastructure and buildings.

3.3 Building surveys

- 3.3.1 Pre construction condition surveys would be offered and carried out on all properties located within the zone of influence, which will be confirmed following the final design of the tunnel alignment for the Project. These would be undertaken by an independent chartered building surveyor commissioned on behalf of Thames Water who would act on a joint instruction for both Thames Water and the building owner prior to any works that could cause an impact. Although jointly reported these would be paid for by Thames Water. In any event the surveys should be completed no earlier than three months prior to tunnelling under the property to capture the condition of the property immediately prior to any Project works.
- 3.3.2 A copy of the Record of Condition produced would be available to the property owner in hardcopy or electronic version upon request. This document would comprise a written and photographic factual record of the existing condition of the property, including information on the structure, the finishes and evidence of any existing cracking or visible defects. This would provide a true record of the condition of the property before construction works start in the area. Should a building owner decide to carry out their own survey in addition to this, it would be at their own cost.
- 3.3.3 Should the building owner reasonably believe that the construction of the Project has caused damage, they should inform Thames Water in writing. This notification should take place before the end of the period of two years from the date of opening of the Project.

- 3.3.4 Following this notification, a second survey would be carried out by the building surveyor, jointly instructed, to identify any additional defects and to determine the extent of any liability and damage. The building owner may request that their own surveyor attend the second survey and provide comments on the draft report produced on behalf of the Project. Reasonable professional fees incurred by the building owner, which have been agreed with Thames Water in advance, would be reimbursed if there is a successful claim.
- 3.3.5 A comparison of the pre and post construction condition survey reports may form the basis of any claim. The extent of damage attributable to the Project would be assessed and an agreement made for the repair works to be carried out at the cost of the Project. An owner should not carry out their own repairs without first reaching an agreement in writing with Thames Water.

3.4 Infrastructure surveys

- 3.4.1 Pre construction condition surveys would be offered and carried out on significant and sensitive assets within the zone of influence of the Project and agreed with the asset owner and consenting authority where appropriate. This would include bridges, tunnels, in-river structures and flood defence structures.
- 3.4.2 The extent and level of detail of these surveys would be determined in agreement with the asset owners and other consenting authorities where required. Suitable arrangements will be made with the asset owners to ensure safe access to these assets is obtained to carry out the necessary surveys e.g. with London Underground Ltd for tube tunnels.
- 3.4.3 In addition to surveys, as outlined in Section 3.2, monitoring of significant and sensitive assets would be undertaken where appropriate and feasible as agreed with the asset owners. This will assist with managing the risks associated with the tunnelling activities within the vicinity of these assets.
- 3.4.4 Following the completion of works within the vicinity of the asset, if the asset owner reasonably believes that damage due to the works has occurred, then the procedures as set out on 3.3.3 to 3.3.5 above will apply. Where it is necessary to undertake repair works these would be carried out in accordance with the terms and conditions of the associated asset protection agreement or flood defence consent.

3.5 Repair works to buildings

- 3.5.1 The DCO includes powers for Thames Water to remediate damage caused by the Project. Otherwise, property owners would be reimbursed for reasonable costs incurred in remediating material physical damage which has arisen from ground settlement caused by the works provided:
- a. the damage is caused by the works undertaken as part of the Project

- b. the property owner has an agreement in writing from Thames Water of the Project as to the scope of works to be undertaken and the cost to be reimbursed
 - c. any claim is made before the end of the period of two years from the date of opening of the Project.
- 3.5.2 In the event that the building owner has properly submitted a claim for remedial works and received no response within two calendar months, the property owner may proceed to carry out the works and seek reimbursement of the reasonable cost. The owner's reasonable steps must include having obtained three competitive quotes for the repair works prior to carrying them out.
- 3.5.3 On receipt of an advanced notice of the proposal to carry out repair work Thames Water may decide to carry out the repair work itself.
- 3.5.4 If there are any defects that exist beforehand, which are worsened as a result of the works, then the additional cost of repair works over and above the cost to rectify the existing defect will be recoverable.

4 Heritage considerations

4.1 Listed buildings

- 4.1.1 Detailed assessments were carried out on all listed buildings within the potential zone of influence of the works. The risk of damage was assessed, which considered heritage sensitivity and structural form of the building in addition to predicted ground movements, for 31 listed buildings.
- 4.1.2 Lots Road Pumping Station and Greenwich Sewage Pumping Station were also assessed for any impacts from other site works in addition to ground movements from tunnel and shaft construction.
- 4.1.3 As well as using information regarding the buildings provided by English Heritage and local authorities, internal and external inspections of the buildings were carried out where access was available.
- 4.1.4 The buildings have been assigned a risk of damage category in accordance with the framework developed by Burland (1995), shown in Appendix A. Lots Road Pumping Station obtained a risk of damage category of 2, 'slight' and Greenwich Sewage Pumping Station a risk of damage category of 3, 'moderate'. The other 29 buildings all obtained a risk of damage category of 0, 'negligible'.
- 4.1.5 The structural, condition and heritage sensitivities were assessed based on a methodology developed in consultation with English Heritage and the relevant local authorities.
- 4.1.6 The structural sensitivity is based on a number of factors identified as being significant in the anticipated response of the building to ground movement, as shown in the table in Appendix B. These factors are reviewed in relation to the predicted ground movements in order to provide a structural sensitivity score.
- 4.1.7 Each building has been graded due to its current condition as either 'good', 'poor' or 'very poor'. This is then reviewed against the risk of damage to ascertain whether the building would be more sensitive to damage. A condition score is then assigned to the building.
- 4.1.8 The poorer the condition of a building, the higher its sensitivity is likely to be. However, if a building is in poor condition but is structurally sound and in an area where settlement is predicted to be minimal, then its sensitivity due to condition will be low and the proposed works would not be expected to produce any further deterioration.
- 4.1.9 A heritage sensitivity score has been assigned to each building based on its structural form, sensitive features, fixtures and finishes in relation to the predicted risk of damage.
- 4.1.10 The matrix in Appendix B was developed as a guide to assist the scoring of the structural, condition and heritage sensitivities of each of the listed buildings. The scores from the risk of damage category, structural, condition and heritage sensitivities were reviewed and combined to produce an overall score for each building.

- 4.1.11 The results of the assessments show that seven of the 31 listed buildings attained a combined score of 3 or more. Of these seven, all have been assigned a risk of damage category of 0 other than Lots Road Pumping Station and Greenwich Sewage Pumping Station as explained in Section 4.1.4. The scores for structural and heritage sensitivities were not greater than 1 and the condition scores allocated were generally 1 or less, except for one building in Tower Hamlets which was given a condition score of 2. One building in Lewisham was provisionally assigned a condition score of 2 as access was not available for inspection.
- 4.1.12 For these seven buildings mitigation measures would not be considered to be required or appropriate as intervention measures would be likely to be more intrusive and damaging to heritage fabric than a carefully managed process of survey and repair of minor defects, if required, using appropriate materials and techniques.

4.2 Listed bridges and tunnels

- 4.2.1 There are 24 listed bridges and one listed tunnel which are within the potential zone of influence of the works. Detailed assessments were carried out for these assets, as described in Section 2.6. The results of these assessments were then reviewed and further inspections and assessments were undertaken by heritage specialists to ascertain the likely impact on the heritage aspects of these structures.
- 4.2.2 It is not anticipated that there would be any adverse impact on the heritage features of the listed bridges and tunnel. Appropriate measures would be put in place during construction to record and monitor these assets and if required carefully manage the repair of any minor defects.

5 Settlement deeds for buildings

5.1 Settlement deed

- 5.1.1 This paper sets out the obligations and responsibilities of Thames Water which arise as a consequence of promoting a project to tunnel at depth beneath privately owned property. Those obligations and responsibilities are to the property owners and are generally applicable throughout the timescale of the project. It has become best practice for promoters to encapsulate these responsibilities into a deed which owners are invited to enter into with Thames Water.
- 5.1.2 Thames Water will develop a Deed which the owner of a building within the potential zone of influence may request. This would be a formal legal undertaking concerning settlement, giving effect to the matters set out in this paper.
- 5.1.3 The settlement deed would be provided to give reassurance to property owners who during the lifetime of the project may from time to time require the benefit of having a personal contract with Thames Water as a guarantee on their property.
- 5.1.4 Qualifying criteria will apply and are set out below. The Deed will incorporate the commitments made in this paper.
- 5.1.5 It will not be necessary to enter into the deed in order to benefit from the processes set out in this paper.
- 5.1.6 The owner applying for a deed must have a legal estate interest in all or part of a building within the potential zone of influence.
- 5.1.7 The owner must give reasonable notice to Thames Water prior to construction of the part of the tunnel intended to go under the property. The notice must give sufficient information in order for Thames Water to complete the deed. At this stage Thames Water will confirm or refuse the owners application for a deed. On receipt of a deed the owner must return his counterpart completed within 21 days.
- 5.1.8 Where a qualifying building is in multiple ownership each owner will be entitled to a deed.
- 5.1.9 The deed will remain in place and expressed to be attached to the property so that the benefit of it can be assigned on any subsequent transfer.
- 5.1.10 The deed will transfer from Thames Water to an appointed Infrastructure Provider on the basis that in all other respects the conditions and obligations set out in the deed for the benefit of the owner will remain unaltered. The deed would provide as follows:-
- 5.1.11 Prior to the commencement of relevant construction activity in the area of the owners property Thames Water would carry out an assessment of the property to determine what, if any, monitoring and surveying would be necessary to accord with the terms of the deed. The results of this

assessment would be made available to the owner prior to commencement of relevant construction activity.

- 5.1.12 The owner would be obliged to permit Thames Water's personnel the required access to the qualifying building for the purpose of carrying out the assessments and any subsequent monitoring, surveying or preventative works of mitigation.
- 5.1.13 Thames Water would reimburse the reasonable cost of repairing any damage caused to the qualifying building by the work carried out in connection with assessment, monitoring, surveying or mitigation.
- 5.1.14 If as a consequence of ongoing monitoring Thames Water identifies the need to revisit the qualifying building to install additional monitoring or carry out preventative works it would be permitted to do so subject to informing the owner beforehand.
- 5.1.15 If during the period of the deed the owner became aware of damage to the property that they believe could be being caused by the Project's construction activity they can contact Thames Water and request a further assessment be carried out. This would be conducted at Thames Water's expense and may be triggered by the owner at any time.
- 5.1.16 This may result in additional monitoring equipment being installed or additional preventative works to mitigate the effects of settlement that may be taking place.
- 5.1.17 On completion of the relevant construction activity, if there has been damage caused or the owner suspects that damage has been incurred the qualifying building would be subject to a post construction condition survey and a report prepared to identify and explain any differences from the pre construction condition survey that will have been held on record by both Thames Water and the property owner.
- 5.1.18 In the event of a dispute over liability for damage that may have occurred the deed provides for cases to be referred for arbitration.
- 5.1.19 On completion of the works or after a period during which no further settlement as defined in Section 3.2.4 has occurred the deed will expire.
- 5.1.20 The deed would be available from the date of acceptance of application for Development Consent.

Abbreviations

CSO	Combined sewer overflow
DCO	Development consent order

This page is intentionally left blank

Bibliography

Attewell, Yeates and Selby (1986) soil movements induced by tunnelling and their effects on pipelines and structures, Blackie and Son Ltd. London.

Bowers and Moss (2005) settlement due to tunnelling on the CTRL London tunnels, proceedings of the geotechnical aspects of underground construction in soft ground conference, Amsterdam, 2005.

Bracegirdle, A., Mair, R.J., Nyren, R.J. & Taylor, R.N. (1996) a methodology for evaluating potential damage to cast iron pipes induced by tunnelling, geotechnical aspects of underground construction in soft ground, Balkema, Rotterdam ISBN 905410856 8 pp659-664.

Burland, J.B.(1995), assessment of risk of damage to buildings due to tunnelling and excavation, invited special lecture: 1st international conference on earthquake geotechnical engineering, IS Tokyo '95.

CIRIA SP200 (2001) Building response to tunnelling. Case studies from the Jubilee Line Extension, London. 3 Assessment methods used in design, Burland J. B.,

Harris, D.I. and Franzius, J.N. (2005) settlement assessment for running tunnels – a generic approach, proceedings of the international symposium; geotechnical aspects of underground construction in soft ground, Amsterdam, 2005.

Mair, R.J., Taylor, R.N. & Bracegirdle, A. (1993) subsurface settlement profiles above tunnels in clay; geotechnique, Vol 43 No. 2 pp315-320.

New and Bowers (1994) ground movement model validation at the Heathrow express rail tunnel; tunnelling 94, institution of mining and metallurgy, London, pp301-329.

New and O'Reilly (1991) tunnelling induced ground movements: predicting their magnitude and effects; Invited review paper to 4th international conference on ground movements and structures, Cardiff, Pentech press, London.

O'Reilly and New (1982) settlements above tunnels in the United Kingdom – their magnitude and prediction; tunnelling 82, institution of mining and metallurgy, London pp173-181.

This page is intentionally left blank

Glossary

Term	Description
asset	An existing or proposed/planned physical object, whose stability, form or function is responsive to ground movements to such an extent that these responses need to be fully understood and investigated prior to commencing construction works.
combined sewer overflow (CSO)	A structure, or series of structures, that allows sewers that carry both rainwater and wastewater to overflow into a river when at capacity during periods of heavy rainfall. The flows are discharged to river in order to prevent the sewers backing up and flooding streets or houses. Flows may discharge by gravity or by pumping.
condition survey	A survey of an asset that is undertaken prior to construction works that may affect the asset. A further survey can be carried out once construction is complete, if required.
connection tunnel	A tunnel that connects a drop shaft to the main tunnel.
construction site	The area of a site used during the construction phase.
Development Consent Order (DCO)	An order under the Planning Act 2008 approving a development that is or forms part of a Nationally Significant Infrastructure Project. The order can grant planning permission and compulsory purchase powers. The order is granted by the Government ministers.
dewatering	<p>The removal of water from solid material or soil by wet classification, centrifugation, filtration, or similar solid-liquid separation processes, such as removal of residual liquid from a filter cake by a filter press as part of various industrial processes.</p> <p>Construction dewatering is a term used to describe removal or draining groundwater or surface water from a riverbed, construction site, caisson or mine shaft, by pumping or evaporation.</p>
drive/drive option	A possible tunnelling option.
greenfield settlement	The term used to describe predicted movements at the ground surface, calculated on the premise that the ground is a 'green field' (ie, free of development) used as a starting point for ground movement calculations.
ground investigations	Information gathering and collation regarding existing geotechnical ground information to enable the design process (eg, boreholes, groundwater monitoring, trial holes, etc).

Glossary

Term	Description
groundwater	All water below the surface of the ground in the saturation zone and in direct contact with the ground or subsoil. Water contained in underground strata, predominantly in aquifers.
listed buildings	A structure of architectural and/or historical interest included on the Secretary of State's list, which affords statutory protection. Such buildings are subdivided in to Grades I, II* and II (in descending importance).
main tunnel	The large diameter tunnel from Acton Storm Tanks to Abbey Mills.
mitigation measures	Proposed actions to prevent or reduce adverse effects arising from the whole or specific elements of a development.
monitoring	Monitoring, recording and collection of existing situation data prior to construction (eg, CSO spill frequency, vehicle or pedestrian traffic movements or building settlement monitoring before or during construction).
secondary lining	A second, internal lining of the tunnel to provide additional strength.
sensitive asset	An asset that has limited scope to accommodate the effects of ground movements without adverse effects. This may be due to age, value (heritage and financial), ownership, location, form, function and nature, and construction materials.
settlement	Ground movements arising from construction.
shaft	Duct, pipe or vertical tunnel.
Thames Water	Thames Water Utilities Ltd. The <i>Draft Development Consent Order</i> (DCO) contains an ability for Thames Water to transfer powers to an Infrastructure Provider (as defined in article 2(1) of the DCO) and/or another body, with the consent of the Secretary of State.
tunnel alignments	The horizontal and vertical routes of a tunnel.
tunnel boring machine (TBM)	A machine that has a circular cross-section used to excavate tunnels through a variety of geological conditions.
weir	A dam in a watercourse or sewer that alters and manages the flow.
works	All construction work associated with the construction of the Thames Tideway Tunnel project.

Appendix A

A.1 Risk of damage category for buildings

- A.1.1 The risk of damage to buildings classification system is based on a framework developed by Burland (1995). This framework appraises potential damage to buildings based upon the calculated tensile strains for a deep beam and relates these to the likely approximate crack widths and degrees of damage severity based upon ease of repair.
- A.1.2 Where an individual building does not fit within the Burland framework, consideration has been given to the applied displacements and the structural form of the building.

Table A.1 Building damage categorisation

Category of damage	Description of typical damage (<u>Ease of repair is underlined</u>)	Approx. crack width (mm)	ϵ_{lim} , Limiting tensile strain (%)
0 Negligible	Hairline cracks.	< 0.1	< 0.05
1 Very Slight	Fine cracks that can easily be treated during normal decoration. Perhaps isolated slight fracture in buildings. Cracks in external brickwork visible on inspection.	1	0.05 - 0.075
2 Slight	Cracks easily filled. Redecorating probably required. Several slight fractures showing inside of building. Cracks are visible externally and some repointing may be required externally to ensure weather tightness. Doors and windows may stick slightly.	5	0.075 - 0.15
3 Moderate	The cracks require some opening up and can be patched by a mason. Recurrent cracks can be masked by suitable linings. Repointing of external brickwork and possibly a small amount of brickwork to be replaced. Doors and windows sticking. Service pipes may fracture. Weather tightness often impaired.	5 - 15 or a number of cracks > 3	0.15 – 0.3
4 Severe	Extensive repair work involving breaking out and replacing sections of walls, especially over doors and windows. Windows and door frames distorted, floor sloping noticeably. Walls leaning and bulging noticeably, some loss of bearing in beams. Service pipes disrupted.	15 – 25 but also depends on number of cracks	> 0.3
5 Very severe	This requires a major repair job involving partial or complete rebuilding. Beams lose bearing, walls lean badly and require shoring. Windows broken due to distortion. Danger of instability.	Usually >25 but depends on number of cracks	
<p>Note: Crack width is only one factor in assessing category of damage and should not be used on its own as a direct measure of it.</p> <p>Note: Local deviation of slope, from the horizontal or vertical, of more than 1/100 will normally be clearly visible. Overall deviations in excess of 1/150 are undesirable.</p>			

This page is intentionally blank

Appendix B

B.1 Listed building: Additional evaluation criteria

Table B.1 Structural, heritage and condition scoring matrix for listed buildings

Score	STRUCTURE	HERITAGE FEATURES	CONDITION
	Sensitivity of the structure to ground movements and interaction with adjacent buildings	Sensitivity to calculated movement of particular features within the building	Factors which may affect the sensitivity of structural or heritage features
0	Masonry buildings with lime mortar and regular openings, not abutted by other buildings, and therefore similar to the buildings on which the original Burland assessment was based.	No particular sensitive features	Good - not affecting the sensitivity of structural or heritage features
1	Buildings not complying with categories 0 or 2, but still with some sensitive structural features in the zone of settlement e.g.: cantilever stone staircases, long walls without joints or openings, existing cracks where further movements are likely to concentrate, mixed foundations	Brittle finishes, e.g. faience or tight-jointed stonework, which are susceptible to small structural movements and difficult to repair invisibly.	Poor - may change the behaviour of a building in cases of movement. Poor condition of heritage features and finishes. Evidence of previous movement.
2	Buildings which, by their structural form, will tend to concentrate all their movements in one location (e.g.: a long wall without joints and with a single opening).	Finishes which if damaged will have a significant effect on the heritage value of the building, e.g. Delicate frescos, ornate plasterwork ceilings.	Very poor – parlous condition of heritage features and finishes, or severe existing damage to structure including evidence of ongoing movement. Essentially buildings which are close to collapse or where finishes are loose such that even very small movements could lead to significant damage.

Copyright notice

Copyright © Thames Water Utilities Limited January 2013.
All rights reserved.

Any plans, drawings, designs and materials (materials) submitted by Thames Water Utilities Limited (Thames Water) as part of this application for Development Consent to the Planning Inspectorate are protected by copyright. You may only use this material (including making copies of it) in order to (a) inspect those plans, drawings, designs and materials at a more convenient time or place; or (b) to facilitate the exercise of a right to participate in the pre-examination or examination stages of the application which is available under the Planning Act 2008 and related regulations. Use for any other purpose is prohibited and further copies must not be made without the prior written consent of Thames Water.

Thames Water Utilities Limited

Clearwater Court, Vastern Road, Reading RG1 8DB

The Thames Water logo and Thames Tideway Tunnel logo are © Thames Water Utilities Limited. All rights reserved.

DCO-DT-000-ZZZZ-072100

