Preliminary environmental information report

Volume 5: Assessment methodologies

Regulations 2 and 10 of the Infrastructure Planning (Environmental Impact Assessment) Regulations 2009
Phase two consultation documentation

General
- Your guide to phase two consultation
- Why does London need the Thames Tunnel?
- Feedback form
- Equalities form
- Customer overview leaflet

Project information papers
- Build
- Changes
- Consultation
- Design
- Environment
- Funding
- Managing construction
- Odour
- Options
- Overflow
- Regulatory framework
- Route and tunnel alignment
- Route to consent
- Settlement
- Site selection
- Timing
- Transport

Technical documents
- Air management plan
- Book of plans
- Code of construction practice
  Part A: General requirements
- Consultation strategy and statement of community consultation
- Design development report
- Draft waste strategy
- Interim engagement report
- Needs Report
- Phase two scheme development report
  • Preliminary environmental information report
    • Report on phase one consultation
    • Background technical paper
    • Site selection methodology paper

Site information papers
- Abbey Mills Pumping Station
- Acton Storm Tanks
- Albert Embankment Foreshore
- Barn Elms
- Beckton Sewage Treatment Works
- Bekesbourne Street
- Blackfriars Bridge Foreshore
- Carnworth Road Riverside
- Chambers Wharf
- Chelsea Embankment Foreshore
- Cremorne Wharf Depot
- Deptford Church Street
- Dormay Street
- Earl Pumping Station
- Falconbrook Pumping Station
- Greenwich Pumping Station
- Hammersmith Pumping Station
- Heathwall Pumping Station
- Jews Row
- King Edward Memorial Park Foreshore
- King George’s Park
- Kirtling Street
- Other works
- Putney Bridge Foreshore
- Shad Thames Pumping Station
- Victoria Embankment Foreshore
Thames Tunnel

Preliminary environmental information report

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Volume 8  Hammersmith Pumping Station CSO interception site
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Volume 10  Putney Bridge Foreshore CSO interception site
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Volume 12  King George’s Park CSO interception and connection tunnel reception site
Volume 13  Carnwath Road Riverside main tunnel drive and reception, and connection tunnel reception site
Volume 14  Falconbrook Pumping Station CSO interception site
Volume 15  Cremorne Wharf Depot CSO interception site
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Volume 17  Kirtling Street main tunnel double drive site
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<td>AOD</td>
<td>Above Ordnance Datum</td>
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<td>AQO</td>
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<td>ASR</td>
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<td>ASSI</td>
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<td>ATC</td>
<td>Automated Traffic Counter</td>
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<td>Above Tunnel Datum (defined at ~100m AOD)</td>
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<td>Control of Pollution Act</td>
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<td>CROW</td>
<td>Countryside and Rights of Way</td>
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<td>CSO</td>
<td>Combined Sewer Overflow</td>
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<tr>
<td>Abbreviation</td>
<td>Description</td>
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<tr>
<td>dB</td>
<td>Decibel</td>
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<tr>
<td>dB LAeq,T</td>
<td>A equivalent continuous A-weighted sound pressure level having the same energy as a fluctuating sound over a specified time period T</td>
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<td>Department for Culture, Media and Sport</td>
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<td>Development Consent Order</td>
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<td>DCLG</td>
<td>Department for Communities and Local Government</td>
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<td>DCMS</td>
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<td>Department of the Environment, Food and Rural Affairs</td>
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<td>DFT</td>
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<td>DMRB</td>
<td>Design Manual for Roads and Bridges</td>
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<td>DPD</td>
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<td>European Commission</td>
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<td>Ecological Impact Assessment</td>
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<td>eVDV</td>
<td>Estimated Vibration Dose Value</td>
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<td>Earth Pressure Balance</td>
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<tr>
<td>EPBM</td>
<td>Earth Pressure Balance Machine</td>
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<td>ES</td>
<td>Environmental Statement</td>
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<td>European Union</td>
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<tr>
<td>FAQ</td>
<td>Frequently Asked Questions</td>
</tr>
<tr>
<td>FIDOR</td>
<td>Frequency, Intensity, Duration, Offensiveness, Receptor</td>
</tr>
<tr>
<td>Acronym</td>
<td>Description</td>
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<td>FRA</td>
<td>Flood Risk Assessment</td>
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<td>General Aquifer Research Development and Investigation Team</td>
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<td>GI</td>
<td>Ground Investigation</td>
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<td>Greenspace Information for Greater London</td>
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<td>Geographical Information System</td>
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<td>Greater London Historic Environment Record</td>
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<td>GQA</td>
<td>General Quality Assessment (EA water quality classification)</td>
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<td>GSHP</td>
<td>Ground Source Heat Pump</td>
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<tr>
<td>GWB</td>
<td>Groundwater Body: distinct volume of groundwater within an aquifer or aquifers</td>
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<td>Ground Water Management Unit</td>
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<tr>
<td>H₂S</td>
<td>Hydrogen sulphide</td>
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<tr>
<td>ha</td>
<td>hectares</td>
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<td>Highways Authority</td>
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<td>Heavy Duty Vehicle</td>
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<td>Historic Environmental Assessment</td>
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<td>Historic Environment Record</td>
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<td>Heavy Goods Vehicle</td>
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<td>Headquarter</td>
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<td>Habitats Regulations Assessment</td>
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<td>Hammersmith Town Centre</td>
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<td>Hazardous Waste Regulations (2005)</td>
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<td>Institute of Ecology and Environmental Management</td>
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<td>IEMA</td>
<td>Institute of Environmental Management and Assessment</td>
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<td>Index of Multiple Deprivation</td>
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<td>IPC</td>
<td>Infrastructure Planning Commission</td>
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<td>Iron Age</td>
<td>600 BC – AD 43</td>
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<td>JNCC</td>
<td>Joint Nature Conservation Committee</td>
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<tr>
<td>kg</td>
<td>kilograms</td>
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<td>km</td>
<td>kilometre</td>
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<tr>
<td>kVA</td>
<td>kilo watt amperes</td>
</tr>
<tr>
<td>Abbreviation</td>
<td>Full Form</td>
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<tr>
<td>kW</td>
<td>kilowatt</td>
</tr>
<tr>
<td>l/d</td>
<td>litres per day</td>
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<tr>
<td>l/s</td>
<td>litres per second</td>
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<td>LA</td>
<td>Local Authority</td>
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<td>LAARC</td>
<td>London Archaeological Archive and Research Centre</td>
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<td>LAQM</td>
<td>Local Air Quality Management</td>
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<td>LAQN</td>
<td>London Air Quality Network</td>
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<td>LB</td>
<td>London Borough</td>
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<td>LBAP</td>
<td>Local Biodiversity Action Plan</td>
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<td>LDF</td>
<td>Local Development Framework</td>
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<td>Light Goods Vehicle</td>
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<td>LHA</td>
<td>Local Highway Authority</td>
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<td>LMB</td>
<td>Lambeth Mottled Beds</td>
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<td>LNR</td>
<td>Local Nature Reserve</td>
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<td>IoWR</td>
<td>List of Wastes Regulations 2005</td>
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<td>LSB</td>
<td>Lower Shelly Beds</td>
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<td>LtB</td>
<td>Laminated Beds</td>
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<tr>
<td>LTI</td>
<td>London Tideway Improvements</td>
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<tr>
<td>LTT</td>
<td>London Tideway Tunnels</td>
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<tr>
<td>LUL</td>
<td>London Underground Limited</td>
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<td>LVMF</td>
<td>London View Management Framework</td>
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<tr>
<td>m</td>
<td>metre</td>
</tr>
<tr>
<td>m AOD</td>
<td>metres above Ordinance Datum (see AOD)</td>
</tr>
<tr>
<td>m ATD</td>
<td>metres above temporary datum (see ATD)</td>
</tr>
<tr>
<td>m/s</td>
<td>metres per second</td>
</tr>
<tr>
<td>MAGIC</td>
<td>Multi-Agency Geographic Information for the Countryside</td>
</tr>
<tr>
<td>Mbgl</td>
<td>Metres below ground level</td>
</tr>
<tr>
<td>MEICA</td>
<td>Mechanical Electrical Instrumentation Controls Automation</td>
</tr>
<tr>
<td>Ml/d</td>
<td>Megalitres per day (million litres per day)</td>
</tr>
<tr>
<td>MoD</td>
<td>Ministry of Defence</td>
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<tr>
<td>MOL</td>
<td>Metropolitan Open Land</td>
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<td>MOLA</td>
<td>Museum of London Archaeology</td>
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<tr>
<td>NE</td>
<td>Natural England</td>
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<td>NESR</td>
<td>North East Storm Relief</td>
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<td>NCR</td>
<td>National Cycle Route</td>
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</table>
NGR    National Grid Reference
NMR    National Monuments Record
NNR    National Nature Reserve
NO₂    Nitrogen dioxide
NOₓ    Oxides of nitrogen
NPPF   National Planning Policy Framework
NPS    National Policy Statement
NRMM   Non Road Mobile Machinery
NSIP   Nationally Significant Infrastructure Project
NSRA   National Small-bore Rifle Association
NTS    Non Technical Summary
OCU    Odour Control Unit
Ofwat   The Water Services Regulations Authority
OS     Ordnance Survey
OUₑ    European Odour Unit
PAH    Polycyclic aromatic hydrocarbons
PCB    Polychlorinated Biphenyl
PEI    Preliminary Environmental Information
PEIR   Preliminary Environmental Information Report
PEL    Probable Effect Levels
PICP   Pollution Incident Control Plan
PIP    Project Information Paper
PLA    Port of London Authority
PM     Afternoon
PM₁₀   Particles on the order of ~10 micrometers or less
PPC    Pollution Prevention and Control
PPE    Personal Protective Equipment
PPG    Pollution Prevention Guidance
PPS    Planning Policy Statement
PPV    Peak Particle Velocity
PRoW   Public Rights of Way
PS     Pumping Station
pSPA   Potential Special Protected Area
PWS    Public Water Supply
RAMS   Risk Assessment Method Statement
RAMSAR  The Convention on Wetlands of International Importance
RB     Royal Borough
RBKC   Royal Borough of Kensington and Chelsea
RBMP   River Basin Management Plans
RDB    Red Data Book
RHS    Royal Horticultural Society
RPG    Regional Planning Guidance
RSPB   Royal Society for the Protection of Birds
RDB    Red data book
RTC    Real Time Control
RTD    River Terrace Deposits
SA     Sustainability Appraisal
SAC    Special Area of Conservation
SAM    Scheduled Ancient Monument. More commonly referred to as ‘Scheduled Monument’
SCI    Statement of Community Involvement
SCL    Sprayed Concrete Lining
SFRA   Strategic Flood Risk Assessment
SI     Statutory Instrument
SINC   Site of Importance for Nature Conservation
SMI    Site of Metropolitan Importance
SNCI   Site Nature Conservation Importance
SO₂    Sulphur dioxide
SoCC   Statement of Community Consultation
SPA    Special Protection Area
SPD    Supplementary Planning Document
S-P-R  Source-pathway-receptor
SPZ    Source Protection Zone
SR     Storm Relief
SRN    Strategic Road Network
SSR    Site Suitability Report
SSSI   Site of Special Scientific Interest
STW    Sewage Treatment Works
SUDS   Sustainable (Urban) Drainage Systems
SWMP   waste - Site Waste Management Plan
<table>
<thead>
<tr>
<th>Acronym</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>WWT</td>
<td>Wildfowl and Wetlands Trust</td>
</tr>
<tr>
<td>ZTV</td>
<td>Zone of Theoretical Visibility</td>
</tr>
<tr>
<td>ZVI</td>
<td>Zone of Visual Influence</td>
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</tbody>
</table>
1 **Introduction**

1.1.1 This volume sets out both the general assessment methodology and the specific methodologies for assessing each environmental topic included in this report. These are set out in alphabetical order and for each topic describe the following:

a. Information on specific Scoping Opinions and technical engagement relevant to environmental topics, with cross references to Volume 4 where necessary

b. the baseline data collection methodology for both desk and field based studies

c. the assessment methodology including assumptions and limitations for construction, operational, cumulative, in combination and project-wide effects

d. the approach taken to mitigation

1.1.2 This volume includes the full EIA methodology for the assessment of effects associated with the Thames Tunnel project. Work which has not been fully completed for the PEIR will be completed for the ES, and this is noted where necessary in this volume, and within each site specific assessment volume.

1.1.3 Following this introduction the volume includes the following sections:

a. general environmental assessment methodology, including information on:
   i. the approach to baseline data collection,
   ii. the assessment cases, years and areas,
   iii. assessment of effects terminology and definitions
   iv. the approach to assessing effects
   v. significance criteria
   vi. mitigation
   vii. project-wide assessment
   viii. outstanding actions for the ES

b. topic specific assessment methodology, including:
   i. how Scoping Opinions and technical engagement have specifically informed the topic
   ii. baseline data collection methodology
   iii. assessment methodology, including construction and operational effects, cumulative, in combination and compound effects, project-wide effects
   iv. assumptions and limitations
   v. approach to mitigation, for the following topics:

c. ecology – aquatic
d. ecology – terrestrial  
e. historic environment  
f. land quality  
g. noise and vibration  
h. socio-economics  
i. townscape and visual  
j. transport  
k. water resources – groundwater  
l. water resources – surface water  
m. water resources – flood risk (this does not follow the standard topic structure as it reflects the approach adopted for a flood risk assessment as opposed to an environmental assessment)
2 General assessment approach

2.1 Introduction

2.1.1 The proposed Environmental Impact Assessment (EIA) methodology has been developed in line with the requirements of the 2011 EIA Regulations (Town and Country Planning Act 1999) and the 2009 EIA Regulations (Planning Act, 2008), and guidance associated with both.

2.1.2 Both the 2011 EIA Regulations and the 2009 EIA Regulations state that the ES must describe the likely significant effects of the project on aspects of the environment, including:

a. human beings
b. fauna
c. flora
d. soil
e. water
f. air
g. climatic factors
h. material assets (including the architectural and archaeological heritage)
i. landscape
j. the inter-relationships between the above factors.

2.1.3 The methodologies for the assessments provided in this volume vary from topic to topic. In general, however, all of the assessments will involve a process of interaction between engineering design, planning and environmental considerations to ensure that mitigation measures are considered and wherever possible incorporated in the project. Throughout the design process, attention will be paid to minimising adverse effects on the environment during construction and operation. The project will incorporate wherever possible, measures to prevent adverse effects arising and seek to maximise likely beneficial effects.

2.1.4 The following sub-sections describe the general approach to baseline data collection, assessment cases, assessment years, the types of effect and mitigation that will be adopted throughout the EIA. Important terminology is clearly defined.

2.2 Baseline data collection

2.2.1 Prior to undertaking the impact assessments for each topic the baseline environmental conditions have been identified.

2.2.2 A wide range of information about the existing environment has been obtained from observations made on-site, field surveys, information provided by consultees and desk based information. This allows the existing environmental resources present to be identified and evaluated.
2.2.3 Baseline data collection for the EIA process is still underway. This report includes details of desk based data review, supported by site visits undertaken where appropriate, and survey data collection that has been completed to date.

2.2.4 Sufficient information and data have been obtained from the various sources to allow the preliminary findings of the assessment presented to be robust.

2.2.5 The new data arising from the completion of the ongoing surveys will be taken into account in the ongoing EIA and presented in the ES.

2.3 **Assessment cases**

**Base case**

2.3.1 The base case for assessment is a future case, without the project in any particular assessment year (ie, a ‘do-nothing’ case). Whilst the existing baseline data which is collected forms a ‘current baseline’, it is important within the EIA to consider how the environment is likely to change, in any event, in the absence of the project. For example terrestrial ecological habitats are likely to change over time (through habitat ‘succession’) and traffic levels typically increase year-on-year. The base case (a future year scenario) will be predicted as accurately as is possible to ensure the robustness of the subsequent assessment.

2.3.2 Data validity periods will be carefully evaluated across all topics as a routine part of the assessment process.

**Development case**

2.3.3 A development case is a future case during the construction or operation of the project in the same assessment year as the equivalent base case (ie, a ‘do-something’ case). The assessments will usually consider the ‘development case’ compared with the ‘base case’ in any particular assessment year (see below).

**Assessment years**

**Assessment year: construction**

2.3.4 It is currently anticipated that the overall construction programme will last from 2015 to 2022 (enabling construction will start in construction Year 1). However, the assessment year (or years) for the assessment of construction impacts at any one site varies since the peak in construction activities varies from site to site. The appropriate assessment year for each site will be identified utilising relevant best practice guidance, professional judgement and discussion with statutory consultees.

2.3.5 Where project-wide or cumulative construction effects are assessed, it has been necessary to identify the overall peak in construction activities across all sites between Year 1 and Year 6. The worst case scenarios considered for these effects are discussed where relevant.

**Assessment year: operation**

2.3.6 The assessment year of operation will be Year 1, the first full normal 12 months of operation (excluding any commissioning period).
Other additional assessment years

2.3.7 Some topics may require additional future assessment years, including:

a. Townscape and visual: year of operation plus 15 years – to assess a situation in which any mitigation planting has had the time to become established.

b. Water resources (surface water): year of operation plus 60 years – to assess a situation when the impacts of climate change on rainfall and river temperature are taken into account.

Spatial scope of assessment

2.3.8 The spatial scope of the study areas has been identified under each of the environmental assessment topics.

2.4 Effects

2.4.1 It is important to identify the total effects arising from the project. While there are predicted to be particular site specific effects associated with the proposed assessment topics, the assessment also considers the potential significant overall project-wide, cumulative effects, in combination and compound effects (adverse and beneficial) arising at or in the vicinity of sites, and across the project. The assessment considers all types of effects as required by the 2009 EIA Regulations, comprising:

a. direct and indirect effects
b. short term (less than 12 months), medium term (1 to 5 years) and long-term (+ 5 years) effects
c. permanent and temporary effects
d. cumulative effects
e. beneficial and adverse effects.

2.4.2 The 2009 EIA Regulations also refer to secondary effects; these are encapsulated under indirect effects, above.

2.4.3 Two main categories of effects are assessed, namely construction effects and operational effects. For this project the majority of potential adverse significant effects will be experienced during construction and the potential beneficial significant effects will be experienced during operation. For each phase, construction and operation of the project, these effects have been considered at a site specific and at a project-wide level. This is discussed further below.

2.4.4 No combined construction and operational phase is envisaged during the project (ie, the project will be constructed before any operational activity).

2.4.5 No decommissioning stage is envisaged.

Construction phase assessment of effects

2.4.6 The construction phase assessment considers effects which arise during enabling works and main project works. This includes the temporary, construction specific activities and works such as construction traffic and
temporary haul roads. It also includes an assessment of effects which although arising during the construction phase, will result in permanent works, such as the construction of shafts and the tunnel, and ventilation structures.

2.4.7 Construction phase effects on receptors will be managed through the implementation of a Code of Construction Practice (CoCP), which will form an Appendix to the ES.

2.4.8 A draft CoCP is appended to Volume 2.

**Operational phase assessment of effects**

2.4.9 The operational phase assessment assesses the effects which arise during the operational phase of the project. These effects may arise due to the presence of the new infrastructure including new above ground buildings and structures, and the tunnels and shafts below ground, and the associated activities. These effects can also arise due to operation of the tunnel and related infrastructure (eg, reduced discharges) and operational maintenance activities.

**Site specific effects**

2.4.10 Site specific effects arise at or near discrete Thames Tunnel sites. Most of the effects which arise as a result of the project are expected to be site specific since the project needs to be delivered using a number of discrete construction sites across London. These discrete sites will continue to have an operational function during the operational phase of the project.

2.4.11 Where relevant, the assessment of site specific effects includes consideration of upstream and downstream effects, in line with the spatial scope of each assessment identified by each EIA topic.

**Project-wide effects**

2.4.12 Project-wide effects arise at or near discrete sites but are also typically more wide-ranging, generally because of the nature of the impacts and the extensive nature of the receptors. In some cases the effects might be synonymous with cumulative effects (eg, beneficial effect on water quality from reduction in CSO spill frequency) and/or compound / in combination effects (see below).

2.4.13 The individual technical approaches to the assessment of project-wide effects are addressed in this report where sufficient information is available. Where no specific project-wide approach is identified, any assessment of these effects will follow the approach used for the main site assessments.

**Cumulative effects**

2.4.14 Cumulative effects arise at a site from the accumulation of effects from a single Thames Tunnel site, plus other non Thames Tunnel sites.

2.4.15 An assessment will be undertaken of the effects likely to result from the project in parallel with any number of other developments. This includes consideration of other relevant projects under construction, with planning
permission or where there is a strong likelihood that a project will come forward for development during the construction or operation of the project.

2.4.16 Cumulative effects could arise within most technical topics and will depend on the proximity of other developments to the relevant site or sites under consideration. The following major London-wide projects are illustrative (not limited to) of the types of project which will require consideration in relation to cumulative effects:

a. Crossrail
b. various utilities tunnels
c. Thameslink
d. High Speed Rail 2.

2.4.17 Where relevant, potential cumulative effects arising at sites are identified in the site specific assessments included in Volumes 7 to 28. Major developments, both existing and planned, in the vicinity of each site, have been incorporated into the future baselines that are being used as part of the assessment. This allows the effects of the project to be assessed cumulatively with other major local developments.

2.4.18 The assessment of cumulative effects is underway but not suitably advanced for all topics for consideration in this report. Where the assessment of cumulative effects is suitably advanced, this report includes initial assessment outcomes.

2.4.19 The ES will include full details of the cumulative assessment methodology and outcomes.

**In combination effects**

2.4.20 In combination effects refer to Thames Tunnel project effects only and may be site specific, or project-wide. In combination effects describe the consequence of combining effects from more than one topic on specific receptors, e.g., noise, dust and visual amenity effects on local residents alone may not be significant separately, but in combination may be of greater significance.

2.4.21 The assessment of in combination effects is underway but not suitably advanced for all topics for consideration in this report. Where preliminary environmental information on potential in combination effects arising is available it is presented in the project-wide (Volume 6) and site specific assessments presented in Volumes 7 to 28.

2.4.22 The ES will include full details of the in combination assessment methodology and outcomes.

**Compound effects**

2.4.23 Compound effects are those topic specific effects that may not be significant when assessed within a single site but when combined (or compounded) by the same effect occurring at more than one nearby Thames Tunnel site the effect is of greater significance.
2.4.24 The assessment of compound effects is underway but not suitably advanced for all topics for consideration in this report. Where preliminary environmental information on potential compound effects arising is available it is presented in the project-wide (Volume 6) and site specific assessments presented in Volumes 7 to 28.

2.4.25 The ES will include full details of the in combination assessment outcomes.

**Transboundary effects**

2.4.26 Regulation 24 of the 2009 EIA Regulations requires that the IPC should notify other European Economic Area (EEA) States and publicise an application if the IPC is of the view that the proposed development is likely to have a significant effect on the environment of another EEA Member State.

2.4.27 It is considered unlikely that the proposed development will result in any significant effects on the environment of another EEA Member State. Therefore transboundary effects have not been considered.

**Significance criteria**

2.4.28 In order to allow comparison of effects to be made across the extent of the project and to allow a robust assessment of project-wide effects to be clearly understood, a series of generic significance criteria descriptors has been developed.

2.4.29 The actual criteria used for the individual topic assessments are specific to each topic although based on the generic significance criteria. The criteria are based on established standards appropriate to each of the topics assessed. Where topic specific guidance stipulates other criteria to be applied, this is explained in the methodology for that topic. Also, if topic specific national limiting values apply then these override the generic significance criteria.

2.4.30 The table below is a generic significance criteria matrix that has been used, or adapted for individual topic assessments, in order to determine the significance of effects:
Vol 5 Table 2.4.1 Generic significance matrix

<table>
<thead>
<tr>
<th>Impact magnitude</th>
<th>Receptor value/sensitivity</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>High</td>
</tr>
<tr>
<td>High</td>
<td>Major adverse</td>
</tr>
<tr>
<td>Medium</td>
<td>Major adverse</td>
</tr>
<tr>
<td>Low</td>
<td>Moderate adverse</td>
</tr>
<tr>
<td>Negligible</td>
<td>Minor adverse</td>
</tr>
</tbody>
</table>

Notes:
1. For some topics, the relevant professional bodies prefer approaches which only identify ‘Significant’ or ‘Not significant’ effects (rather than a graded scale of significance). In this case the red shaded area will represent ‘Significant effects’, and the green shaded area represents ‘Not significant effects’.
2. There is a mirror of this relating to beneficial effects (Major, Moderate, Minor) but this is not shown.

2.5 Approach to mitigation

2.5.1 Mitigation opportunities can be identified at any stage in the evolution of a scheme. The EIA process feeds into an iterative design process that has been, and continues to be, used to help refine the project, with the objectives of avoiding and reducing adverse environmental effects.

2.5.2 Mitigation measures are being incorporated into the design so far as possible. A Code of Construction Practice is being developed (see Volume 2, Appendix A for the current draft CoCP), and environmental design considerations have been incorporated in the phase two preferred scheme.

2.5.3 Mitigation measures have generally been identified by regularly reviewing the emerging preliminary likely environmental effects arising from the ongoing assessment process, and discussing these at regular project design workshops. Where practicable and economic, design adjustments have already been made to project.

2.5.4 The mitigation measures that have been incorporated within the project, and the CoCP, to date are the environmental design measures. Likely significant effects and associated potential environmental response measures that have not been addressed in the project to date are outstanding mitigation measures. As the design is refined through the ongoing environmental assessment process, involving regular iteration between the engineering design and environmental assessment process, more outstanding mitigation measures are captured within the evolving design.

2.5.5 Summaries of the environmental design elements already utilised in the project are included in the proposed development section of the PEIR site assessment Volumes 7 to 28.

2.5.6 Where residual effects remain after the proposed mitigation has been applied, these will be clearly identified.
2.5.7 The site assessments presented in Volumes 7 to 28 of this report identify the mitigation principles that are likely to be applicable. Where necessary, detailed mitigation proposals will be developed as part of the EIA process and included within the ES.

2.5.8 Where there are opportunities created by the project to improve environmental conditions (over and above the baseline condition), these will be identified as enhancement.
3 Air quality and odour

3.1 Introduction

3.1.1 This section sets out the full EIA methodology for the assessment of air quality and odour effects associated with the Thames Tunnel project. Work which has not been fully completed for the PEIR will be completed for the ES, and this is noted below and within each site specific assessment volume.

3.1.2 The methodologies outlined in this section are applied to all sites, unless otherwise indicated.

3.1.3 The local air quality assessment examines the effects of the project during construction arising from road transport, plant and equipment (compressors, generators, cranes, etc), and where relevant, river barges. The local air quality assessment also includes a construction dust assessment.

3.1.4 For the assessment of operational effects, an odour assessment has been undertaken which assesses emissions from the ventilation structures at the Thames Tunnel sites. Operational transport effects have been scoped out from the assessment of air quality due to the very limited number of maintenance visits required and hence the low number of vehicular movements.

3.1.5 The local air quality assessment is dependent on data, some of which have not yet been finalised. Therefore, the proposed methodologies for the EIA have been described in this section, but, for the purposes of the PEIR, qualitative assessment using professional judgement has been used to predict the likely effects of some aspects at this stage. In the ES, quantitative assessments using the methodologies outlined in this section will be reported.

3.1.6 It has been possible to undertake full assessments for construction dust and odour. The qualitative construction dust assessment has been undertaken in accordance with the best practice guidance produced by Greater London Authority (GLA) while a quantitative assessment, using dispersion modelling, has been employed for the odour assessment.

3.2 Scoping Opinions and technical engagement

3.2.1 A summary of scoping and stakeholder engagement undertaken in relation to air quality and odour is provided in Volume 4, Sections 3.3 and 3.4.

3.3 Baseline data collection methodology

Local air quality

3.3.1 The local air quality assessment requires both the collection of existing local monitoring data and the establishment of a local monitoring network to supplement the monitoring undertaken by local authorities. These data

---

1 A local air quality assessment usually involves the prediction of concentrations within short distances of relevant emissions sources (typically 200m) and is characterised by pollutants with immediate impacts, which are generally defined by the UK air quality objectives and the EU Limit values.
provide both a baseline position for air pollutant concentrations and sufficient data for the verification of the modelling work for the local air quality assessment for the construction phase.

3.3.2 In addition, local authority review and assessment work has been evaluated in relation to each site. This work provides a context for the baseline situation and informs the assessment of the major pollutant sources in the vicinity of each site.

3.3.3 Sensitive receptors for the assessment will be selected on a site-specific basis and will be presented as part of the baseline for each site.

**Construction dust**

3.3.4 Receptors are also selected for the purposes of the construction dust assessment which is undertaken as part of the baseline. These receptors are selected in accordance with Vol 5 Table 2.4.1 and their proximity to sources of dust.

3.3.5 In addition, monitoring of particulate concentrations is required to provide a baseline for the monitoring that will be undertaken during construction. This monitoring will be undertaken for at least 12 months prior to construction at all sites. These data would provide a baseline for the monitoring undertaken during the construction phase of the tunnel. The monitoring data will not be available to form part of the PEIR or the ES (not needed for the assessment which is qualitative rather than quantitative), but the methodology is outlined in para. 3.3.17.

**Odour**

3.3.6 The principal baseline data for the odour assessment is qualitative odour complaint data in the vicinity of the sites. These data indicate whether there are existing odour issues in the vicinity of any of the sites that warrant further investigation to identify potential sources. Baseline hydrogen sulphide monitoring is also being undertaken at all sites (in August 2001 with repeat monitoring to be undertaken in Autumn 2011).

**Desk based baseline data**

**Local air quality**

3.3.7 Monitoring data for nitrogen dioxide (NO₂) and particulate matter (PM₁₀) have been collected from local authorities. These data have been sourced through direct consultation, local authority websites and the London Air Quality Network (LAQN). These data have been collected for the last four years (where available) to provide an indication of historical trends at the monitoring site. The 2010 data will be used for the verification of the modelling work.

3.3.8 Background data have also been collected from the air quality section of the Defra website. These data will be used in conjunction with local monitoring to provide background concentrations for the modelling.

3.3.9 Selected receptors can be ranked in terms of their sensitivity based on the exposure and vulnerability of the receptor.
3.3.10 The sensitivity of the selected receptors for the assessment is based on Defra guidance LAQM.TG(09)\textsuperscript{2} which uses the criteria detailed in the table below.

**Vol 5 Table 3.3.1 Air quality – local sensitive receptors**

<table>
<thead>
<tr>
<th>Receptor value and/or sensitivity</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>Residential properties, hospitals and clinics, retirement homes, schools, food processing, libraries, community facilities</td>
</tr>
<tr>
<td>Medium</td>
<td>Hotels, gardens of residential properties, vegetation, parks, playgrounds, places of worship</td>
</tr>
<tr>
<td>Low</td>
<td>Busy pedestrian areas such as shopping areas, unenclosed areas of bus and rail stations</td>
</tr>
</tbody>
</table>

**Construction dust**

3.3.11 In accordance with the Design Manual for Roads and Bridges\textsuperscript{3}, the closest receptors within 200m of any areas of construction are identified. In determining the sensitivity/value of receptors, consideration is given to the dust sensitive receptor listings detailed below.

**Vol 5 Table 3.3.2 Air quality - dust sensitive receptors**

<table>
<thead>
<tr>
<th>Receptor value and/or sensitivity</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>Hospitals and clinics, retirement homes, hi-tech industries, painting, furnishing food processing</td>
</tr>
<tr>
<td>Medium</td>
<td>Food retailers, schools, residential areas, parks, playgrounds, hotels, greenhouses and nurseries, horticultural land, offices, vegetation, places of worship</td>
</tr>
<tr>
<td>Low</td>
<td>Farms, light and heavy industry, outdoor storage</td>
</tr>
</tbody>
</table>

**Odour**

3.3.12 Odour complaints for the area in the vicinity of each site have been collected from the local authorities. In addition, complaints registered with Thames Water have been collated.

3.3.13 Relevant receptors for the odour assessment have also been identified and their sensitivity determined in Vol 5 Table 3.3.3. The odour criterion set by the draft national policy statement (NPS) on wastewater\textsuperscript{4} applies in areas where people are likely to be exposed such as housing, schools and hospitals. These types of properties are deemed to be of high sensitivity. Medium sensitivity receptors would be areas where people are likely to be exposed over short periods such as recreational areas or in the workplace. Low sensitivity receptors would be in areas where there is infrequent human exposure such as footpaths and roads.
Vol 5 Table 3.3.3 Odour - receptor sensitivity criteria

<table>
<thead>
<tr>
<th>Receptor value and/or sensitivity</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>Housing, pub/hotels, schools, hospitals</td>
</tr>
<tr>
<td>Medium</td>
<td>Industrial or commercial workplaces, recreational areas, places of worship</td>
</tr>
<tr>
<td>Low</td>
<td>Areas where individuals are exposed for a very short period of time such as footpaths and roads</td>
</tr>
</tbody>
</table>

Note: Adapted from EA’s odour management (April 2011) and draft NPS on waste water

Field survey baseline data

Local air quality

3.3.14 In addition to the monitoring collected by the local authorities as part of their duties under the local air quality management regime, baseline monitoring has been established at all the proposed sites. The locations of the monitoring sites are included in the site-specific assessment volumes (Volumes 7-28). The monitoring is employing diffusion tubes to measure monthly mean NO2 concentrations. A triplicate site has been established next to a continuous monitoring station in Putney for bias adjustment purposes. The monitoring started in April/May 2011 and the results will be included in the ES.

3.3.15 As the quantitative assessment of local air quality is likely to be undertaken in 2011, it will not be possible to collect a full year’s worth of monitoring data prior to this assessment. Therefore, following bias adjustment using the co-located diffusion tubes, the results will be seasonally adjusted to estimate annual mean NO2 concentrations. Mean concentrations, for the period covered by the diffusion tubes, and annual mean concentrations will be collated from four nearby background continuous monitoring sites measuring NO2 and with data capture rates greater than 90%. The average of the ratios between the period and annual means will be used to calculate the seasonal adjustment factor, which will then be applied to all monitoring undertaken for the project.

Construction dust

3.3.16 Monitoring of background dust levels and particulates would be undertaken in the year prior to any construction activity to provide a baseline. This monitoring would last for 12 months. Subsequent particulate and dust monitoring would then be undertaken during the construction period using the same methodology.

3.3.17 The methodology for this monitoring will be in accordance with the GLA Best Practice Guidance¹. This will entail monitoring a transect across the construction site using light-scattering monitors. This monitoring will also be located close to the most sensitive receptors where at all possible. These monitors can measure a range of particulate fractions from PM₁ to PM₃₀. There will be real-time access to the data on an appropriate
3.4 **Assessment methodology**

**General**

**Legislation and guidance**

3.4.1 The assessment methodology has been developed using relevant legislation and air quality guidance documents. This includes the following:

a. Environment Act
c. The Air Quality Standards Regulations 2010
e. Air Quality Framework Directive 96/62/EC
f. Air Quality Directive 2008/50/EC
g. The Non-Road Mobile Machinery Regulations 1999 and Amendment Regulations 2005
h. Clean Air Act (1993)
i. Best Practice Guidance: Control of Dust and Emissions from Construction and Demolition
j. Minerals Policy Statement
k. Design Manual for Roads and Bridges (DMRB), Volume 11, Section 3, Part 1
l. BRE Control of Dust from Construction and Demolition Activities
m. CIRIA Environmental Good Practice on Site.

**Local air quality**

3.4.2 The provisions of Part IV of the Environment Act 1995 establish a national framework for air quality management, which requires all local authorities in England, Scotland and Wales to conduct local air quality reviews. Section 82(1) of the Act requires these reviews to include an assessment of the current air quality in the area and the predicted air quality in future years. Should the reviews indicate that the objectives prescribed in the Defra Air Quality Strategy are not achieved, the local authority is required to designate an Air Quality Management Area (AQMA). Action must then be taken at a local level to ensure that air quality in the area improves. This process is known as ‘local air quality management’.

3.4.3 The air quality objectives applicable to local air quality management (LAQM) in England are set out in the Air Quality (England) Regulations 2000 and the Air Quality (England) (Amendment) Regulations 2002.
3.4.4 The Air Quality Framework Directive (96/62/EC) on ambient air quality assessment and management defines the European Union (EU) policy framework for 12 air pollutants known to have a harmful effect on human health and the environment. The mandatory limit values for the pollutants were set through a series of Daughter Directives. The limit values for nitrogen dioxide and particulate matter have recently been amalgamated with those for other pollutants into a new air quality directive (Directive 2008/50/EC of the European Parliament and of the Council of 21 May 2008 on ambient air quality and cleaner air for Europe) that came into force in June 2008, and has recently been transposed into national legislation (The Air Quality Standards Regulations 2010 SI 2010 No.1001).

3.4.5 The local air quality assessment focuses on the two main pollutants of concern: NO₂ and PM₁₀. The majority of the sites are in AQMAs for these two pollutants. Exceedences of the other air quality objectives and limit values are considered to be very unlikely and are therefore not considered in the assessment. The only other pollutant considered is NOx which is considered at the Barn Elms site only due to the proximity of the site access road to the Barn Elms Wetland Centre SSSI.

3.4.6 The objectives and limit values for NO₂ and PM₁₀ are shown in Vol 5 Table 3.4.1. This table shows the objectives and limit values in units of microgrammes per cubic metre (µg/m³). The table below includes the number of permitted exceedences in any given year (where applicable).

**Vol 5 Table 3.4.1 Air quality objectives/limit values – NOx, NO₂ and PM₁₀**

<table>
<thead>
<tr>
<th>Pollutant</th>
<th>Concentration</th>
<th>Measured as</th>
<th>Date to be achieved by</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nitrogen dioxide (NO₂) objective</td>
<td>200µg/m³ not to be exceeded more than 18 times a year</td>
<td>1-hour mean</td>
<td>31.12.2005</td>
</tr>
<tr>
<td></td>
<td>40µg/m³</td>
<td>Annual mean</td>
<td>31.12.2005</td>
</tr>
<tr>
<td>Nitrogen dioxide (NO₂) limit value</td>
<td>200µg/m³ not to be exceeded more than 18 times a year</td>
<td>1-hour mean</td>
<td>01.01.2010</td>
</tr>
<tr>
<td></td>
<td>40µg/m³</td>
<td>Annual mean</td>
<td>01.01.2010</td>
</tr>
<tr>
<td>Particles (PM₁₀) (gravimetric) objective</td>
<td>50µg/m³, not to be exceeded more than 35 times a year</td>
<td>24-hour mean</td>
<td>31.12.2004</td>
</tr>
<tr>
<td></td>
<td>40µg/m³</td>
<td>Annual mean</td>
<td>31.12.2004</td>
</tr>
<tr>
<td>Particles (PM₁₀) (gravimetric) limit value</td>
<td>50µg/m³, not to be exceeded more than 35 times a year</td>
<td>24-hour mean</td>
<td>01.01.2005^</td>
</tr>
<tr>
<td></td>
<td>40µg/m³</td>
<td>Annual mean</td>
<td>01.01.2005^</td>
</tr>
</tbody>
</table>
### Preliminary environmental information report

<table>
<thead>
<tr>
<th>Pollutant</th>
<th>Concentration</th>
<th>Measured as</th>
<th>Date to be achieved by</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nitrogen oxides (NOx) vegetation objective</td>
<td>30µg/m³</td>
<td>Annual mean</td>
<td>19.07.2001*</td>
</tr>
<tr>
<td>Nitrogen oxides (NOx) vegetation limit value</td>
<td>30µg/m³</td>
<td>Annual mean</td>
<td>01.01.2001*</td>
</tr>
</tbody>
</table>

*Time extension granted for Greater London until 11.06.11

The limit value applies only to locations more than 20km from towns with more than 250,000 inhabitants or more than 5km from other built-up areas, industrial installations or motorways. The policy of the UK statutory nature conservation agencies is to apply the 30µg/m³ criterion in internationally designated conservation sites and SSSIs on a precautionary basis.

#### 3.4.7 This work is undertaken in line with methodologies outlined in the Defra guidance LAQM.TG(09)² and the Design Manual for Roads and Bridges³.

### Construction plant

#### 3.4.8 Directive 97/68/EC (emission of gaseous and particulate pollutants from internal combustion engines to be installed in non-road mobile machinery) was first adopted in 1997. The Directive requires all engines for use in non-road mobile machinery to be sold in the EU to clearly demonstrate compliance with the Directives pollutant emission limits. The key driver for the Directive stemmed from an EC policy aimed at harmonising national arrangements of Member States, and in doing so removing possible trade barriers. Directive 97/68/EC has been subsequently amended by 2001/63/EC and 2004/26/EC.

#### 3.4.9 The Directive was imposed into UK law through the "Non-Road Mobile Machinery (Emission of Gaseous and Particulate Pollutants) Regulations 1999" (Statutory Instrument No. 1999/1053), subsequently amended as shown in the table below. The Regulations apply to new engines to be installed in non-road mobile machinery, intended and designed to move, or to be moved on the ground, either on or off the road.

**Vol 5 Table 3.4.2 Air quality - EU directive and UK regulations amendments**

<table>
<thead>
<tr>
<th>Directive</th>
<th>Subsequent UK Regulations</th>
<th>Scope</th>
</tr>
</thead>
</table>
3.4.10 Since the Directive came into force, tighter emissions controls have been progressively applied to diesel engine machinery in various power bands between 18kW and 560kW. The relevant emissions standards are based on levels of particulate matter, nitrogen oxides, hydrocarbons and carbon monoxide. The standards vary according to equipment type and engine size. The table below illustrates the standard for non-mobile machinery. Stage IIIA comes into force between 2006 and 2011; stage IIIB between 2010 and 2012; and stage IV between 2013 and 2014.

### Vol 5 Table 3.4.3 Air quality - EU emission directives for diesel machinery

<table>
<thead>
<tr>
<th>Category</th>
<th>Net power [kW]</th>
<th>NOx [g/kWh]</th>
<th>PM [g/kWh]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stage IIIA (V- variable speed, C-constant speed)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>H (V)</td>
<td>130 ≤ P &lt; 560</td>
<td>NOx + HC: 4.0</td>
<td>0.2</td>
</tr>
<tr>
<td>H (C)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I (V)</td>
<td>75 ≤ P &lt; 130</td>
<td>NOx + HC: 4.0</td>
<td>0.3</td>
</tr>
<tr>
<td>I (C)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>J (V)</td>
<td>37 ≤ P &lt; 75</td>
<td>NOx + HC: 4.7</td>
<td>0.4</td>
</tr>
<tr>
<td>J (C)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Preliminary environmental information report

**Category** | **Net power [kW]** | **NOx [g/kWh]** | **PM [g/kWh]**
--- | --- | --- | ---
K (V) | $19 \leq P < 37$ | NOx + HC: 7.5 | 0.6
K (C) | | | |

**Stage IIIB**

| Category | **Net power [kW]** | **NOx [g/kWh]** | **PM [g/kWh]** |
--- | --- | --- | ---
L | $130 \leq P < 560$ | 2.0 | 0.025
M | $75 \leq P < 130$ | 3.3 | 0.025
N | $37 \leq P < 75$ | 3.3 | 0.025
P | $19 \leq P < 37$ | NOx + HC: 4.7 | 0.025

**Stage IV**

| Category | **Net power [kW]** | **NOx [g/kWh]** | **PM [g/kWh]** |
--- | --- | --- | ---
Q | $130 \leq P < 560$ | 0.4 | 0.025
R | $56 \leq P < 130$ | 0.4 | 0.025

*Note: for diesel fuelled non-road machinery*

3.4.11 Replacement engines must meet the emissions requirements in place at the time the machinery was originally put into service.

**Odour**

3.4.12 Odour can be caused by a mix of chemicals in gaseous form or a single chemical. As the individual constituents of the odour may not be known, it is practical to use a descriptor that allows for this. The European odour unit (ouE) is widely used for this purpose and describes the strength of an odour. One European odour unit (1ouE/m³) is the concentration at which half of the people on an odour panel can detect the odour. The strength of an odour in odour units is defined as the number of times a sample needs to be diluted with odour free air to reach a point at which half of the people on an odour panel can detect the odour. The odour panel sampling (olfactometry) is carried out in laboratory conditions where odours are more noticeable than in real world conditions.

3.4.13 Whether or not odour emissions cause a problem depends on a number of factors. There is no single method of reliably measuring or assessing odour pollution and any conclusion is best based on a number of pieces of evidence. The Environment Agency has produced (in odour management guidance) the FIDOR acronym as a useful reminder of some of the odour factors that will determine the severity of an odour. The acronym is explained in the table below.

---

*The European odour unit (ouE) is the amount of odorant that when evaporated into one cubic metre of neutral gas at standard conditions, elicits a physiological response from an odour panel equivalent to that elicited by one European Reference Odour Mass (EROM) evaporated in one cubic metre of neutral gas at standard conditions. 1 EROM is 123 µg of n-butanol which produces a concentration of 40 ppb. Standard CEN EN 13725:2003 describes the measurement of odour concentrations by dynamic olfactometry.*
Vol 5 Table 3.4.4 Odour - FIDOR factors determining offensiveness

<table>
<thead>
<tr>
<th>FIDOR</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency</td>
<td>How often an individual is exposed to odour. Even an odour that is inoffensive can be perceived as a nuisance if exposure is frequent. At low concentrations a rapidly fluctuating odour is more noticeable than a steady background, ie, is an aggravating factor.</td>
</tr>
<tr>
<td>Intensity</td>
<td>The perceived strength of the odour is proportional to concentration. The intensity is often assessed in terms of odour units. For new proposals, it can be assessed by dispersion modelling. The human nose responds to odour exposure over a one to five second interval. Average exposure levels may very well be below the detection threshold but still expose people to short-term concentrations which are much higher.</td>
</tr>
<tr>
<td>Duration</td>
<td>The length of a particular odour event. This is mainly determined by the frequency of emissions and wind direction.</td>
</tr>
<tr>
<td>Offensiveness</td>
<td>Relative character. Some odours are generally regarded as more unpleasant than others. Odour from sewage is regarded as being one of the most offensive.</td>
</tr>
<tr>
<td>Receptor</td>
<td>The characteristics of the neighbourhood where the odour occurs. Some receptors are more sensitive than others. Domestic residences, or a pub with a beer garden, are more likely to be sensitive than an industrial complex or passers-by. The degree of pollution increases with the size of the exposed population.</td>
</tr>
</tbody>
</table>

3.4.14 The Environment Agency’s H4 odour management guidance⁹ advises that modelling can be a useful source of predictive information to assess the likely impact of odour. The benchmark modelling method commonly used in the UK calculates a 98th percentile of hourly average odour concentrations over a year. The Environment Agency (EA) uses this benchmark and sets a concentration of 1.5ouE/m³ at the site/installation boundary for the most offensive odours. This means that two per cent (175 hours) of the hourly average concentrations in a year can exceed 1.5ouE/m³.

3.4.15 In November 2010, Defra issued a draft NPS for Waste Water⁴. The Thames Tunnel is discussed in the draft NPS. It advises that odour impacts should be assessed using appropriate and objective odour impact standards such as those set out in the Environment Agency’s H4 odour management guidance⁹ or relevant industry guidance. The impact exposure standard expected to be applied at sensitive receptors such as housing, hospitals and schools should be a 98th percentile hourly average odour exposure no higher than 1.5ouE/m³. The effects of odour on
surrounding land uses such as commercial premises, recreational facilities and open spaces should also be considered.

3.4.16 It then adds that the IPC should not grant development consent unless it is satisfied that all reasonable steps have been identified, and will be implemented throughout the operational lifetime of the project, to minimise detrimental impact on amenity from odour emissions.

3.4.17 The impact of the Thames Tunnel on odour has been assessed using dispersion modelling with the methodology described in this chapter. Management of odour will be described in the Air Management Plan which accompanies the ES (a draft of this is also available as part of phase two consultation).

**Oxides of nitrogen (NO\textsubscript{X}) and nitrogen dioxide (NO\textsubscript{2})**

3.4.18 Oxides of nitrogen (NO\textsubscript{X}) comprise of nitric oxide (NO) and nitrogen dioxide (NO\textsubscript{2}). Estimates for 2008\textsuperscript{10} show that the transport sector accounted for 32% of the total UK emissions of NO\textsubscript{X}, with the energy industry being another major source. In central London, road transport contributes a significant proportion of NO\textsubscript{X} emissions, estimated at 46% in Greater London and 60% in central London in 2008\textsuperscript{11}.

3.4.19 The majority of NO\textsubscript{X} emitted from vehicles is in the form of NO, which is oxidised in air to produce NO\textsubscript{2}. The conversion of NO to NO\textsubscript{2} takes place via reactions with chemically active air pollutants, such as ozone. NO\textsubscript{2} has the potential to affect human health.

**Particulate matter**

3.4.20 Particulate matter comprises of a wide range of materials arising from a variety of sources. It is any solid matter. Particulate matter is typically assessed as total suspended particulates or as a mass size fraction. The larger particles tend to settle out near the source whilst the fine particles can travel large distances.

3.4.21 PM\textsubscript{10} is a mass fraction of airborne particles of aerodynamic diameter of 10µm or less. The Air Quality Standards Regulations 2007 adopted the PM\textsubscript{10} standard for assessing fine particulate matter. This standard expresses the particulates as the total mass size fraction at or below an aerodynamic diameter of 10µm. Particles of this size have the greatest likelihood of reaching the lung and so have the potential to affect human health.

3.4.22 Road transport, production processes and commercial and residential combustion were the main sources of PM\textsubscript{10} in 2008\textsuperscript{12}. In central London, road transport is the major source, contributing 79% of PM\textsubscript{10} emissions\textsuperscript{11}.

**Dust**

3.4.23 Construction activities can lead to dust emissions. In terms of human and ecological health/nuisance impacts, these can be categorised as particulate matter (PM\textsubscript{10}) and dust, depending upon their size.

3.4.24 Dust is defined as all particulate matter up to 75µm in diameter and comprising both suspended and deposited dust, whereas PM\textsubscript{10} is a mass fraction of airborne particles of diameter of 10µm or less. The health
impacts associated with PM$_{10}$ include eye, nose and throat irritation; dust nuisance is caused by deposition on cars, windows and property. Dust and PM$_{10}$ emissions arise from a number of sources, so both construction activities and emissions from vehicles associated with the construction site need to be considered.

**Construction and operational effects**

**Assessment cases and years**

3.4.25 The generic assessment cases are described in Section 2. The following sections describe the specific approach for air quality and odour receptors.

**Assessment cases**

**Base case**

3.4.26 The base case for the assessment is a future case, without the project, in a particular assessment year.

3.4.27 This is derived from the baseline (2010) taking account of how the air quality environment may change due to modifications in the sources of air pollution. For example, for road vehicles, there will be change in the penetration of new Euro standards to the fleet composition between the current situation and the future base case. Additionally, background air pollution concentrations will reduce due to local and national policies. These aspects will be taken into account in the modelling of the base case scenario(s).

**Development case**

3.4.28 The development case is a future case during either the construction or operation of the Thames Tunnel in the same assessment year as the equivalent base case. The assessment considers the ‘development case’ compared with the ‘base case’ in a particular assessment year.

**Assessment years and areas**

3.4.29 The assessment years and areas used for the assessment of construction and operational effects are detailed in the sections below.

**Construction: local air quality**

3.4.30 Generically, the effects from construction on local air quality would be on pollutant concentrations of NOx, NO$_2$ and PM$_{10}$ from construction traffic, construction plant and, for the sites where materials are delivered or taken away via the river, from barges. These emission sources could also affect the deposition of nitrogen to the Barn Elms Wetland Centre SSSI. Additionally, there would be effects on dust and PM$_{10}$ concentrations from dust generated by the construction activities at each of the sites.

3.4.31 This section describes the methodology for the assessment of local air quality effects, identifying the assessment years, assessment areas, modelling undertaken (including model inputs and outputs) and significance criteria used.

3.4.32 As detailed in Section 3.1, the local air quality assessment is dependent on data, some of which have not yet been finalised. Therefore, for the
purposes of the PEIR, a qualitative assessment using professional judgement has been used to predict the likely effects for some air quality aspects at this stage. In the ES, the full assessment undertaken in accordance with the methodologies outlined in this section will be reported.

**Assessment years**

3.4.33 The assessment year will be the peak construction year for each site. For the identified peak year, a base case will be assessed including all appropriate emission sources without the Thames Tunnel project.

3.4.34 The development case will be assessed in the same peak construction year, but including the Thames Tunnel project.

3.4.35 A comparison of the two different scenarios for the assessment year will provide a measure of the effect of the Thames Tunnel project on local air quality.

**Assessment areas**

3.4.36 The assessment areas are site-specific (defined in Volumes 7-28). For local air quality, the assessment areas are primarily driven by the extent of roads that are significantly affected by the proposed construction traffic from the site. As a minimum, the assessment area extends up to 200m from the site boundaries.

**Overview of modelling process**

3.4.37 The assessment will comprise separate modelling studies for road transport, river barges (where applicable) and construction plant. The results from these separate modelling exercises will then be amalgamated to give an overall output. The significance of these effects will be assessed individually and jointly.

3.4.38 A flow diagram of the modelling process is included below.

*Vol 5 Figure 3.4.1 Air quality - modelling process*
Assessment of emissions from road transport

Model overview

3.4.39 Road transport from the project may have an effect on local air quality through the movements of heavy good vehicles (HGVs) transporting materials to and from the sites.

3.4.40 The effects of these movements on local air quality will be modelled using the regional dispersion model AAQuIRE (version 6.2). Concentrations of NO₂ and PM₁₀ arising from road traffic sources will be predicted at receptors across the study area using the AAQuIRE model which has been used widely for the past 17 years. The model uses the dispersion algorithm, CALINE4, which has been independently and extensively validated.

3.4.41 With regard to the assessment of NOₓ concentrations and nitrogen deposition at the Barn Elms Wetland Centre SSSI, NOₓ concentrations due to road traffic sources will be predicted using the AAQuIRE model. Nitrogen deposition will be derived from the predicted NO₂ concentrations using the DMRB methodology.

Model inputs

Road transport emissions

3.4.42 For road vehicles, emission factors and fleet compositions will be taken from the latest Department for Transport figures. In the future, there will be a change in the fleet composition due the penetration of new Euro standards. The uptake of newer vehicles with improved emission controls should lead to a reduction in existing NO₂ and PM₁₀ concentrations. However, the uptake of newer vehicles has not improved NO₂ concentrations greatly in the last ten years in London, so as a worst case the NOₓ contribution from diesel vehicles has assumed to be the same for Euro 1 to 5 vehicles in line with Defra advice. Reduced emission factors from the introduction of Euro 6 vehicles in 2016 should reduce base case concentrations compared with baseline concentrations.

3.4.43 Traffic data will be taken from the Transport Assessment. These data will include Annual Average Daily Traffic (AADT) flows, heavy duty vehicles (HDV) proportions and speeds for each road link assessed.

Background concentrations

3.4.44 A large number of small sources of air pollutants exist, which individually may not be significant, but collectively over a large area need to be considered in the modelling process. The emissions from these background sources will be applied to the model as background concentrations. In this assessment, pollutant contributions from all sources other than the modelled road traffic sources will be included as background concentrations.

3.4.45 The primary source of background pollutant concentrations is the estimated national background maps. Mapped background pollutant concentrations are available for each 1km by 1km grid square within every local authority’s administrative area and for each year from 2008 to 2020,
inclusive. For each study area the mapped background pollutant concentrations for nearby 1km grid squares will be considered alongside local urban background monitoring data (where available) to determine the most representative background concentration for the study areas. Having obtained appropriate background concentrations for the baseline modelling year (2010) the same grid square will be selected to determine background concentrations for the peak construction year. This data will be used in conjunction with local monitoring to provide background concentrations for the modelling.

3.4.46 To avoid double counting of road traffic sources the contribution to background pollutant concentrations from motorways, trunk roads and primary A roads within each grid square will be subtracted from the total background concentrations for NO\textsubscript{X} and PM\textsubscript{10}. Adjusted background NO\textsubscript{2} concentrations will be obtained using the NO\textsubscript{2} adjustment for NO\textsubscript{X} sector removal tool in accordance with the methodology outlined in LAQM.TG(09)\textsuperscript{2}.

3.4.47 Road transport and other emissions sources should reduce over time due to local and national policies. However, due to the uncertainty in emission factors from diesel road traffic sources (see para. 3.4.42), this component will remain unchanged for the purposes of the assessment. The non-road sources of the background used in the modelling will be reduced in line with Defra guidance LAQM.TG(09)\textsuperscript{2}.

3.4.48 The background deposition rate in the 5km by 5km square containing the Barn Elms Wetland Centre SSSI will be taken from the APIS website\textsuperscript{14}. The critical load for deposition of nitrogen will also be obtained from this website.

**Meteorological data**

3.4.49 Meteorological data from 2010 will be used for the local air quality assessment. For all the sites, this meteorological data will be taken from Heathrow Airport as this has the most complete and longest running historical dataset in the area. Sensitivity analyses will be undertaken with meteorological data for the years 2006-2009 for all the sites. For the eastern sites, sensitivity analysis will also be undertaken with meteorological data taken from London City Airport.

**Conversion of NO\textsubscript{X} to NO\textsubscript{2}**

3.4.50 The proportion of NO\textsubscript{2} in NO\textsubscript{X} varies greatly with location and time according to a number of factors including the amount of ozone available and the distance from the emission source.

3.4.51 The Air Quality Expert Group (AQEG)\textsuperscript{15} reported that urban NO\textsubscript{X} concentrations had declined since the early 1990s as a result of decreasing road traffic emissions, but corresponding decreases in NO\textsubscript{2} had not been observed, resulting in an increase in the NO\textsubscript{2}/NO\textsubscript{X} ratio. The magnitude of the increase was inconsistent with the increase expected solely as a consequence of reduced NO\textsubscript{X} concentrations. The findings were supported by monitoring data from a number of locations in London and AURN data from across the UK. These observations prompted
research into the NO₂/NOₓ relationship and an updated version of the relationship was published.¹⁶

3.4.52 The NOₓ from NO₂ calculator spreadsheet, provided by AEA on behalf of Defra provides a revised methodology for converting NOₓ to NO₂ for any given year where NOₓ is predicted by modelling road traffic emissions. The calculator can also be used to derive the road component of NOₓ from roadside NO₂ diffusion tube measurements. It incorporates the impact of expected changes in the fraction of NOₓ emitted as primary NO₂ and changes in regional concentrations of NOₓ, NO₂ and O₃.

3.4.53 The NOₓ from NO₂ calculator will be used for the purpose of this assessment for all scenarios as the best representation of the NO₂/NOₓ relationship. The calculator will be run for each assessment year and local authority area using the “All London Traffic” traffic mix option.

3.4.54 More recent studies also confirmed that primary NO₂ has increased in many locations in the UK and Europe because of changes in the vehicle fleets composition and the introduction of vehicle emission technologies that have been fitted to meet emission limits for pollutants. Primary NO₂ is predicted to increase until 2015 and then decline by 2020. This increase is dealt with by the NOₓ to NO₂ calculator.¹⁷

Model outputs

3.4.55 The effects of the Thames Tunnel project on local air quality will be assessed by predicting annual mean concentrations of NOₓ, NO₂ and PM₁₀. Discussion of the likely effects on the 1-hour mean NO₂ concentration and the daily mean PM₁₀ concentration will also be undertaken using the relationship between annual mean and peak concentrations to assess whether shorter-term peak criteria are likely to be exceeded.

3.4.56 The modelling procedure adopted will calculate annual mean NO₂ and PM₁₀ concentrations at receptors covering the study area using a Cartesian grid of receptors at a height of 1.5m above ground level to simulate human exposure. These receptors will be evenly spaced at 10m intervals to ensure that a high level of spatial resolution is obtained. The results produced will allow the generation of NO₂ and PM₁₀ concentration contours. Pollutant concentrations will also be predicted at specific sensitive receptors. These receptors will be selected using professional judgement and through consultation with the relevant local authorities.

3.4.57 These specific sensitive receptors will include the Barn Elms Wetland Centre SSSI (at the Barn Elms site only) at which annual mean NOₓ concentrations and nitrogen deposition levels will be calculated in a transect up to 200m from the nearest emission sources of NOₓ. The results of this modelling will be discussed with the ecologists on the project.

Model verification

3.4.58 For the detailed dispersion modelling assessment proposed, it is necessary to consider and account for random errors in both the modelling and the monitoring data.
3.4.59 The predicted results from a dispersion model may differ from measured concentrations for a number of reasons, including:

a. estimates of background concentrations
b. meteorological data uncertainties
c. uncertainties in source activity data such as traffic flows, stack emissions and emissions factors
d. model input parameters such as roughness length
e. uncertainties associated with monitoring data, including locations.

3.4.60 Model verification is the process by which model performance is assessed at the local level. The verification process involves a comparison between predicted and measured pollutant concentrations at one or more suitable local sites. In particular, the verification of road traffic modelling considers the predicted versus measured “road traffic contribution” to concentrations, so that the model performance can be adequately assessed.

3.4.61 NO\textsubscript{X} concentrations modelled using the AAQuIIRE model will be verified against local continuous monitoring and diffusion tube sites located within each of the study areas. In accordance with LAQM.TG(09)\textsuperscript{2}, the initial step of model verification was carried out for NO\textsubscript{X} concentrations.

3.4.62 A ratio between modelled and monitored road traffic NO\textsubscript{X} concentrations will be obtained by plotting modelled and monitored NO\textsubscript{X} concentrations against one another and performing linear regression on the data. Following checks of the model input data and further refinement where appropriate (eg, reduction of vehicle speeds near junctions and areas of congestion, selection of background concentration), a factor F (from the slope of linear regression equation) will be calculated.

3.4.63 All modelled road traffic NO\textsubscript{X} contributions will be adjusted by the factor F to obtain adjusted modelled road traffic NO\textsubscript{X} concentrations. The adjusted modelled NO\textsubscript{X} contributions will be compared against monitored concentrations to ensure good agreement.

3.4.64 Adjusted road traffic NO\textsubscript{X} concentrations will then be converted to modelled NO\textsubscript{2} concentrations using the method described in para. 3.4.52. Modelled NO\textsubscript{2} concentrations will also be compared against monitored NO\textsubscript{2} concentrations to determine whether secondary adjustment of NO\textsubscript{2} concentrations is necessary.

3.4.65 PM\textsubscript{10} concentrations modelled using the AAQuIIRE model will be verified against local continuous monitoring sites located within each of the study areas. In accordance with LAQM.TG(09)\textsuperscript{2}, an adjustment factor will be derived from the linear regression of modelled road traffic PM\textsubscript{10} concentrations and monitored road traffic PM\textsubscript{10} concentrations. Model input data will be checked and further refinement of the model (eg, reduction of vehicle speeds near junctions and areas of congestion, selection of background concentration) undertaken where appropriate, to optimise the model output.

3.4.66 An adjustment factor, F taken from the linear regression equation, will be applied to all modelled road traffic PM\textsubscript{10} concentrations to calculate
adjusted road traffic concentrations. Mapped background PM$_{10}$ concentrations will be subsequently added to the adjusted modelled values to derive total modelled PM$_{10}$ concentrations, which will then be compared against monitored concentrations to ensure a good agreement.

**Assessment of emissions from river barges**

**Model overview**

3.4.67 An air quality assessment of barges will be undertaken for sites that utilise river transport for the import and/or export of materials.

3.4.68 The emissions from the river barges will be modelled as area sources due to the uncertainty over the point of emission. These sources will be modelled using the US Environment Protection Agency's (EPA) preferred regulatory model, AERMOD. AERMOD version 6.7.1 from Lakes Environmental will be used for this study.

**Model inputs**

**Barge emissions**

3.4.69 Data regarding the river barges and the operation of these barges are currently being collated. Input data will be required on the number of barges per day, the movement of these barges, the time spent manoeuvring and docked, etc.

3.4.70 In order to convert from these units to units applicable to dispersion modelling the following information relating to the barges and their activity will be required:

a. power output of each barge (or an average figure representative of the fleet)

b. the engine type used by each barge (or a type considered representative of the fleet)

c. fuel type(s) used by the barges

d. an estimate of operational hours in a given time period, eg, per year.

3.4.71 Pollutant emissions from barges will be modelled using emission factors sourced from the EMEP Corinair Pollutant Emissions Inventory Guidebook$^{19}$. Chapter 1.A.3.d provides guidance on estimating emissions from navigation and outlines emission factors for domestic navigation and inland goods carrying vessels (Snap Code 080304).

3.4.72 Emission factors are also given based on mass of pollutant emitted per unit mass of fuel consumed. Fuel consumption figures will also be reviewed if available so that emission factors can be estimated by this method in the absence of more detailed information.

3.4.73 In the absence of sufficiently detailed input data EMEP Corinair$^{19}$ outlines a simplified methodology using emission factors based on an assumed fleet average technology, which will be adapted for application in this modelling.
Background concentrations

3.4.74 The same background concentrations as employed for road transport will be used for river barges (see paras. 3.4.44-3.4.47).

Meteorological data

3.4.75 As for the assessment of road transport, the meteorological data used for the assessment of river barges will be Heathrow Airport 2010 data (with sensitivity analyses undertaken for other meteorological years).

NOx:NO2 conversion

3.4.76 The methodology for the NOx to NO2 conversion employed for the road transport assessment will be used for the assessment of river barges (see paras. 3.4.50-3.4.54).

Model outputs

3.4.77 The effects of the Thames Tunnel project from river barges will be assessed in the same way as for road transport assessing the same pollutants / averaging periods and receptors (see paras. 3.4.55-3.4.56).

Model verification

3.4.78 Model verification is not possible for the assessment of emissions from barges given that there are currently no significant barge operations at the sites against which the model can be verified.

Assessment of emissions from construction plant

Model overview

3.4.79 Emissions from the various construction plant for each site, as described in para. 3.4.82, will be modelled using the US EPA dispersion model AERMOD.

Model inputs

Plant emissions

3.4.80 The proposed construction plant for each of the construction sites used in the modelling are as described Section 3 of Volumes 7-28. For each site a schedule has been provided which lists the type of all proposed plant (with descriptions) to be used at each stage of the construction process.

3.4.81 The British Standard document BS 5228-1-2009 Part 1: Noise also defines the power ratings in kW for the listed construction plant, a required input for calculating the emission factors used in the AERMOD air quality model.

3.4.82 There are a number of items of plant that may produce emissions that could affect local air quality. This plant includes:

a. excavators
b. generators
c. compressors
d. cranes
e. dumpers
f. pumps  
g. fuel bowser  
h. welders  
i. jack-up barges  
j. ventilation fans.

3.4.83 Appropriate emission factors will be assigned to each item of plant and the effects of the plant on local air quality predicted dependent upon the duration of operation.

3.4.84 The base emission factors used for the construction plant equipment are those set out in the EMEP/EEA Guidebook\textsuperscript{19}. Whist not providing equipment specific factors, the Guidebook does provide indicative factors relating to equipment power range.

3.4.85 In order to take into account the change of emissions with age, degradation factors as shown in the Guidebook for diesel machinery will be applied where relevant.

3.4.86 Section 3 of Volumes 7-28 describes the proposed phasing of the construction at each site. This information, along with that provided in the plant schedules is therefore used to estimate the likely on-time duration of the various listed construction plant throughout the defined construction phases. This assessment then allows the likely total emissions associated with the various construction plant from the construction process as a whole to be determined.

**Background concentrations**

3.4.87 The same background concentrations employed for road transport sources will be used for the assessment of construction plant (see paras. 3.4.44-3.4.47).

**Meteorological data**

3.4.88 Meteorological data from Heathrow Airport (for 2010) will again be used for the assessment of construction plant. Sensitivity analyses will be undertaken for other meteorological years.

**NOx:NO\textsubscript{2} conversion**

3.4.89 The methodology for the NO\textsubscript{X} to NO\textsubscript{2} conversion employed for the road transport assessment will also be used for the assessment of construction plant (see paras. 3.4.50-3.4.54).

**Model outputs**

3.4.90 The effects of the Thames Tunnel project from construction plant will be assessed in the same way as for road transport (see paras. 3.4.55-3.4.56), predicting NO\textsubscript{2} and PM\textsubscript{10} concentrations for short- and long-term averaging periods over a receptor grid and at specified sensitive receptors.
Model verification

3.4.91 As with the assessment of barge emissions, model verification is not possible for construction plant emissions given that construction plant is not present in the baseline against which the model can be verified.

Overall assessment of significance of effects

3.4.92 Having separately assessed emissions from road transport, barges (where applicable) and construction plant, the significance of effects associated with each of these will be assessed. As well as being assessed individually, the results will also be amalgamated (see Vol 5 Figure 3.4.1) to give an overall output, the significance of which will also be assessed.

3.4.93 With regard to the significance, air quality effects of a proposed development may be considered to be significant if air quality objectives or limit values are predicted to be breached or if the development leads to material impacts on air quality at sensitive receptors. According to Environmental Protection UK\textsuperscript{20}, there are two main aspects which need to be taken into account when determining significance. These are:

a. the magnitude of the change
b. the absolute concentration in relation to air quality objectives.

3.4.94 The first aspect is addressed in Vol 5 Table 3.4.5, in which impacts are assigned a magnitude according to the absolute change in pollutant concentrations. This table has been designed for use for specific receptors and will therefore be used at worst-case receptors.

Vol 5 Table 3.4.5 Air quality – local assessment of the magnitude of change

<table>
<thead>
<tr>
<th>Magnitude of change</th>
<th>Annual mean NO\textsubscript{2}/PM\textsubscript{10}</th>
<th>Number of days PM\textsubscript{10} above 50µg/m\textsuperscript{3}</th>
</tr>
</thead>
<tbody>
<tr>
<td>Large</td>
<td>Increase / decrease &gt;4µg/m\textsuperscript{3}</td>
<td>Increase / decrease &gt; 4 days</td>
</tr>
<tr>
<td>Medium</td>
<td>Increase / decrease 2-4µg/m\textsuperscript{3}</td>
<td>Increase / decrease 2-4 days</td>
</tr>
<tr>
<td>Small</td>
<td>Increase / decrease 0.4-2µg/m\textsuperscript{3}</td>
<td>Increase / decrease 1-2 days</td>
</tr>
<tr>
<td>Negligible</td>
<td>Increase / decrease &lt;0.4µg/m\textsuperscript{3}</td>
<td>Increase / decrease &lt; 1 day</td>
</tr>
</tbody>
</table>

3.4.95 The magnitude of change, as determined in Vol 5 Table 3.4.5, can then be compared to the absolute concentration in relation to the relevant air quality criteria (for annual mean NO\textsubscript{2} and annual mean PM\textsubscript{10}) to describe predicted air quality effects as detailed in Vol 5 Table 3.4.6 – this determines the significance of effects. This table comes from the Environmental Protection UK guidance\textsuperscript{20} and relates to those receptors of high sensitivity. Within Vol 5 Table 3.4.6, moderate and major adverse / beneficial effects represent a significant effect.
3.4.96 Vol 5 Table 3.4.6 should be used in conjunction with the following factors when judging overall significance:

a. Number of properties affected by minor, moderate or major air quality impacts and a judgement on the overall balance.

b. Where new exposure is being introduced into an existing area of poor air quality, then the number of people exposed to levels above the objective or limit value will be relevant.

c. The magnitude of the changes and the descriptions of the impacts at the receptors.

d. Whether or not an exceedence of an objective or limit value is predicted to arise in the study area where none existed before or an exceedence area is substantially increased.

e. Whether or not the study area exceeds an objective or limit value and this exceedence is removed or the exceedence area is reduced.

f. Uncertainty, including the extent to which worst-case assumptions have been made.

g. The extent to which an objective or limit value is exceeded, eg, an annual mean NO\(_2\) of 41μg/m\(^3\) should attract less significance than an annual mean of 51μg/m\(^3\).

Vol 5 Table 3.4.6 Air quality – magnitude of change criteria

<table>
<thead>
<tr>
<th>Absolute concentration in relation to standard</th>
<th>Magnitude of change</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Small</td>
</tr>
<tr>
<td>Above Objective/Limit Value With Scheme (&gt;40μg/m(^3))</td>
<td>Minor</td>
</tr>
<tr>
<td></td>
<td>Adverse / Beneficial</td>
</tr>
<tr>
<td>Just Below Objective/Limit Value With Scheme (36-40μg/m(^3))</td>
<td>Minor</td>
</tr>
<tr>
<td></td>
<td>Adverse / Beneficial</td>
</tr>
<tr>
<td>Below Objective/Limit Value With Scheme (30-36μg/m(^3))</td>
<td>Negligible</td>
</tr>
<tr>
<td></td>
<td>Adverse / Beneficial</td>
</tr>
<tr>
<td>Well Below Objective/Limit Value With Scheme (&lt;30μg/m(^3))</td>
<td>Negligible</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

3.4.97 A similar approach can be used for the assessment of the effects of NO\(_x\) and nitrogen deposition at the Barn Elms Wetland Centre SSSI. There are no statutory guidelines for significance, but Natural England and the Environment Agency commonly use a 1% threshold for determining whether an effect is significant\(^2\).

3.4.98 Firstly the magnitude of change is identified using the criteria shown in Vol 5 Table 3.4.7.
Vol 5 Table 3.4.7 Air quality - ecosystems assessment magnitude of change

<table>
<thead>
<tr>
<th>Magnitude of Change</th>
<th>Annual Mean NO\textsubscript{X}</th>
<th>Nitrogen Deposition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Large</td>
<td>Increase / decrease &gt;3µg/m\textsuperscript{3}</td>
<td>Increase / decrease &gt; 10%</td>
</tr>
<tr>
<td>Medium</td>
<td>Increase / decrease 1.5-3µg/m\textsuperscript{3}</td>
<td>Increase / decrease 5%-10%</td>
</tr>
<tr>
<td>Small</td>
<td>Increase / decrease 0.3-1.5µg/m\textsuperscript{3}</td>
<td>Increase / decrease 1%-5%</td>
</tr>
<tr>
<td>Negligible</td>
<td>Increase / decrease &lt;0.3µg/m\textsuperscript{3}</td>
<td>Increase / decrease &lt; 1%</td>
</tr>
</tbody>
</table>

3.4.99 The magnitude of change, as determined in Vol 5 Table 3.4.7, can then be compared to the absolute concentration / deposition in relation to the relevant air quality criteria or critical load to describe predicted air quality effect as detailed in Vol 5 Table 3.4.8 – this determines the significance of effects.

Vol 5 Table 3.4.8 Air quality - significance criteria for ecosystems effects

<table>
<thead>
<tr>
<th>Absolute concentration in relation to standard</th>
<th>Magnitude of change</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Small</td>
</tr>
<tr>
<td>Above Objective/Limit Value With Scheme (&gt;40µg/m\textsuperscript{3})</td>
<td>Minor</td>
</tr>
<tr>
<td></td>
<td>Adverse / Beneficial</td>
</tr>
<tr>
<td>Below Objective/Limit Value With Scheme (36-40µg/m\textsuperscript{3})</td>
<td>Minor</td>
</tr>
<tr>
<td></td>
<td>Adverse / Beneficial</td>
</tr>
</tbody>
</table>

Construction: construction dust

Assessment cases

3.4.100 These are as described in para. 3.4.26.

Assessment years

3.4.101 The construction dust assessment does not focus on any particular assessment year, but deals with the potential sources of dust holistically. The assessment concentrates on minimising or removing dust generating processes before the implementation of mitigation measures.

Assessment areas

3.4.102 Sensitive receptors closest to the dust generating processes (within 200m) have been identified to determine the closest sensitive receptors.
Methodology and significance criteria

3.4.103 As is standard practice in UK environmental assessment, construction dust has been assessed qualitatively.

3.4.104 In line with the GLA Best Practice Guidance\(^1\), the assessment has categorised each site in terms of risk using the criteria given in Vol 5 Table 3.4.9. The assessment criteria takes into consideration the following:

a. the area taken up by the development  
b. the number of properties being developed  
c. the potential impact of the development on sensitive receptors close to the development (e.g., housing, schools, hospitals and other building uses which would be affected by high levels of air pollution or dust).

Vol 5 Table 3.4.9 Air quality - construction dust site evaluation guidelines

<table>
<thead>
<tr>
<th>Low risk sites</th>
<th>Medium risk sites</th>
<th>High risk sites (if any of the following apply)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Development of up to 1,000 square metres of land</td>
<td>Development of between 1,000 and 15,000 square metres of land</td>
<td>Development of over 15,000 square metres of land</td>
</tr>
<tr>
<td>Development of one property and up to a maximum of ten</td>
<td>Development of between ten to 150 properties</td>
<td>Development of over 150 properties</td>
</tr>
<tr>
<td>Potential for emissions and dust to have an infrequent impact on sensitive receptors</td>
<td>Potential for emissions and dust to have an intermittent or likely impact on sensitive receptors</td>
<td>Major Development referred to the Mayor and/or the London Development Agency</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Major development defined by a London Borough (LB)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Potential for emissions and dust to have significant impact on sensitive receptors</td>
</tr>
</tbody>
</table>

3.4.105 Having identified whether a site is high, medium or low risk, sensitive receptors within 200m of the construction site boundaries have then been identified and the receptors categorised according to their sensitivity to dust as shown in Vol 5 Table 3.3.2.

3.4.106 This information on the site risk level and the sensitivity and distance of receptors from the site has then been used to determine the significance of dust effects using the criteria detailed in Vol 5 Table 3.4.10. These
assessment criteria are based on professional experience of similar types of projects and discussions with practitioners in the field.

**Vol 5 Table 3.4.10 Air quality assessment criteria for dust - construction**

<table>
<thead>
<tr>
<th>Significance</th>
<th>Sensitivity of receptor</th>
<th>High risk site</th>
<th>Medium risk site</th>
<th>Low risk site</th>
</tr>
</thead>
<tbody>
<tr>
<td>Major adverse</td>
<td>High</td>
<td>Within 10m</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td></td>
<td>Medium</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td></td>
<td>Low</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Moderate adverse</td>
<td>High</td>
<td>Between 10m-100m</td>
<td>Within 50m</td>
<td>Within 10m</td>
</tr>
<tr>
<td></td>
<td>Medium</td>
<td>Within 50m</td>
<td>Within 10m</td>
<td>N/A</td>
</tr>
<tr>
<td></td>
<td>Low</td>
<td>Within 10m</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Minor adverse</td>
<td>High</td>
<td>Between 100m-200m</td>
<td>Between 50m-200m</td>
<td>Between 10m-100m</td>
</tr>
<tr>
<td></td>
<td>Medium</td>
<td>Between 50m-200m</td>
<td>Between 10m-100m</td>
<td>Within 50m</td>
</tr>
<tr>
<td></td>
<td>Low</td>
<td>Between 10m-100m</td>
<td>Within 50m</td>
<td>Within 10m</td>
</tr>
<tr>
<td>Negligible</td>
<td>High</td>
<td>Over 200m</td>
<td>Over 200m</td>
<td>Over 100m</td>
</tr>
<tr>
<td></td>
<td>Medium</td>
<td>Over 200m</td>
<td>Over 100m</td>
<td>Over 50m</td>
</tr>
<tr>
<td></td>
<td>Low</td>
<td>Over 100m</td>
<td>Over 50m</td>
<td>Over 10m</td>
</tr>
</tbody>
</table>

3.4.107 As the effects are transient, temporary and likely to be noticeable only in dry weather, a significant effect applies to moderate and major adverse effects.

**Operation: odour**

**Assessment cases**

3.4.108 These are as described in para. 3.4.26.

**Assessment years**

3.4.109 Dispersion modelling is undertaken for a typical use year representing typical rainfall levels. This ‘typical’ year was derived from an analysis of measured rainfall in London in 34 year carried out by the Water Research Council. This identified October 1979 – September 1980 to represent a ‘typical’ year, the meteorological data for which is therefore used in the assessment.

**Assessment areas**

3.4.110 For odour, the assessment areas are site-specific (defined in Volumes 7-28), being large enough to cover the area that could be affected by
emissions from the vent. This area typically extends about 500m from the vent.

Model overview

3.4.111 The US EPA AERMOD atmospheric dispersion model (version 6.7.1 from Lakes Environmental) was used to predict concentrations across the study area. AERMOD is a steady-state atmospheric dispersion model that incorporates air dispersion based on modern atmospheric physics, including treatment of both surface and elevated sources, and both simple and complex terrain. The model calculates downwind concentrations in the surrounding area for each hour in the hourly sequential meteorological dataset. Statistics on the frequency and concentration at the receptors are based upon these hourly calculations. This model is used to support regulatory and non-regulatory requirements worldwide and is widely used in the UK for odour modelling.

3.4.112 Odour concentrations were predicted for 98th percentile of hourly values in a year for comparison with the Defra and Environment Agency odour benchmark and the number of hours with odour concentrations above 1.5ouE/m³ was calculated.

3.4.113 When a plume flows over nearby buildings or other structures, turbulent eddies are formed in the downwind side of the building. Those eddies cause a plume from a stack source located within about five times the height of a nearby building or structure to be forced down to the ground much sooner than it would if a building or structure were not present. The effect can greatly increase the resulting nearby ground-level pollutant concentrations downstream of the building or structure. This phenomenon is known as building downwash and was taken into account in the modelling by using the Building Profile Input Program Prime (BPIP Prime). As many of the sites are near tall buildings, this is an important effect in central London.

Model inputs

3.4.114 The model uses source emission characteristics, meteorological data, terrain data and building information to predict pollutant concentrations.

Emission rates

3.4.115 Hydraulic modelling of inflow and depth in the Tunnel at each shaft was carried out using the InfoWorks software. The results from this modelling were used in the air movement model to estimate air release rates and H₂S concentrations at each shaft. H₂S concentrations in sewers are very variable as the actual concentration depends upon a variety of factors. For this assessment, conservative assumptions have been made so the estimated concentrations are an upper estimate. Odour concentrations in the tunnel air were estimated from the H₂S concentrations using a correlation between the two based on odour and H₂S measurements made in sewers at a range of London sites. As the H₂S emission rates are an upper estimate, the odour emission rates also represent an upper estimate.
**Meteorological data**

3.4.116 A meteorological dataset was compiled specifically for use in the AERMOD model using data from London Heathrow. Meteorology is affected by ground surface conditions so the surrounding land was characterised in terms of surface roughness, Bowen ratio and albedo for each season. The surface roughness length used was 1m. The meteorological file for use in AERMOD was prepared using the processor AERMET. The urban option was selected in AERMOD to take account of the extra heat in the city compared with rural areas that can affect the stability of the atmosphere.

3.4.117 As the emission and flow rates for the typical year relate to an actual year, the corresponding meteorological dataset for that year was used in the modelling which was 1979-80. The corresponding meteorological dataset was used as it would give a better indication of concentrations rather than using a recent year of data where the meteorological data may not be consistent with a rainfall event leading to the tunnel emissions. Hours with missing meteorological data in the dataset were infilled, based on the meteorological conditions in the adjacent hours, to avoid a missing hour of meteorology coinciding with an hour of high emissions.

3.4.118 Wind roses for the typical year assessment (1979-1980 – as determined by the analysis of 34 years of measured rainfall data in London as explained in para. 3.4.109) are shown in Vol 5 Figure 3.4.2. Both wind roses clearly show a predominant south-westerly wind, with winds originating in this quadrant for 30-35% of the time. Light winds (up to 2m/s) occurred for 13-14% of the time in both years. The dominant wind direction with light winds was southerly. It is generally considered that light winds and calm conditions result in the greatest odour impact.

**Vol 5 Figure 3.4.2 Odour – wind roses for Heathrow 1979 and 1980**

**Terrain data**

3.4.119 The ventilation sites are located near the River Thames and are generally on low level flat ground. In order to allow for any local topography that
could affect air movements, digital terrain mapping (DTM) with a resolution of 5m was used in the modelling. This was processed in the US EPA terrain pre-processor AERMAP to produce data in a suitable format for use in AERMOD. This file contained elevation and hill height scaling factors for each receptor in AERMOD.

**Building information**

3.4.120 Building height data was provided by Thames Water from the Digital Surface Model. Any buildings that could affect dispersion of the tunnel air plumes were entered into the model.

**Background concentrations**

3.4.121 The Tunnel ventilation shafts at Beckton would be located at the sewage treatment works. All sources within the sewage treatment works have been modelled so that the total odour concentration can be assessed. At the other sites, no allowance has been made for the odour contribution from other sources.

3.4.122 For EIA of new developments, a background odour concentration of zero is generally used. This is because of the difficulties of measuring background or existing odour continuously throughout the year to quantitatively determine background levels. Odour can be caused by a wide range of substances so no instrument can detect every odorant at once. Monitoring of hydrogen sulphide as an indicator of odour is being carried out for the EIA.

3.4.123 At the majority of sites, there are no significant sources of sewage odour in the surroundings and no complaints have been made indicating that background odour levels are likely to be low. At some of the sites, odour complaints have been made indicating that background odour concentrations have been raised on some occasions. With the Thames Tunnel project, it is expected that background odour levels would decrease at some sites and remain the same at others. The sites are discussed individually in Volumes 7-28. The total odour concentration at some of the sites could be higher than that modelled for sites where there are other odour sources in the area such as restaurants or diesel engines.

**Model outputs**

3.4.124 Concentrations were predicted at 5m intervals across the study area in a Cartesian grid at a height of 1.5m to represent breathing height. Maximum concentrations at ground level beyond the site boundary (if there is one) are reported. In addition flagpole receptors were placed at 3m intervals up the side of tall buildings to assess concentrations at height at buildings close to the vent where concentrations could be higher at height and people could be exposed. The maximum concentrations reported for buildings are either those from the 5m Cartesian grid (so could be at any location within the building at ground level) or from the flagpole sensitive receptors at height.

**Model verification**

3.4.125 The AERMOD dispersion model has been extensively verified as part of its development so the dispersion algorithms within the model perform
well. In principle, model verification should also be carried out for each modelling study using emission factors, topography and sources similar to those in the study. For odour modelling of proposed sources, model verification is not carried out as there is no monitoring data from a similar environment that can be used for the verification.

**Significance criteria**

3.4.126 As the Defra and Environment Agency benchmark for odour is the 98\textsuperscript{th} percentile of hourly values, the magnitude of impact should also be assessed using this metric. Impact magnitude criteria are given in Vol 5 Table 3.4.11 based on the detection threshold and benchmarks set by the Environment Agency for various levels of offensiveness of odour.

Vol 5 Table 3.4.11 Odour - impact magnitude criteria

<table>
<thead>
<tr>
<th>Impact magnitude</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>98\textsuperscript{th} percentile of hourly concentrations in a year &gt;3ouE/m\textsuperscript{3}</td>
</tr>
<tr>
<td>Medium</td>
<td>98\textsuperscript{th} percentile of hourly concentrations in a year 1.5-3ouE/m\textsuperscript{3}</td>
</tr>
<tr>
<td>Low</td>
<td>98\textsuperscript{th} percentile of hourly concentrations in a year 1-1.5ouE/m\textsuperscript{3}</td>
</tr>
<tr>
<td>Negligible</td>
<td>98\textsuperscript{th} percentile of hourly concentrations in a year &lt;1ouE/m\textsuperscript{3}</td>
</tr>
</tbody>
</table>

3.4.127 The significance criteria have been derived from the impact magnitude shown in Vol 5 Table 3.4.11 and the sensitivity of receptors shown in Vol 5 Table 3.3.1. The significance criteria are shown in Vol 5 Table 3.4.12 with moderate and major adverse effects identified as being significant effects.

Vol 5 Table 3.4.12 Odour - significance of effect criteria

<table>
<thead>
<tr>
<th>Significance of receptor</th>
<th>Impact magnitude</th>
<th>Impact magnitude</th>
<th>Impact magnitude</th>
<th>Impact magnitude</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>High impact</td>
<td>Medium impact</td>
<td>Low impact</td>
<td>Negligible impact</td>
</tr>
<tr>
<td>Sensitivity of receptor</td>
<td>Major adverse</td>
<td>Major adverse</td>
<td>Minor adverse</td>
<td>Negligible</td>
</tr>
<tr>
<td></td>
<td>Medium</td>
<td>Moderate adverse</td>
<td>Minor adverse</td>
<td>Negligible</td>
</tr>
<tr>
<td></td>
<td>Low</td>
<td>Minor adverse</td>
<td>Negligible</td>
<td>Negligible</td>
</tr>
</tbody>
</table>

Cumulative, in combination and compound effects

3.4.128 The general approach to assessing cumulative, in combination and compound effects is described in Section 2. The specific approach for air quality and odour is described below.
Construction

3.4.129 Road traffic effects from other Thames Tunnel sites may act together to affect local air quality. These compound effects are most likely at sites where lane closures are likely and will be modelled using the methodologies outlined above.

3.4.130 Other committed developments in the vicinity of each site likely to be in place for peak construction year will be included in the traffic data used in the modelling in order that cumulative effects of likely developments will be included in the air quality assessment.

3.4.131 No in combination effects are anticipated for air quality.

Operation

3.4.132 The sites at Kirtling Street and Heathwall are close together so have been modelled in one study area as the plume could affect the same area. Compound effects are therefore inherently assessed as part of the odour assessment undertaken for each site.

3.4.133 No cumulative or in combination effects are anticipated for odour during the operation of the Thames Tunnel.

Project-wide effects

Construction

3.4.134 Construction works at the Thames Tunnel sites may lead to traffic management and lane closure which may result in diversions and/or congestion which may affect air quality. There may also be project-wide interactions of construction traffic along major road corridors to and from the depots which could have air quality impacts. Other potential project-wide air quality effects may arise from the emissions from tugs moving river barges and the movement of construction personnel by car.

3.4.135 A qualitative assessment of these project-wide air quality effects based on professional judgement has been undertaken for the PEIR. When full traffic modelling results are available, a more detailed quantitative assessment using air quality modelling will be undertaken, the findings of which will be reported in the ES. This will be undertaken using the above described methodologies.

Operation

3.4.136 Project-wide effects are not expected for odour.

Assumptions and limitations

Local air quality

3.4.137 Vehicle emission factors and fleet composition data have been based on those provided by Defra\textsuperscript{22}. These emission factors have been modified in light of the Defra note posted in September 2010\textsuperscript{23}. In consultation with the local authorities, the present position is that all diesel vehicles that meet Euro 1 to 5 standards are treated as Euro 1 in terms of their emissions. This worst case assumption is to cover the present uncertainty.
on the performance of diesel exhaust emission management under urban driving conditions.

3.4.138 Plant emission factors have been taken from EMEP/EEA Guidebook\textsuperscript{19}. In order to take into account the change of emissions with the age, degradation factors as shown in Guide Book for diesel machinery will be applied where relevant.

3.4.139 Barge emission factors have been taken from EMEP Corinair Pollutant Emissions Inventory Guidebook\textsuperscript{19}.

3.4.140 The modelling for future years are dependent on forecasts of:
   a. traffic data
   b. vehicle fleet compositions
   c. the maintenance of older vehicles
   d. the performance of the UK economy
   e. the predictions of the models
   f. the predictions of background concentrations.

3.4.141 An assumption has been made regarding background concentrations due to the uncertainty of the emission factors used to produce the road element of the background concentrations. Road transport and other emissions sources should reduce due to local and national policies. However, due to the uncertainty in emission factors from road traffic sources (see para. 3.4.42), this component will remain unchanged. The non-road sources of the background concentrations used in the modelling will be reduced in line with Defra guidance.

\textbf{Odour}

3.4.142 A range of conservative assumptions have been made regarding the odour emission rates including a minimum odour strength in releases from the ventilation columns. These assumptions are likely to have led to an overestimate of concentrations. The relationship between odour and H\textsubscript{2}S concentrations in the releases was estimated based on measurements made at Thames CSO sites. The correlation between odour and H\textsubscript{2}S concentrations showed considerable variation between samples leading to greater uncertainty in the odour emissions but are still likely to have been overestimated.

3.4.143 The odour assessment assumes ventilation columns at the passively ventilated sites to be 3m in height. This provides a conservative assessment of the odour effects at surrounding receptors as actual ventilation column heights are likely to be greater than this. Some of the site layouts may have been modified since the odour dispersion modelling was carried which could result in maximum impacts occurring in slightly different areas. Once finalised through the design development process, the odour assessment reported in the ES will assess the actual heights and site layouts as defined for each site.
3.5 Approach to mitigation

Construction

3.5.1 The Thames Tunnel project has been designed with input from the environmental team and therefore the proposed development already takes account of air quality considerations including measures within the CoCP. Where such measures form part of the project to date, they are identified in Volumes 7-28.

3.5.2 Where the assessment indicates effects of a significance that requires additional mitigation, further mitigation measures will be identified as appropriate.

Operation

3.5.3 Environmental design input was provided during the design of the ventilation system which included odour management input. This is described in Section 4.2 of Volumes 7 to 28. If the assessment indicates effects of a significance that required additional mitigation, further mitigation measures will be identified as appropriate.
4 Ecology - aquatic

4.1 Introduction

4.1.1 This section sets out the full EIA methodology for the assessment of aquatic ecology effects associated with the Thames Tunnel project. Work which has not been fully completed for the PEIR will be completed for the ES, and this is noted below and within each site specific assessment volume.

4.1.2 The tidal River Thames extends from the upstream tidal limit at Teddington lock to the limit of the inner estuary, as shown in Vol 5 Figure 4.1.1.

Vol 5 Figure 4.1.1 Aquatic ecology – assessment area
(see Volume 1-6 Figures document)

4.1.3 Receptors considered within this assessment are those which occur within the Thames Tideway and its tidal tributaries:
   a. river dependent habitats
   b. mammals
   c. fish
   d. benthic and pelagic invertebrates
   e. algae.

4.1.4 The aquatic ecology assessment considers effects within the subtidal and intertidal zone of the river. Habitats and species outside these zones, including birds and specifically waterfowl are considered under the terrestrial ecology topic (Section 5). Inter-relationships between the receptors considered within terrestrial and aquatic ecology are highlighted throughout.

4.1.5 The water quality improvements arising from the Thames Tunnel project are assessed under the surface water resources topic (Section 13). Information from this assessment and from predictive water quality modelling has been used to inform the assessment of effects on aquatic ecology receptors during the operational stage of the project. Measures to control impacts on water quality during the construction stage are contained within the Code of Construction Practice (Volume 2). These measures are cross referred to in the aquatic ecology section where necessary. Cross reference is also made to the noise and vibration topic in relation to anticipated levels of waterborne noise and vibration during construction. Specific measures limiting noise and vibration impacts are covered in the Code of Construction Practice.

4.2 Scoping Opinions and technical engagement

4.2.1 A summary of scoping and technical engagement undertaken in relation to aquatic ecology is provided in Volume 4, Sections 3.4 and 4.4.
4.3 **Baseline data collection methodology**

4.3.1 The assessment is based on field survey data collected for the project, and background data obtained from desk study. The scope and methodologies adopted for the field surveys has been agreed with the Environment Agency. Where possible, survey methodologies are based on published good practice. These are referenced below where appropriate.

**Desk based baseline data**

4.3.2 Desk based baseline data was collected in 2010 and 2011. The data sets are described below and summarised in Vol 5 Table 4.3.1. In all cases during the course of the assessment desk based data will continue to be updated as appropriate.

**Designated sites**

4.3.3 Details of statutory and non-statutory designated sites, including site descriptions and boundaries were obtained from Greenspace Information for Greater London (GiGL)⁲⁴.

**Biodiversity Action Plans**

4.3.4 Biodiversity Action Plans were sourced from Local authority web sites, and through web sites for organisations such as the London Biodiversity Partnership and Thames Estuary Partnership.

**Mammals**

4.3.5 Information regarding cetaceans and other marine mammals has been obtained from three sources; Zoological Society of London, British Divers Marine Life Rescue and Essex Biodiversity Partnership. Data is available for the past 10 years and includes anecdotal records of whales, dolphins, porpoises and seals throughout the Thames Tideway.

**Fish**

4.3.6 The Environment Agency also carries a long term monitoring programme for fish. Surveys are carried out using various methods (beam trawling, beach seining and hand net kick-sampling from between 1964 and 2010). The survey programme covers a series of six sites through the estuary from Richmond to West Thurrock. Although the sampling points are dispersed too widely through the estuary to provide a baseline for the site specific assessments for this project, the data is valuable as a basis for identifying long term trends.

**Invertebrates**

4.3.7 The Thames Estuary Benthic Programme (TEBP) was established in 1989 to determine the current pollution status of the estuary, as reflected by benthic macroinvertebrate community structure, and to provide a baseline to monitor changes in ambient water quality. Sampling stations were set up at 34 sites along the Estuary, from the upstream tidal limit at Teddington Weir, to the downstream limit at Sea Reach Number 2 channel marker buoy at the north of the outer estuary.
4.3.8 Samples were taken from the intertidal zone, using core and kick samples, where the sediments were firm enough, while in soft sediments sub-tidal day grab or core samples were taken from a boat. A small number of samples were also taken with a dredge. The results cover the period from 1989 to 2010, although not all sites were sampled in any one-year. Sampling and analytical methods have varied with time, requiring care in interpretation.

4.3.9 The Environment Agency also supplied data on invertebrate samples identified to family level taken during the Teddington Low Flow Survey of 1994-95 in which quarterly samples were taken at a number of sites in the upper Tideway.

**Algae**

4.3.10 The Environment Agency was contacted for information on algae. The Environment Agency conducted a desk based study using aerial imagery to determine compliance with Water Framework Directive (WFD) standards for the Thames Upper and Thames Middle (see Section 13 Water Resources of this volume for an explanation of WFD zones). The study found that coverage was below 5% and hence no further work was undertaken. Algae were thus scoped out of the assessment in the Scoping Report. Subsequent discussions with stakeholders highlighted further data sources held by the Natural History Museum for this receptor. This data is currently being sought and an assessment will be undertaken once the data is received. This will be reported in the ES.

**Other information sources**

4.3.11 The table below provides the data sources used for collecting baseline data for the assessment. Data used to inform specialist studies associated with the assessment, such as the fish impact modelling is cited through references.

**Vol 5 Table 4.3.1 Aquatic ecology desk based baseline data sources**

<table>
<thead>
<tr>
<th>Source</th>
<th>Data</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Environment Agency</td>
<td>Invertebrate data from the Thames Estuary Benthic Programme Background data for benthic invertebrates.</td>
<td>Data is available for 34 sites along the estuary, relating to the current EA biological monitoring stations. Data collection began in 1989, but there is not a complete dataset for all sites.</td>
</tr>
<tr>
<td>Natural History Museum</td>
<td>Data on algae anticipated. To be reported in the ES.</td>
<td>This will assist in evaluating the potential significance</td>
</tr>
</tbody>
</table>
Field survey baseline data

4.3.12 The Environment Agency background data sets for fish and invertebrates provide valuable contextual information. However, the distribution of sites was considered inadequate for establishing a detailed baseline at each of the sites where there would either be construction work on the foreshore, or a CSO discharge point where improvements in water quality are predicted. A programme of field surveys for habitats, fish and invertebrates has therefore been undertaken in autumn 2010 and spring 2011.

4.3.13 The aim of the surveys was to determine the diversity and abundance of fish and invertebrate species at each of the sites where there would be works on the foreshore in order to establish a baseline against which effects can be assessed. A further aim of the surveys was to sample fish and invertebrates at the most polluting of the existing CSO discharges in order to provide a baseline against which potential improvements following interception can be assessed. Survey results are presented in the project-wide (Volume 6) and site specific volumes (Volumes 7-28). Appendix A of Volume 6 contains all of the survey findings.

Fish survey methods

Trawling

4.3.14 A 1 metre survey Agassi trawl with 3mm mesh liner was towed behind a PLA registered Thames work boat along parallel paths covering an area of at least 100 metres upstream and 100m downstream of the limit of each working area. Catches were sorted to species level, weighed and recorded in terms of species composition, size range and biomass. Catches were reported with reference to trawled area (distance by trawl width).
Seine netting

4.3.15 A 25 by 2.7m net made from 9mm mesh wings with a 3mm knotless micro-mesh centre section was used. It was deployed from an inflatable raft powered by a 4hp outboard motor as a tender from a PLA registered Thames work boat at low tide.

4.3.16 Vol 5 Figure 4.3.1 illustrates how seine netting is undertaken. The net is dealt out in parallel to the shoreline, approximately 10m from the water line, using oars, so as not to disturb resident fish. The upstream end ropes are dropped to a member of staff on the shingle, whilst the net will be deployed downstream. Following this, with the net forming a semi-circle, both of the ends are pulled in by the remaining ground crew. A minimum of two seine hauls per site have been completed, however, where conditions allowed, up to three were carried out.

4.3.17 Following each haul, fish samples were placed in aerated bins, the individuals identified and measured aboard the work boat before being returned to the water.

4.3.18 Depending on numbers of fish caught, sub-samples were identified by species, measured and weighed. If very large numbers of fish were captured, then a DAFOR abundance scale (D – dominant, A - abundant, F - frequent, O - occasional, R - rare) was used to assess their abundance and digital photographs taken of batches laid in ‘gridlined tray’.

Vol 5 Figure 4.3.1 Aquatic ecology – Seine netting
A Riley push-net with a D-shaped mouth measuring 1.0m by 0.3m and a mesh size of 3mm in the cod-end will be used as an ancillary method where conditions are suitable. Vol 5 Figure 4.3.2 illustrates how Riley push-netting is undertaken. A member of staff in a dry-suit works the net against the flow for approximately 50m, depending on conditions and substrate type. Typically this will be parallel and approximately 2m from the water line. Since the technique involves wading, suitable conditions constitute a relatively flat, even substrate. Cobbles or large stones represent a tripping hazard.

The timing of this technique is less tide-dependent and it will be fitted in around seine-netting, for which the general constraint will be tide status and transect length.

Following each haul, samples will be placed in aerated bins, identified and measured aboard the raft before being returned to the water.

**Kick-sampling**

An approximately 60cm wide D-net with 3mm knotless mesh will be used for the kick-sampling. The method is described in this volume paras. 4.3.27 to 4.3.29.

Following each haul, samples will be placed in aerated bins, identified and measured before being returned to the water.

A summary of field survey baseline data sources is provided below.

**Vol 5 Table 4.3.2 Aquatic ecology - field survey baseline data sources**

<table>
<thead>
<tr>
<th>Data</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aquatic invertebrate baseline surveys</td>
<td>Undertaken in October 2010.</td>
</tr>
<tr>
<td>Data</td>
<td>Notes</td>
</tr>
<tr>
<td>-------------------------------</td>
<td>------------------------------------------------------------</td>
</tr>
<tr>
<td>Fish baseline surveys</td>
<td>Undertaken in October 2010 and spring 2011.</td>
</tr>
<tr>
<td>Juvenile fish surveys</td>
<td>Undertaken monthly over a 6 month period May to September 2011.</td>
</tr>
</tbody>
</table>

Invertebrate survey methods

4.3.25 Invertebrate sampling targeted both the subtidal and intertidal environments using the following techniques.

Airlift sampling

4.3.26 Four subtidal samples were taken from a boat at each site listed in using an airlift sampler. The sampler uses compressed air to sample material from a fixed area (approximately 0.5m by 0.5m). This technique is more reliable than a traditional Day grab in habitats such as the River Thames where silt is underlain by a hard substrate. Intertidal samples were taken from the shore using the standard kick sampling methodology.

Kick sampling

4.3.27 An approximately 60cm wide D-net, or pond net with 3mm knotless mesh is used for kick-sampling. The surveyor deploys the net downstream directly adjacent to their standing point. The substrate is then disturbed using a kicking motion for a period of three minutes. Animals dislodged from the substrate are carried by the current into the net and collected as a sample.

4.3.28 At all sites, access to the intertidal habitat was gained from a boat, either directly from the work boat, or from a tender towed behind the work boat. Two samples were taken at each intertidal site.

4.3.29 Invertebrate samples were processed and specimens identified at a mixed taxa level of species and families, as appropriate, for each site. Mean abundance will be calculated for the intertidal and subtidal samples.

Habitat survey methodology

4.3.30 No standardised methodology exists to record riverine habitats associated with the tidal reaches of rivers. Instead, existing methodologies (eg, those for River Corridor and River Habitat Survey (RHS)) have focussed on habitats above the tidal limit that are predominantly freshwater in character. These existing methodologies were used to inform the development of a bespoke methodology tailored to meet the requirements of this project and that was capable of capturing details of the various habitats associated with the tidal reach of the River Thames. The methodology also took account of the Thames Tidal Habitat Action Plan (HAP), which identifies a list of target habitats for the tidal Thames, these being:

a. Mudflats
b. Saltmarsh
c. Gravel foreshore
d. River Wall  
e. Sublittoral sands and gravels  
f. Reedbeds  
g. Tidal Creek  
h. Marginal vegetation.

4.3.31 The habitat survey was undertaken by experienced aquatic ecologists and involved recording the types of habitats, and relative distribution of these, at each of the sample sites visited during the fish and invertebrate surveys. Surveys were undertaken at low water and details of the aquatic, marginal and bank zone habitats were recorded onto standardised recording sheets (Appendix A). This included recording the presence of any BAP target habitats. Substrate size was categorised in accordance with established RHS size classes.

4.3.32 A sketch map was also produced for each site to provide a visual record of the distribution of the various habitats observed. Representative photographs were made using a digital camera.

4.3.33 Because of the turbid nature of the Tidal Thames, it was not possible to accurately record the distribution of habitats and substrate in submerged and subtidal areas using the methods described. Records were made of the types of sediment present from the invertebrate airlift samples (see below), at specific locations. However, this is limited to the areas in which the samples were taken and may not represent the sample site as a whole.

**Autumn 2010 surveys**

4.3.34 The autumn surveys were undertaken during October 2010. This is considered to be an optimum period for fish population surveys; late enough into autumn to allow juvenile fish sufficient maturation to allow them to be sampled, but early enough to avoid prolonged and heavy rainfall which would increase flows and hamper sampling.

4.3.35 Based on the preferred scheme presented at the phase one consultation, the autumn fish, invertebrate and habitat surveys focused on the following three categories of site:

a. sites where there would be works on the foreshore  
b. river infrastructure  
c. major existing CSOs where there is likely to be a significant improvement once the CSO is intercepted. Sampling at these sites will allow accurate prediction of the scale of improvement. These are referred to as improvement sites.

4.3.36 The sites surveyed and their categories are presented in Vol 5 Table 4.3.3. The location of sites are illustrated in Vol 5 Figure 4.3.3.
4.3.37 Sites not within these three categories, namely Acton Storm Tanks, Earl Pumping Station, Deptford Church Street, Beckton Sewage Treatment Works and Falconbrook Pumping Station, were not directly surveyed.

4.3.38 Greenwich and Abbey Mills Pumping Stations could not be surveyed in autumn 2010 due to issues associated with access. In addition, the fisheries element of surveys at Dormay Street could not be completed, as at access at low tide, the Creek was found to be too shallow and narrow to sample using the proposed methods.

Vol 5 Table 4.3.3 Aquatic ecology surveys autumn 2010

<table>
<thead>
<tr>
<th>Site name</th>
<th>Foreshore construction site</th>
<th>River infrastructure site</th>
<th>Improvement site</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hammersmith Pumping Station</td>
<td></td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Barn Elms</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Putney Bridge</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bell Lane Creek</td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Jews Row</td>
<td></td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Tideway Walk</td>
<td></td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Cremorne Wharf</td>
<td>✓</td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Chelsea Embankment</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Western Pumping Station</td>
<td></td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Albert Embankment</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Victoria Embankment</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Blackfriars Bridge</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>King Edward Memorial Park</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>King Stairs Gardens</td>
<td></td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Borthwick Wharf/Deptford Storm Relief</td>
<td>✓</td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Greenwich PS</td>
<td></td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Abbey Mills</td>
<td></td>
<td></td>
<td>✓</td>
</tr>
</tbody>
</table>

* fish, invertebrate and habitat
Spring 2011 surveys

4.3.39 Further surveys have been undertaken in spring 2011 to provide additional data. The project has changed since the phase one preferred scheme as a result of considering the responses to consultation (eg, the location of preferred sites, or the nature of activities on them), scheme development and/or other changes in circumstances. The spring 2011 surveys provide baseline data for newly identified alternative foreshore sites. The additional sites are: Carnwarth Road, Kirtling Street, Heathwall Pumping Station and Chambers Wharf. The surveys also aim to provide further information on the location of smelt spawning habitat in the Battersea area.

4.3.40 Sampling targeted the period when adult fish (especially smelt) are spawning (April to June), with the further aim of providing further information on the location and extent of spawning habitat. Since it was considered that the area around the CSO discharges was unlikely to offer suitable spawning habitat, additional sites between the CSO locations were selected in the stretch between Putney Bridge and Chelsea Bridge. This is considered to be the most likely spawning area for smelt. These were referred to as ‘Intermediate sites’ 1 to 4.

4.3.41 Further invertebrate surveys were undertaken at Lots Road Pumping Station, Western Pumping Station and Deptford Storm Relief in order to collect additional control samples outside the zone of influence of the CSO discharge at these locations. These sites were selected because they are the largest CSO discharge points (greater than 1Mm³ per year) and therefore were considered likely to have the greatest impact on the ThamesTideway.

The sites surveyed in spring 2011 are presented in Vol 5 Figure 4.3.4 Aquatic ecology – spring 2011 survey locations
(see Volume 1-6 Figures document)

4.3.42 Vol 5 Table 4.3.4 and illustrated in Vol 5 Figure 4.3.4.

Vol 5 Figure 4.3.4 Aquatic ecology – spring 2011 survey locations
(see Volume 1-6 Figures document)

Vol 5 Table 4.3.4 Aquatic ecology surveys spring 2011

<table>
<thead>
<tr>
<th>Site name</th>
<th>Foreshore construction site</th>
<th>River infrastructure site</th>
<th>Improvement site</th>
<th>Fish spawning site</th>
</tr>
</thead>
<tbody>
<tr>
<td>Putney Bridge</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intermediate site 1</td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Bell Lane Creek</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intermediate site 2</td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
</tr>
</tbody>
</table>
4.3.43 The fish surveys were undertaken from a boat and used trawling and seine netting. The invertebrate surveys used air lift sampling and kick sampling. Details of the individual survey methodologies are provided below (para. 4.3.14 to para. 4.3.23). Habitat surveys were also undertaken at new sites.

Spring 2011 – autumn 2011 surveys

4.3.44 A further suite of surveys have been undertaken to inform the assessment of potential hydrodynamic effects associated with the permanent and temporary structures on juvenile fish. A numerical modelling technique, based on the existing hydraulic model for the Tideway is proposed in order to assess the combined effects of all construction sites operating simultaneously. Further information regarding the model is presented in paras. 4.4.68 to 4.4.71.

4.3.45 Data regarding the distribution of juvenile fish in key intertidal habitats is required in order to inform the proposed model. The aim of the juvenile fish survey is to examine seasonal changes in the spatial distribution of juvenile fish in the Thames Tideway, particularly in the context of migratory behaviour and the need of juvenile fish to pass foreshore construction sites.

4.3.46 In order to survey the foreshore a multi-method fish survey program has been adopted with the following integrated mix of sampling methods:

<table>
<thead>
<tr>
<th>Site name</th>
<th>Foreshore construction site</th>
<th>River infrastructure site</th>
<th>Improvement site</th>
<th>Fish spawning site</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carnworth Road</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kirtling Street</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Heathwall Pumping Station</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lots Road Pumping Station</td>
<td></td>
<td></td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Intermediate site 3</td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Western Pumping Station</td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Chambers Wharf</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Deptford Storm Relief PS</td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Greenwich PS</td>
<td>✓</td>
<td></td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Abbey Mills</td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
</tr>
</tbody>
</table>

* fish, invertebrate and habitat
a. seine netting,
b. Riley push-netting
c. kick-sampling.

4.3.47 These techniques have been adopted from similar surveys carried out by the Environment Agency on the Thames Tideway\textsuperscript{25}. These methods are described below.

4.3.48 Surveys have been undertaken at five sites in the Tideway from the tidal limit at Kew to King Edward Memorial Park. The sites have been selected based on two criteria:

a. to provide data from a selection of representative habitat types
b. to target a selection of sites where there will be works on the foreshore.

4.3.49 A series of six surveys have been undertaken, covering each of the five sites, from May 2011 until September 2011. The findings of the surveys will be analysed and reported in the ES.

4.4 Assessment methodology

General

4.4.1 The methodology is based on the standard approach to ecological impact assessment as defined by the IEEM guidance (2006)\textsuperscript{26} and (2010)\textsuperscript{27}. The methodology has been developed and agreed with consultees for previous projects relating to the Thames Tideway, such as the Lee Tunnel and Beckton, and Crossness Sewage Treatment Works improvements.

4.4.2 The methodology consists of evaluating receptors within a defined geographical scale. The approach to evaluating receptors is described in para. 4.4.28 and the criteria for evaluation presented in Vol 5 Table 4.4.2. For the purposes of this assessment, the term ‘impact’ is used to describe a force which exerts an influence on a receptor, whilst ‘effects’ are the response of a receptor to an impact.

4.4.3 The approach to mitigation within the assessment will be informed by the ‘Mitigation and Compensation Hierarchy’ discussed with the Thames Tunnel EA Biodiversity Working Group as a systematic and transparent decision-making process. The hierarchy is sequential and seeks to avoid adverse environmental effects. The hierarchy of ‘avoid effect’, ‘minimise’, ‘control’, ‘compensate’, and ‘enhance’ will be strictly applied in this sequence. The mitigation hierarchy is described in detail in Appendix A.

4.4.4 The following section describes the approach to assessment of effects for an individual site during the construction and operational period. In general the approach to assessment of construction and operational effects is the same. Project-wide effects are dealt with separately in paras. 4.4.61 to 4.4.74.

4.4.5 The approach to assessing effects for each individual receptor is described below. A summary of effects relevant to each receptor is presented in Vol 5 Table 4.4.1.
Habitats

4.4.6 Habitats have been evaluated based on their designation status and intrinsic value. The assessment at a site specific level considers the magnitude of losses from individual habitat types due to landtake and disturbance.

Mammals

4.4.7 Mammals have been evaluated at each site according to the protection status of species recorded at the site relative to the frequency of records for individual species, and the potential for the site to support any specific features of importance, such as haul out areas for seals. It takes into account the use of the whole Thames Tideway as a migratory pathway.

4.4.8 Effects include disturbance and the potential for interference with migratory movements. The level of effect has been based on the importance of the receptor, and the magnitude, duration and seasonal timing of the impact.

Fish

4.4.9 Fish have been evaluated according to the protection status of species recorded at the site, and the diversity and abundance of the fish community. Physical factors such as salinity which may limit fish distribution have been considered when putting communities in context.

4.4.10 Effects include direct mortality, loss or degradation of feeding and spawning habitat, disturbance, and interference with migratory movements. Losses from habitats have been considered in the context of the importance and availability of the habitat for an individual species. Interference with migratory movements will be judged using hydraulic data showing extent of change in velocities in intertidal and subtidal areas.

Invertebrates

4.4.11 Invertebrates have been evaluated based on rarity status and diversity, and abundance of communities. The presence of pollution sensitive species has been used as a measure of value.

4.4.12 Losses from habitats will be considered in the context of the importance and availability of the habitat. Benefits have been assessed in terms of predicted changes in community abundance and composition. Individual species and groups considered either to be indicators of pollution or of recovering conditions have been highlighted at the site specific and project-wide level.

Algae

4.4.13 Algal communities will be evaluated according to species rarity status and overall habitat value. Algal ‘mats’ form important habitats for fish and invertebrates and their value, is recognised in the Tidal Thames Biodiversity Action Plan. The valuation of algal communities will be reported in the ES.
Vol 5 Table 4.4.1 Aquatic ecology - impacts on individual receptors

<table>
<thead>
<tr>
<th>Impact</th>
<th>Receptor</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Habitats</td>
</tr>
<tr>
<td>Landtake (temporary and permanent)</td>
<td>✓</td>
</tr>
<tr>
<td>Disturbance and compaction</td>
<td>✓</td>
</tr>
<tr>
<td>Change to hydrodynamic regime</td>
<td>✓</td>
</tr>
<tr>
<td>Disturbance due to waterborne noise and vibration</td>
<td>✓</td>
</tr>
<tr>
<td>Increase in suspended sediment</td>
<td>✓</td>
</tr>
<tr>
<td>Spillage of light into riverine habitat</td>
<td></td>
</tr>
<tr>
<td>Constriction of the channel</td>
<td>✓</td>
</tr>
<tr>
<td>Improvement of local water quality</td>
<td>✓</td>
</tr>
</tbody>
</table>

Construction and operation effects

Assessment cases and years

4.4.14 The generic assessment cases are described in Section 2. The following section describes the specific approach for aquatic ecology receptors.

Base case

4.4.15 The base case for assessment will be a future case, without the project, in any particular assessment year.

4.4.16 The base case conditions can be assumed to be identical to the current baseline established from the data sources outlined in Section 4.2 as the intertidal and riverine habitats/species in the Thames Tideway are unlikely to change significantly between the time of baseline establishment and the start of construction despite predicted increases in wastewater and storm water flows over the same period. There will be improvements to the main Thames Tideway sewage treatment works and the Lee Tunnel scheme during this period, but the benefits of these schemes are not anticipated until Year 1 of operation.

Development case

4.4.17 A development case is a future case during either the construction or operation of the project in the same assessment year as the equivalent base case. The assessment typically considers the 'development case' compared with the 'base case' in any particular assessment year (see below).
Assessment years: construction

4.4.18 For aquatic ecology the assessment of construction effects generally will be based on Year 1 of construction in which site establishment is taking place when river based activities, such as piling and dredging are at a peak, since these activities carry the greatest risk of effects. The assessment of aquatic ecology effects compares the base case and the development case in this year.

Assessment years: operation

4.4.19 The assessment years for the operational assessment are Year 1 of operation, when the project becomes operational and Year 6 of operation when it is considered that there would have been a measurable recovery of fish and invertebrate communities. The assessment of aquatic ecology compares the base case and the development case in these years.

4.4.20 The base case conditions in the Thames Tideway in Year 1 and Year 6 of operation are expected to have undergone a recovery as a result of the Lee Tunnel scheme and upgrades at the main Tideway sewage treatment works (STW) at Mogden in the upper Tideway and Beckton and Crossness in the mid Tideway. The Lee Tunnel scheme will intercept the CSO at Abbey Mills, which accounts for nearly half of the CSO discharges to the Thames Tideway. The STW upgrades will improve the quality of the treated effluent entering the Tideway. As a result of the Lee Tunnel and sewage treatment works upgrade schemes there will be a significant reduction in the occurrence of summer fish-kill events resulting from low dissolved oxygen (hypoxia), and the enhanced dissolved oxygen conditions will improve the ability of fish to migrate through the Tideway. Changes in invertebrate communities are anticipated to be less marked, but will include an increase in the occurrence of pollution sensitive species and an increase in the diversity of invertebrate communities.

4.4.21 However, apart from the Abbey Mills CSO, these schemes will not stop the CSO discharges into the river. Thus improvements in the local area of the other CSO discharges will be limited and the increases in dissolved oxygen concentration required for the Thames Tideway to meet WFD standards will not be achieved.

4.4.22 The assessment considers effects on receptors within the local area which is defined as 100m up and downstream of the discharge point. The contribution that interception of this discharge makes to receptors at a Thames Tideway wide scale is considered in Volume 6 (Project-wide assessment). Further assessment years are also considered within Volume 6, as described in para. 4.4.63.

Assessment areas

4.4.23 The following section includes the approach to defining the spatial scope, or assessment area for each site, for the aquatic ecology assessment.

4.4.24 The assessment area for an individual site encompasses an area in which there is potential for direct and indirect effects on all relevant receptors. Direct effects are those which arise as a direct consequence of an impact, such as the landtake causing the loss of habitat. An example of an
indirect effect would be the displacement of fish from a site as a result of loss of habitat causing competition for resources elsewhere.

4.4.25 For construction, the assessment area will be defined by the outer extent of any landtake (either permanent or temporary), plus an area considered through professional judgement to be subject to indirect change (e.g., due to hydraulic changes arising from the construction works). For the purposes of this assessment this is considered to be a total of 100m up and downstream of the maximum working area.

4.4.26 At sites where direct impacts are anticipated outside the maximum working area (e.g., from dredging, or scour or deposition arising from it), a 100m zone will be drawn around these additional impact areas.

4.4.27 Predicting the effects arising from all construction sites in operation simultaneously is particularly relevant for mobile receptors such as fish and mammals, since they are likely to encounter and respond to multiple sites during a single migration. These effects will be addressed in Volume 6 (Project-wide assessment). The approach to the project-wide assessment, including the specific techniques used to assess cumulative and in combination effects are described in paras. 4.4.61 to 4.4.74.

Defining resource value / receptor sensitivity

4.4.28 An ecological resource is defined as a site or area of nature conservation value (i.e., EM, 2006)\(^1\). Each site/area may have more than one feature of value that it supports (for example different habitats or populations and/or communities of species). Individual ecological resources and the features that comprise each resource are evaluated according to generally accepted criteria, including designation and protection status. To attain each level of value or importance, an ecological resource or feature should meet the criteria set out below. In some cases, professional judgement may be required to increase or decrease the allocation of specific value. This judgement is based on consideration of the following additional criteria:

a. population trends
b. sustainability of resource
c. representativeness
d. potential for substitution/re-creation
e. position in the ecological unit
f. biodiversity value.

4.4.29 The legislation relating to site and species protection is described below. The scale used to evaluate receptors is presented in Vol 5 Table 4.4.2. The criteria are based on the IEEM Guidelines\(^1\) with reference to methodologies developed for previous Thames Tideway projects\(^28,29\):

EU Habitats Directive (92/43/EEC)

4.4.30 The main aim of the Habitats Directive is to promote the maintenance of biodiversity by requiring Member States to take measures to maintain or
restore natural habitats and wild species listed on the Annexes to the Directive at a favourable conservation status.

4.4.31 The provisions of the Directive require Member States to introduce a range of measures, including:

a. maintain or restore European protected habitats and species listed in the Annexes at a favourable conservation status as defined in Articles 1 and 2

b. contribute to a coherent European ecological network of protected sites by designating Special Areas of Conservation (SACs) for habitats listed on Annex I and for species listed on Annex II. These measures are also to be applied to Special Protection Areas (SPAs) classified under Article 4 of the Birds Directive. Together SACs and SPAs make up the Natura 2000 network (Article 3)

c. ensure conservation measures are in place to appropriately manage SACs and ensure appropriate assessment of plans and projects likely to have a significant effect on the integrity of an SAC.


4.4.32 The Water Framework Directive commits EU member states to achieve good qualitative and quantitative status of all water bodies (including marine waters up to one kilometre from shore) by 2015.

4.4.33 The Directive defines 'surface water status' as the general expression of the status of a body of surface water, determined by the poorer of its ecological status and its chemical status. Thus, to achieve 'good surface water status' both the ecological status and the chemical status of a surface water body need to be at least 'good'. Ecological status refers to the quality of the structure and functioning of aquatic ecosystems of the surface waters. Water is an important facet of all life and the Water Framework Directive sets standards which ensure the safe access of this resource.

4.4.34 The Directive requires the production of a number of key documents over six year planning cycles. Most important among these is the River Basin Management Plans, to be published in 2009, 2015 and 2021.


4.4.35 This is the principal piece of legislation in the UK in terms of wildlife protection. It translates the Convention on the Conservation of European Wildlife and Natural Habitats (the Bern convention) into UK law. There are two main aspects, namely the re-designation of Sites of Special Scientific Interest (SSSI) and species protection.

4.4.36 Species protection applies to aquatic invertebrates (including tentacled lagoon worm) and marine mammals (all dolphins and porpoises).

4.4.37 These species are protected from:

a. killing, injuring or taking
b. damage to, destruction of, obstruction of access to any structure or place used by a scheduled animal for shelter or protection

c. disturbance of animal occupying such a structure or place.

4.4.38 The Act also applies to some fish species, but does not include species found with regularity in the Thames Tideway.

**Countryside and Rights of Way (CroW) Act 2000**

4.4.39 The CRoW Act only applies to England and Wales. The CRoW Act does not actually provide any legal protection itself, rather it makes amendments to the Wildlife and Countryside Act. It strengthens the provisions of the Wildlife and Countryside Act (1981) in several key areas:

a. strengthening of SSSI protection

b. the inclusion of reckless in addition to the intentional nature of offences listed within parts of Wildlife and Countryside Act 1981

c. a further requirement on the Government to have regard for biodiversity and to take positive steps to further the conservation of species and habitats listed in the Convention on Biological Diversity.

**Natural Environment and Rural Communities Act (2006)**

4.4.40 This act places a requirement on all public bodies to have regard for biodiversity and tasks the Government to take positive steps to further the conservation of species and habitats listed in the Convention on Biological Diversity.

4.4.41 Section 41 identifies key UK habitats and species. These form the UK Biodiversity Action Plan. Section 40 identifies that local authorities must 'have regard' for such habitats and species. Sites of Importance for Nature Conservation are designated in line with Section 41.

**Marine and Coastal Access Act 2009**

4.4.42 The Act creates a network of Marine Conservation Zones to protect some of the UK’s most important marine species and habitats, overseen by a Marine Management Organisation. This body will determine licensing decisions in line with the streamlined Marine Plan.

**Eels (England and Wales) Regulations 2009**

4.4.43 The Regulations implement EC Council Regulation 1100/2007 which establishes measures for the recovery of European eel stocks. Eleven Eel Management Plans have been prepared relating to each of the River Basin Districts in England and Wales established under the Water Framework Directive. The overall objective is to achieve a target of ensuring that 40% of adult eels are able to return to the sea to spawn.

**UK Biodiversity Action Plan**

4.4.44 This is the UK Government's response to the Convention on Biological Diversity (1992). It describes the country’s important biological resources and has resulted in the production of detailed plans for the protection of key habitats and species.
<table>
<thead>
<tr>
<th>Receptor value and/or sensitivity</th>
<th>Definition</th>
</tr>
</thead>
</table>
| Very High (International)        | An internationally designated site or candidate site (SPA, pSPA, SAC, cSAC, pSAC, Ramsar site and Marine Conservation Zones).  
A substantial proportion (eg, 1%) of the international resource of a habitat listed in Annex I of the Habitats Directive.  
Water bodies designated under the Freshwater Fisheries Directive (2006/44/EC).  
A substantial proportion of the international resource of an internationally important species or site supporting such a species (or supplying a critical element of their habitat requirement).  
UK Red Data Book species\(^\text{31}\) listed as occurring in 15 or fewer 10 km squares in the UK, that is of unfavourable conservation concern in Europe or of uncertain conservation Status or global conservation concern in the UK BAP.  
Species listed in Annex II or Annex IV of the Habitats Directive. |
| High (National)                  | A nationally designated site (SSSI, ASSI, NNR, Marine Nature Reserve) or a discrete area, which meets the selection criteria for national designation (eg, SSSI selection criteria).  
A substantial proportion (eg, 1%) of the UK resource of a habitat listed in Annex I of the Habitats Directive or the UK BAP.  
A substantial proportion of a nationally important species or site supporting such a species (or supplying a critical element of their habitat requirement) e.g.: European eel which receives protection under the Eels (England and Wales) Regulations 2009.  
Species listed on Schedules 5 and 8 of the WCA (1981).  
Other UK Red Data Book species.  
Other species listed as occurring in 15 or fewer 10km squares in the UK. |
| High Medium (Regional)           | Sites/populations which exceed the County-level designations but fall short of SSSI selection guidelines, including the following:  
A substantial proportion of the regional resource of a UK BAP habitat or a key habitat identified in a Regional BAP. |
<table>
<thead>
<tr>
<th>Receptor value and/or sensitivity</th>
<th>Definition</th>
</tr>
</thead>
</table>
| **Medium (Metropolitan)**       | Some designated sites (including SNCI, County Wildlife Sites, Sites of Metropolitan Importance), Local Nature Reserves.  
A substantial area of habitat identified in the County BAP.  
Substantial populations of the following species:  
Species listed in a County/Metropolitan “red data book” or BAP on account of its rarity/localisation in a county context.  
Sites supporting 1% or more of a county population. |
| **Low-Medium (Borough)**        | Some designated sites (Local Nature Reserves, Sites of Borough Importance).  
Viable areas of habitat identified in a District/Borough BAP.  
Sites/features that are scarce within the District/Borough or that appreciably enrich the District/Borough habitat resource.  
Sustainable populations of the following species:  
Species listed in a District/Borough BAP on account of its rarity/localisation in a district context, or Sites supporting 1% or more of a District/Borough population. |
| **Low (Local)**                 | Sites/populations, which appreciably enrich the local habitat resource. |
| **Negligible**                  | No significant ecological value. |
**Impacts and effects**

4.4.45 Details of the general methodology used within the Environmental Impact Assessment are presented in Section 2.

**Determining magnitude of impacts**

4.4.46 No standard methodology exists for determining and describing the magnitudes of ecological impacts. The IEEM Guidelines (2006\(^26\); 2010\(^32\)) identify a number of parameters which should be considered in defining impact magnitude including extent, duration, reversibility, timing and frequency. The impact magnitude criteria presented below have been developed for previous aquatic ecology assessments and reviewed specifically for this project. The terms high negative, medium negative, low negative, negligible, low positive, medium positive, and high positive are used to assess the magnitude of the impact on receptors. The impact magnitude criteria are presented in the table below.

Vol 5 Table 4.4.3 Aquatic ecology - impact magnitude criteria

<table>
<thead>
<tr>
<th>Impact magnitude</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>High Negative</td>
<td>Disruption of ecosystem functioning, with loss of species and loss of diversity. Changes may be long lasting (greater than 10 years) or permanent, particularly if loss or major alteration of wildlife habitat occurs. Recovery, if possible, is likely to take more than 5 years. Results in permanent loss of attributes.</td>
</tr>
<tr>
<td>Medium Negative</td>
<td>Qualitative or smaller scale quantitative change occurs. The abundance of some of the more sensitive species may be reduced. Changes in habitat may be longer lasting (7 – 10 years). Impact is substantially reversible, although recovery may take 1 to 5 years following cessation of impact.</td>
</tr>
<tr>
<td>Low negative</td>
<td>Some changes in species/habitat abundance may occur, but the impact is reversible. Full recovery is likely in the short term, (up to 1 year), following the cessation of impact.</td>
</tr>
<tr>
<td>Negligible</td>
<td>The chance of any impact is very low and if it occurs it is well below the level of detection.</td>
</tr>
<tr>
<td>Low Positive</td>
<td>Some increases in species abundance may occur but such changes are relatively local</td>
</tr>
<tr>
<td>Medium Positive</td>
<td>Qualitative change occurs. The abundance of some of the more sensitive species increases more widely. Changes in habitat should be longer lasting and less prone to detrimental impacts.</td>
</tr>
<tr>
<td>High Positive</td>
<td>Substantial change of ecosystem functioning, with gain of species and gain of diversity, notably rarer more sensitive species. Changes should generally be long lasting or permanent</td>
</tr>
</tbody>
</table>
4.4.47 For the site specific assessments impact magnitudes for the construction and operational stage will be applied in accordance with the criteria in Vol 5 Table 4.4.3. At the project-wide level, where there is the potential for more complex effects across all of the Thames Tunnel sites, modelling and simulation techniques will be used to predict effects. This is described in paras. 4.4.61 to 4.4.74 below.

**Defining effects**

4.4.48 Ecological effects will be described separately for each individual receptor, and any interactions between receptors highlighted (eg, between benthic invertebrates and waterfowl). The significance of effects will be determined using the matrix presented in Vol 5 Table 4.4.4, in which the value of the receptor is combined with the magnitude of the impact to give a level effect. The matrix has been developed and tested on a variety of ecological impact assessments, including three major schemes on the Thames Tideway.

4.4.49 The assessment will consider all types of effects, including:

- direct and indirect effects
- short term (less than 12 months), medium term (1 – 5 years) and long-term (+ 5 years) effects
- permanent and temporary effects
- beneficial and adverse effects
- In combination effects.

4.4.50 Professional judgement used to determine whether an in combination effect will occur. The approach to assessing in combination effects is described in paras. 4.4.58 and 4.4.59.

4.4.51 The probability of an effect occurring, and confidence in the prediction will be expressed using an objectively defined scale such as the following:

- certain/near-certain: probability estimated at 95% chance or higher
- probable: probability estimated above 50% but below 95%
- unlikely: probability estimated above 5% but less than 50%
- extremely unlikely: probability estimated at less than 5%.

4.4.52 The types of effects and the probability and confidence associated with the prediction outlined above are taken from the IEEM guidelines (2006\textsuperscript{26}; 2010\textsuperscript{27}).

4.4.53 Residual effects will be those remaining following mitigation at a site specific and project-wide level. Residual effects will be determined once all assessments are complete.

**Determining the significance of effects**

4.4.54 Taking the value of the receptor and magnitude of impact into account, these criteria can be combined to produce an overall evaluation of whether an effect is significant, as indicated in the following matrix (Vol 5 Table 4.4.4). Although the matrix is intended as a guide, it should not be applied
rigidly without ecological judgment. There may be instances in which the particular circumstances justify a deviation from this table. In all instances such a deviation will be explained in the assessment text.

Vol 5 Table 4.4.4 Aquatic ecology - significance of effect matrix

<table>
<thead>
<tr>
<th>Magnitude of Impact</th>
<th>Receptor Value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Very High (International)</td>
</tr>
<tr>
<td>High (Positive or Negative)</td>
<td>Major</td>
</tr>
<tr>
<td>Medium (Positive or Negative)</td>
<td>Major</td>
</tr>
<tr>
<td>Low (Positive or Negative)</td>
<td>Major/Moderate</td>
</tr>
<tr>
<td>Negligible</td>
<td>Negligible</td>
</tr>
</tbody>
</table>

Cumulative, in combination and compound effects

4.4.55 The general approach to assessing cumulative, in combination and compound effects is described in Section 2 of this volume. The specific approach for aquatic ecology is described below.

Site cumulative effects

4.4.56 The assessment of site cumulative effects will consider the potential for effects arising from a single Thames Tunnel site to accumulate with effects from other non Thames Tunnel river based developments. This will be particularly important for mobile receptors such as fish which may experience a series of impacts during a single migration. In assessing the potential for cumulative effects consideration will be given to:

a. the scale, number and proximity of the other development(s)
b. the timing of the construction period in relation to the Thames Tunnel site
c. the nature of the construction activity
d. the sensitivity of receptors within the assessment area for that site.

4.4.57 The magnitude of impacts will be scaled using the significance criteria approach discussed in Section 2.

In combination effects

4.4.58 In combination effects arise when impacts from more than one topic act in combination on a receptor, potentially giving rise to a significant effect. For aquatic ecology, this could include noise and vibration combining with increased water column turbidity preventing fish from migrating past a site.
4.4.59 Effects will first be considered in isolation and professional judgement used to determine whether an in combination effect could occur. The significance of any in combination effects will be determined using the matrix in Vol 5 Table 4.4.4.

**Compound effects**

4.4.60 Compound effects may occur where effects arising at two or more Thames Tunnel sites combine (or compound) to give rise to a greater localised impact on a specific receptor than would be expected from simply summing the impacts from a single site. An example of a compound effect would be where a series of Thames Tunnel sites affect spawning habitat for a particular fish species. Since this is a limited, but essential resource for the species, the effect could be the loss or partial loss of a population.

**Project-wide effects**

4.4.61 The general approach to assessment of project-wide effects is presented in Section 2. Specific methodologies relating to aquatic ecology are described below.

4.4.62 The area for the project-wide assessment includes the complete extent of the Thames Tideway from the tidal limit at Teddington Weir to the inner limit of the outer Thames Estuary.

4.4.63 The assessment year for construction is taken to be Year 1 of construction with all sites active and those activities with the greatest potential for impacts such as piling will be taking place. There will be three assessment years for the operational assessment: Year 1 when the project becomes operational; Year 3 when it is considered that there would have been a measurable recovery of fish and invertebrate communities; and 2080, to take account of changes which may result from climate change. This corresponds with the assessment years used for the surface water assessment. The assessment of aquatic ecology effects compares the base case and the development case in these years. The assumptions regarding base case conditions outlined in para. 4.4.15 apply for the project-wide assessment.

4.4.64 Project-wide effects are those effects on a receptor, eg, a fish species that could arise from all (or the majority of Thames Tunnel sites). The same method will be used to scale the magnitude of impacts and evaluate resources as for the site specific assessments (Vol 5 Table 4.4.2 - Vol 5 Table 4.4.4).

4.4.65 The project-wide assessment will capture cumulative, in combination and compound effects on aquatic ecology receptors arising from:

a. all of the Thames Tunnel foreshore sites under simultaneous construction

b. the river wide effects arising from interception of all CSO discharges

c. the effects of other in-river developments in cumulation with the Thames Tunnel sites.

4.4.66 The approach to assessing project-wide effects is described below for fish and invertebrates.
Fish

4.4.67 One of the potential impacts on fish populations is the interference to juvenile fish migrations by the encroachment of permanent and temporary structures into the intertidal zone. Juvenile fish depend on this zone for shelter from strong tidal currents and as a refuge from predatory adult fish.

4.4.68 At a site specific level it is possible to predict effects on juvenile fish migrations using professional judgement informed by the proposed hydraulic footprint of the site. For the project-wide assessment of the hydrodynamic impacts on fish an additional approach will be adopted in which numerical modelling techniques will be used to simulate the response of fish populations to a series of structures encroaching into the channel. Since this is a relatively novel technique for ecological impact assessment in the UK a literature review has been undertaken in order to identify the most appropriate modelling technique. The review is presented in Appendix B.

4.4.69 The approach which has been selected is a mechanistic model of fish behaviour applied to a moving flow field (fluvial/tidal flow) known as Individual Base Modelling (IBM). The base hydraulic model is the major part of an IBM, and this already exists for the Thames Tideway in the form of the Tunnel Project’s Telemac model, which can be run for the base case (‘without development’) or with temporary and permanent new structures in place. IBMs have a further advantage in providing cinematic outputs showing the movements of fish in accelerated time, making it easy to portray results to a wide audience. The model is under development and outputs from it will be incorporated into the ES. The juvenile fish surveys described in Section 4.2 will inform the Individual Base Model being developed to predict the hydrodynamic impacts on fish.

4.4.70 Prediction of the benefits of the water quality improvements of the project on fish populations will be based on outputs from the Tideway Fish Risk Model (TFRM). The TFRM was developed on behalf of Thames Water, in agreement with the Environment Agency, as a tool to improve understanding of the response of fish to low dissolved oxygen events (‘hypoxia’) and to help develop new dissolved oxygen standards for the Thames Tideway. The model has been run for a series of water quality improvement scenarios, including interception of all the Thames Tideway CSOs by means of a Tunnel.

4.4.71 The assumptions of the TFRM and the baseline data on which it was based have been revisited as part of the operational assessment for this project. For example, the model is based on Environment Agency monitoring data, which is based on a limited number of sites. Baseline surveys for the project cover a wider range of sites, and hence have helped to improve the accuracy of the model. A description of the model and examples of outputs from it for previous Thames Tideway Quality Improvement projects such as the Lee Tunnel are included in Volume 6. Outputs from the model based on the current scheme will be presented in the ES.
Invertebrates

4.4.72 The project-wide assessment of effects on invertebrates will use the Environment Agency background data set, as well as data collected for this project to identify temporal trends in species abundance and diversity. For example, a general improvement in the water quality of the Thames Tideway has been accompanied by increasing diversity in invertebrate communities. These trends will be described in the future base case.

4.4.73 Impacts on invertebrates at a project-wide scale will include cumulative loss of foreshore habitat, and possible water quality effects from dredging. The effects will be assessed using professional judgement and will focus on the losses from habitats such as mud flat which are known to support a greater abundance and diversity of invertebrate species. Information from the water quality model relating to reductions in discharge volume and changes in nutrient levels throughout the estuary will be used as a basis for predicting changes in invertebrate communities arising from the project.

4.4.74 A description of the existing and future baselines for invertebrates is contained in Volume 6. The assessment of construction and operational effects at the project-wide scale will be included in the ES.

Assumptions and limitations

4.4.75 A series of general assumptions and limitations are included in Section 2. Site specific assumptions and limitations are contained with the site specific assessment volumes (Volumes 7 – 28).

4.4.76 Specifically for aquatic ecology, Environment Agency baseline data for invertebrates does not include a continuous record for all sites within the Tideway. This means that any observations regarding trends in species distribution and abundance over time are indicative.

4.5 Approach to mitigation

4.5.1 The general approach to mitigation is described in Appendix A.

Construction

4.5.2 Where foreshore sites have been selected the aim has been to minimise the area of landtake from riverine habitats by locating as much of the construction infrastructure on land as possible. Where environmental design changes have already been made to the site or layout which reduces impacts on aquatic ecology receptors, this is described in Section 5 of the site assessment volumes (Volumes 7 – 28).

4.5.3 For all sites, measures to control and minimise construction impacts such as waterborne noise and vibration, and water pollution, are included within the draft Code of Construction Practice Part A. This document is part of the project and it is not considered under mitigation.

4.5.4 Mitigation for other possible construction stage effects such as the interference with juvenile fish migration as a result of the encroachment of temporary structures into the channel are currently under development.
This will be informed by the outcome of the site specific and project-wide assessments and reported in the ES.

4.5.5 In agreement with the Biodiversity Working Group a balance sheet will be prepared presenting losses from individual habitats associated with temporary and permanent landtake, and other area based impacts (such as compaction and dredging). This will be used as a basis for quantifying the requirement for habitat compensation.

Operation

4.5.6 The operational effects of the project on aquatic ecology receptors are would be beneficial and will represent an enhancement to the Thames Tideway. There will be permanent landtake at a site specific and project-wide scale. The approach to compensation for habitat losses will be considered at a site specific and project-wide level. The relative losses of individual habitats as presented in the balance sheet discussed above will inform the approach to compensation as required. The approach to compensation will be guided by general principles to be agreed with the Biodiversity Working Group.
5 Ecology - terrestrial

5.1 Introduction

5.1.1 This section sets out the full EIA methodology for the assessment of terrestrial ecology effects associated with the Thames Tunnel project. Work which has not been fully completed for the PEIR will be completed for the ES, and this is noted below and within each site specific assessment volume.

5.1.2 The assessment includes all ecological receptors above mean high water level with the exception of wintering birds, which can forage on the foreshore below mean high water level.

5.1.3 The PEIR terrestrial ecology assessment identifies how ecological receptors (key resources and features) of each of the sites are likely to be significantly affected by the construction and operational phases of the Thames Tunnel (as described in Volume 2) where seasonal surveys have been completed and analysed.

5.1.4 Through a process of iterative design development, ecological measures have been incorporated into the project. Where significant ecological effects are still likely, mitigation has been proposed to reduce these effects.

5.2 Scoping Opinions and technical engagement

5.2.1 A summary of scoping and technical engagement undertaken in relation to terrestrial ecology is contained in Volume 4, Sections 3.5 and 4.5.

5.3 Baseline data collection methodology

Desk based baseline data

5.3.1 Information on ecological resources has been obtained from a range of primary and secondary sources. Where stakeholders have informed us of possible sources of data, the need for this data has been assessed and the data has been requested where appropriate. The data sources have included the following:

a. aerial photographs
b. data search from Greenspace in Greater London (GiGL), which acts as a central source for collated biological records information from London’s local authorities, statutory and non-statutory agencies, non-governmental organisations, private companies and individuals
c. existing survey reports and publications, where available
d. internet based data sources and general searches
f. London Biodiversity Action Plan and individual Borough Biodiversity Action Plans
g. local, regional and national policy documents.
5.3.2 A full list of data sources is provided in Vol 5 Table 5.3.1.
<table>
<thead>
<tr>
<th>Source</th>
<th>Data</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Satellite imagery 4 band pansharpened 50cm resolution. GeoEye (2008)</td>
<td>Aerial photographs and images used to identify habitats and features of interest, and to plan surveys</td>
<td>For initial ecology baseline assessment</td>
</tr>
<tr>
<td>Satellite imagery 4 band pansharpened 60cm resolution. Ikonos (2009)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Greenspace in Greater London (GiGL)</td>
<td>Electronic records for notable species within 500m and habitats within 2km of the all sites</td>
<td>To identify sensitive ecology receptors</td>
</tr>
<tr>
<td>Tidal Thames Habitat Action Plan. Thames Estuary Partnership (2002).</td>
<td>Details of the Tidal Thames habitats and the species they support. Action targets to maintain and improve the habitats within the Tidal Thames</td>
<td>To identify sensitive ecology receptors and to inform mitigation and enhancement measures</td>
</tr>
<tr>
<td>London Biodiversity Action Plan. London Biodiversity Partnership (2011)</td>
<td>Lists of priority species and habitats within the Greater London area, their status and action targets to protect and enhance priority habitat and species</td>
<td>To identify sensitive ecology receptors and to inform mitigation and enhancement measures</td>
</tr>
<tr>
<td>Local Borough Biodiversity Action Plans</td>
<td>Distribution and status of priority species and habitats within the Borough and targets for their protection and enhancement</td>
<td>To identify sensitive ecology receptors and to inform mitigation and enhancement measures</td>
</tr>
<tr>
<td>London Wildlife Trust Biodiversity Recording Project. Black Redstart Locations [London]. London Biodiversity Partners (website)(2001)</td>
<td>Distribution of black redstarts across London in 2001. This is a general guide and further data has been provided by GiGL</td>
<td>To identify sensitive ecology receptors</td>
</tr>
<tr>
<td>NBN Gateway. National Biodiversity Network (website) (2011)</td>
<td>Relevant protected species distribution data held by the NBN</td>
<td>To identify sensitive ecology receptors</td>
</tr>
</tbody>
</table>
### Preliminary environmental information report

<table>
<thead>
<tr>
<th>Source</th>
<th>Data</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Lee Tunnel Environmental Statement and Beckton Sewage Treatment Works Extension</strong>&lt;sup&gt;39&lt;/sup&gt;.</td>
<td>Phase 1 Habitat Maps, designated sites and protected species survey data for the area in the vicinity of Abbey Mills Pumping Station and Beckton Sewage Treatment Works</td>
<td>To inform scope of surveys and to augment updated survey data for these sites</td>
</tr>
<tr>
<td><strong>London Wildweb. City of London (website) (2010)</strong>&lt;sup&gt;40&lt;/sup&gt;</td>
<td>Non-statutory sites of importance for nature conservation</td>
<td>To identify sensitive ecology receptors</td>
</tr>
<tr>
<td><strong>Cremorne Gardens Management Plan (2010)</strong>.&lt;sup&gt;41&lt;/sup&gt;</td>
<td>Phase 1 Habitat Survey data for Cremorne Gardens and proposed measures to enhance the site for biodiversity</td>
<td>To identify sensitive ecology receptors and to inform mitigation and enhancement measures.</td>
</tr>
<tr>
<td><strong>Breeding Bird Survey, Cremorne Gardens, Kensington</strong>.&lt;sup&gt;42&lt;/sup&gt;</td>
<td>Breeding bird survey data for Cremorne Gardens, Kensington.</td>
<td>To identify sensitive ecology receptors</td>
</tr>
<tr>
<td><strong>Eaton et al, Birds of Conservation Concern 3: the population status of birds in the United Kingdom, Channel Islands and the Isle of Man. (2009)</strong>&lt;sup&gt;43&lt;/sup&gt;</td>
<td>Conservation status of UK bird species using a red, amber and green list classification system</td>
<td>To value receptors</td>
</tr>
<tr>
<td><strong>British Red Data Books</strong></td>
<td>A series of books and publications relevant to taxa (eg, mammals, invertebrates etc.) indicating those species that are considered to be endangered within the region of the British Isles</td>
<td>To value receptors</td>
</tr>
<tr>
<td><strong>Bullock R., Salmon A &amp; Arbon J. Annual review of management – Breeding Birds Monitoring and Survey Work. Wildfowl and Wetlands Trust (2010)</strong>&lt;sup&gt;44&lt;/sup&gt;</td>
<td>Breeding bird survey data in the vicinity of the WWT London Wetland Centre</td>
<td>To identify sensitive receptors</td>
</tr>
<tr>
<td><strong>Bullock R., Salmon A &amp; Arbon J. Annual review of management – WeBS Birds Monitoring and Survey Work. Wildfowl and Wetlands Trust</strong></td>
<td>Bird survey data in the vicinity of the WWT London Wetland Centre</td>
<td>To identify sensitive receptors</td>
</tr>
</tbody>
</table>
### Source

<table>
<thead>
<tr>
<th>Source</th>
<th>Data</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>(2010)&lt;sup&gt;45&lt;/sup&gt;</td>
<td></td>
<td></td>
</tr>
<tr>
<td>N Tanner, (2009) Raw data from bird surveys&lt;sup&gt;46&lt;/sup&gt;</td>
<td>Bird survey data in the vicinity of the WWT London Wetland Centre</td>
<td>To identify sensitive receptors</td>
</tr>
<tr>
<td>Briggs, P., Bullock R J., &amp; Tovey J D.  <em>Ten years of bat monitoring at the WWT London Wetland Centre – a comparison with National Bat Monitoring Programme trends for Greater London.</em>  Bat Conservation Trust, Wildfowl &amp; Wetlands Trust and London Bat Group (2006)&lt;sup&gt;47&lt;/sup&gt;</td>
<td>Bat monitoring data in the vicinity of the WWT London Wetland Centre</td>
<td>To identify sensitive receptors</td>
</tr>
</tbody>
</table>
Field survey baseline data

5.3.3 The surveys that are reported in the PEIR are summarised in Vol 5 Table 5.3.2. Further notable species surveys have been and will be undertaken as shown in Vol 5 Table 5.3.3. The results of these will be used to inform the continuing assessment and will be reported in the ES. All survey methodologies are described in detail in paras. 5.3.4 to 5.3.26.

Vol 5 Table 5.3.2 Terrestrial ecology - field survey baseline data sources

<table>
<thead>
<tr>
<th>Source</th>
<th>Data</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phase 1</td>
<td>Habitat mapping and notable species potential assessment</td>
<td>See paras. 5.3.4 – 5.3.5</td>
</tr>
<tr>
<td>Habitat Survey</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bat triggering</td>
<td>Bat activity records using remote recording equipment, to determine whether there is sufficient bat activity on site to warrant further surveys.</td>
<td>See section See paras. 5.3.6 – 5.3.11</td>
</tr>
<tr>
<td>survey</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wintering bird surveys</td>
<td>Wintering bird counts to determine species and assemblages.</td>
<td>See paras. 5.3.17 – 5.3.20</td>
</tr>
<tr>
<td>Site</td>
<td>Badger</td>
<td>Bats</td>
</tr>
<tr>
<td>---------------------------------------------------------------------</td>
<td>--------</td>
<td>------</td>
</tr>
<tr>
<td>Acton Storm Tanks (PEG1X)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hammersmith Pumping Station (PHF1X)</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Carnworth Road Riverside</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Barn Elms (PRD1X)</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Putney Bridge Foreshore (PWH1X)</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>King George's Park (PWH3X)</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Dormay Street (C07AF)</td>
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<td>✓</td>
</tr>
<tr>
<td>Kirtling Street (S93WH)</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Heathwall Pumping Station and Tideway Walk (PWH6X)</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Cremorne Wharf (PKC1X)</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Chelsea</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Site</td>
<td>Badger</td>
<td>Bats</td>
</tr>
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<td>----------------------------------</td>
<td>--------</td>
<td>------</td>
</tr>
<tr>
<td>Embankment (PKC2X)</td>
<td></td>
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</tr>
<tr>
<td>Albert Embankment (PLH1X)</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Abbey Mills (PNM2X)</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>King Edward VII Memorial Park</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>(PTH1X)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chambers Wharf (S76SK)</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Earl Pumping Station (PLM1X)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Deptford Church Street (C32XZ)</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Greenwich Pumping Station</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Beckton Sewage Treatment Works</td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>

Preliminary environmental information report
Phase 1 habitat surveys

5.3.4 Phase 1 Habitat Surveys have been undertaken in accordance with the *Handbook for Phase 1 Habitat Survey: A Technique for Environmental Audit*. Joint Nature Conservation Committee (JNCC) (2010 revised edition)\(^{48}\) for all sites. The survey area included all habitats within the site boundary and adjacent habitats that could be affected by the works eg, trees with their roots extending across the site boundary. For some sites, the survey area covers a larger area than the proposed works area. This data has been and will be used to inform the project design.

5.3.5 The surveys were carried out by experienced ecologists. The surveys comprised a walkover of the sites to record notable habitat types, evidence of notable species and the potential for notable species. This data was used in combination with the desk study to identify the need for further more detailed botanical and notable species surveys. The sites and associated surveys are shown in Vol 5 Table 5.3.3.

**Bats**

5.3.6 General survey principles are based upon those from Bat Surveys – Good Practice Guidelines, Bat Conservation Trust (2007)\(^{49}\) and the Bat Workers Manual, Bat Conservation Trust (2004)\(^{50}\). The standard survey methodologies have been adapted to allow for survey effort to be most effectively directed towards features of most likely value to bats. Natural England and the London Borough Councils have been consulted (see Volume 4, Section 4.4).

5.3.7 Following an initial walkover and evaluation of each site, remote recording bat detectors have been installed at those sites with the potential to support roosting and/or foraging and commuting bats, in order to monitor general bat activity. The detectors have been secured and left in place to record for three consecutive nights between May and July 2011. This data has then been analysed to reveal the level and type of bat activity present at each site, which has been reported in summary within the site specific volumes as appropriate (Volumes 7 – 28).

5.3.8 Criteria have been applied to the data to assess whether further bat surveys are needed based on whether there is evidence of:
   a. a roost on or near the site
   b. a considerable level of bat activity
   c. notable species on site.

5.3.9 Further surveys are considered necessary when any of the following criteria are met:
   a. registrations occur within 30 minutes of sunset and 1 hour of sunrise (which would be suggestive of roost locations on site or nearby).
   b. Greater than 50 registrations are made at any one Anabat location on a site overnight
   c. species other than common pipistrelle Pipistrellus pipistrellus and soprano pipistrelle Pipistrellus pipistrellus (which are by far the most abundant species in the region) are recorded.
5.3.10 The threshold of less than 50 registrations within a night was determined using a combination of professional judgement and the median value of registrations at all sites, as there is no standard guidance on specifically what might constitute ‘considerable bat activity’. The relative levels of activity between the sites were reviewed, once all the results became available, and knowledge of the number of bat passes generally recorded during surveys of other sites was used in defining this threshold. The mean value of 143 registrations has been skewed by the very high numbers at Barn Elms, whilst the median value of 64 appears to be closer to an appropriate threshold level.

5.3.11 Where the need for further survey was identified, a dawn survey has been undertaken between June and September 2011 using hand-held recording bat detectors. The results of these further surveys will be reported in the ES.

**Badgers**

5.3.12 The badger surveys have followed the standard methodology detailed in Harris S., Cresswell P. and Jefferies D. *Surveying Badgers*, Mammal Society (1989)\(^5\). This comprised a single visit to search for signs of badger presence, including setts, established foraging paths, footprints, hairs and dung pits/latrines within areas of suitable habitat such as grassland, including lawns and pasture, patches of scrub, woodland and along the bases of hedgerows.

5.3.13 All signs of badgers found have been mapped in order to establish patterns of activity across the wider site (and beyond, where possible to do so). Should badger presence be confirmed and a number of different sett locations identified, badger bait marking surveys may be necessary to establish whether the activity relates to a single clan (family group) or a number of independent clans. Coloured pellets coated in peanut butter will be placed around the entrances of the badger setts. If these are then later found within badger latrines around the site and indicate territory boundaries and badger clan (extended family) groupings.

**Birds**

**Black redstart**

5.3.14 Black redstart surveys have been undertaken during 2011 in line with guidance provided in Gilbert, G., Gibbons DW & Evans J. *Bird Monitoring Method*, RSPB (1998)\(^5\). Five fortnightly visits have been undertaken from mid-April to the end of June 2011 (subject to suitable weather conditions such as limited rainfall and wind at the time of survey). The survey area included the potentially suitable features on the site and in close proximity to the site that are considered (using professional judgement) to be potentially affected by the project. The surveys have been undertaken for a minimum of three hours during the early morning period and/or evening hours.

5.3.15 Transect surveys were undertaken, which involves walking at a consistent pace through the site. Surveyors observed and recorded the arrival of black redstarts to the survey area and any indications of territorial and
nesting behaviour, as well as identifying the locations and numbers of any nests present on or near the site.

**Breeding birds**

5.3.16 Breeding bird surveys follow standard survey guidance provided in Marchant, J. H. Common birds census instructions, BTO (1983) The survey area included the potentially suitable features on the site and in close proximity to the site that are considered (using professional judgement) to be potentially affected by the project. Breeding bird surveys commenced in March 2011. Transect and point surveys were undertaken, as described in para. 5.3.15. Three visits have been carried out:

a. March and April (to set up route / count positions and record habitat).

b. early April and mid-May (early transect and count)

c. mid-May and late June (late transect and count).

5.3.17 The latter two visits have been carried out at least four weeks apart. All surveys were undertaken in suitable weather conditions (ie, not in strong wind and rain which would reduce bird activity).

**Wintering birds**

5.3.18 The methodology for wintering bird surveys have been adopted from Gilbert, G., et al, Bird Monitoring Methods. RSPB (1998) 53.

5.3.19 For most sites, surveys commenced in December 2010 and continued at monthly intervals until March 2011 inclusive. This data has been summarised in the site specific volumes as appropriate (Volumes 7 – 28). One further visit will be undertaken in October and November 2011 to provide a full winter data set which will be reported in the ES.

5.3.20 At some sites, where access was not available in Winter 2010/2011, surveys will commence in October 2011 and continue at monthly intervals until March 2012 inclusive. This data will be reported in the ES.

**Botanical**

5.3.21 The need for detailed botanical surveys was identified following the Phase 1 Habitat Survey at a number of sites. These were mostly surveys of river wall habitat. However, a botanical survey was undertaken at Abbey Mills along the edge of the adjacent watercourse. The botanical survey methodology is adapted from the National Vegetation Classification survey methodology documented in Rodwell JS. National Vegetation Classification: Users’ Handbook, JNCC National Vegetation Classification Field Guide Series. JNCC (2000). Five 2m by 2m quadrats, representative of river wall habitat, were sampled by botanists. For the surveys at Abbey Mills, 4m by 4m quadrats, representative of habitat along the edge of the watercourse were used. Small fragments of plant
material were taken off site for further analysis where required. The surveys have been undertaken during the summer months of 2011 at a time when the plants are flowering (and therefore most easily identified).

Invasive plants

5.3.22 Invasive plant surveys were undertaken in the summer of 2011 where either the invasive plants were present, the site was identified as having potential for them (eg, industrial site with excavated material heaps) or areas of the site were not fully accessed during the Phase 1 Habitat Survey. The survey area included the site and areas within 10m of the site boundary. The locations and extents of invasive plants have been mapped to inform later remediation plans.

Invertebrates

5.3.23 The surveys have followed the approach provided in Organising surveys to determine site quality for invertebrates: A framework guide for ecologists. English Nature (2005) with survey effort determined by professional judgement. Surveys were undertaken from May to September 2011. The surveys involved initial site walkovers to identify potentially suitable invertebrate habitats to allow specific habitat types on site to be selected for further invertebrate sampling such as:

a. rough grassland
b. scrub and trees
c. unmanaged brownfield land
d. river walls.

5.3.24 Invertebrate sampling included sweep netting, scrub beating and/or malaise trapping. Sweep netting involves the use of a butterfly net to capture invertebrates, and scrub beating a net to catch invertebrates knocked out of vegetation. Malaise trapping involves a small tent-like net structure which is left on site for a period of weeks to capture flying invertebrates. Captured invertebrates were taken from site for identification and the combined results of the multiple visits used to build up a picture of the size and diversity of invertebrate assemblages present on the sites. Moth trapping may be required where initial survey visits indicate the potential for notable species of moth.

Otter and water vole

5.3.25 Surveys for otter and water vole follow guidance in Eds. D. Ward, N. Holmes & P. José. The new rivers and wildlife handbook. R.S.P.B, N.R.A & R.S.N.C. (1994) 55 and Strachan, R. The water vole conservation handbook. RSPB, Environment Agency, English Nature & Wild CRU (1998) 56. Surveys were undertaken during summer 2011. The surveys involved two surveyors searching the bank of the watercourse and in-channel features such as logs/large stones protruding above the water’s surface (where accessible) for signs of the presence of otter and water vole such as: otter spraint; otter holts; water vole droppings; runs; burrows; and feeding remains. The presence of these signs has been mapped.
Reptiles

5.3.26 The reptile survey methodology has followed the approach provided in Froglife Advice Sheet 10: reptile survey. Froglife (1999)\textsuperscript{57} and Gent T and Gibson S. Herpetofauna Workers Manual. JNCC (2004)\textsuperscript{58}. The aim of the surveys has been to ascertain presence/absence and a population estimate of reptiles on those sites identified as having potential for reptiles. Refugia (sheets of roofing felt approximately 0.75m by 0.75m) were laid at a density of 10/ha, within suitable habitat. Refugia were checked twice a day over a non consecutive period of ten days split between April, May and September 2011. Surveys were undertaken in suitable weather conditions as described in the standard guidance.

5.4 Assessment methodology

General

5.4.1 The ecological impact assessment (EcIA) for this assessment follows the Guidelines for Ecological Impact Assessment in the United Kingdom. IEEM (2006)\textsuperscript{59} commonly known as and referred to from here on as the IEEM Guidelines. Although these guidelines are currently under review, as this is ongoing the current guidelines are applied. Additional terminology is used in the valuation and assessment of significant effects in line with the project-wide approach to the assessment as described in Section 2.

5.4.2 The value of baseline ecological resources is determined using desk based and field survey data described in Section 5.3 and the criteria described in paras. 5.4.22 to 5.4.24.

5.4.3 The significance of likely effects on ecological resources that may arise from the proposals during construction and operation are then assessed. Due to seasonal constraints much of the baseline survey data has not yet been analysed and is therefore not available for the PEIR. Where this is the case, the assessment of value of receptors and the significance effects on those receptors has been deferred to the ES.

5.4.4 Effects on ecological receptors will be assessed for both construction and operational phases as appropriate at each site.

Relevant legislation

5.4.5 Legislation relevant to this assessment includes but is not limited to the following:

   i  all wild birds, their eggs and their active nests are protected
   ii bird species listed in Schedule 1 have additional protection against disturbance while nest building or to an active nest
   iii protects mammals listed in Schedule 5 from killing, injuring or taking, and damage, destruction or obstruction of access to, and disturbance of any structure or place of shelter or protection of a Schedule 5 mammal
iv the mechanism for designation of Sites of Special Scientific Interest (SSSIs)

v prohibits planting in the wild or causing to grow invasive species listed in Schedule 9

b. The Conservation of Habitats and Species Regulations 2010 (The Habitats Regulations 2010)
   i protection for European Protected Species, eg, bats, otter.
   ii mechanism for designation of Natura 2000 sites (Special Area for Conservation (SAC), Special Protection Area (SPA)

c. Convention on Wetlands (Ramsar, 1971)
   i Ramsar Wetlands of International Importance

d. Countryside and Rights of Way (CROW) Act, 2000
   i strengthens protection for species listed in the Schedules of the WCA 1981 and for SSSIs
   ii puts a duty on public authorities to have regard to biodiversity during their undertakings.

Relevant policies

5.4.6 The following policies give context to the assessment process.

Biodiversity Action Plans (BAPs)

5.4.7 Biodiversity: the UK Action Plan (Cm 2428). HMSO (1994) was produced in accordance with the 1992 UN Convention on Biological Diversity. It describes the UK’s biological resources and commits to a detailed plan for the protection of these resources, focusing on key habitats and species considered to be of particular significance to nature conservation within a UK context.

5.4.8 While local councils and planning officers must have due regard for species and habitats on the UK BAP, they must also have due regard for the specific targets of the London BAP (London Biodiversity Action Plan. London Biodiversity Partnership (2011)) and Borough local BAPs (LBAP) where these have been produced.

5.4.9 Thames Water published a four-part company BAP in 1999 to protect and enhance biodiversity on their sites and during their operations.

Planning Policy Statement 9: Biodiversity and Geological Conservation (PPS9)

5.4.10 PPS9 sets out the Government’s planning policies on the protection of biodiversity and geological conservation through the planning system. Under PPS9, where a planning permission would result in significant harm to biodiversity conservation interests the planning authority will need to be satisfied that there are no suitable alternatives and that adequate mitigation and/or compensation measures are in place. The policy also enables planning authorities to request an overall biodiversity enhancement.
Local and regional planning policies

5.4.11 A range of local and regional planning policies are relevant to terrestrial ecology. The majority of local policies seek to avoid, mitigate or compensate scheme effects on local non-statutory site designations and species of local interest and also to provide biodiversity enhancements such as green and brown roofs. Policies relevant to specific sites are referred to in the assessment volumes (Volumes 7 - 28).

Statutory site designations

5.4.12 Statutory and non-statutory site designations that are of particular relevance to this project and methodology include the following:

a. Special Areas for Conservation (SAC) - statutory designation under the Habitats Regulations 2010
b. Ramsar Wetlands of International Importance - statutory designation under the Wetlands Convention 1979
c. Sites of Special Scientific Interest (SSSI) - statutory designation under the WCA 1981
d. National Nature Reserves (NNR) - a selection of the best SSSIs chosen by the statutory authority (Natural England) and often having other designations such as SAC or SPA
e. Local Nature Reserves (LNR) - designated under the National Parks and Access to the Countryside Act 1949, amended by the Natural Environment and Rural Communities Act 2006
f. Sites of Importance for Nature Conservation (SINC) – non statutory designations implemented by the local authority and given material consideration in the planning process. In London, SINCs are subdivided into the following categories:
   i. SINC (Grade L) = Site of Nature Conservation Importance (Grade I of Local importance)
   ii. SINC (Grade B) = Site of Nature Conservation Importance (Grade II of Borough importance)
   iii. SINC (Grade M) = Site of Nature Conservation Importance (Grade III of Metropolitan importance)
g. Nature reserves not designated but managed by a nature conservation organisation.

Construction and operation effects

5.4.13 The assessment methodology is the same for both construction and operation effects.

Assessment cases and years

5.4.14 Section 2 provides generic assessment cases and years methodology information.
Base case

5.4.15 The base case for assessment will be a future case, without the project, in any particular assessment year.

5.4.16 The base case for each site has been predicted based on the current baseline and likely changes in habitat over time due to ecosystem functions such as succession and due to likely external factors such as climate change. Any limitations associated with this prediction are detailed for each site.

Development case

5.4.17 A development case is a future case during either the construction or operation of the project in the same assessment year as the equivalent base case. The assessment typically considers the ‘development case’ compared with the ‘base case’ in any particular assessment year (see below).

Assessment year - construction

5.4.18 The peak activity in relation to ecology would tend to be at the Year 1 of construction when initial site clearance would occur. Further effects are likely during the period of construction although these are likely to be less than at the initial stage. Therefore the construction assessment year for terrestrial ecology will be that of the start of site clearance. The assessment of terrestrial ecology effects compares the base case and the development case in this year.

Assessment year: operation

5.4.19 The assessment year for operation will be the Year 1 of operation commences when maintenance activities could be undertaken. The base case for each site has been predicted based on the current baseline and likely changes in habitat over time due to ecosystem functions such as succession and due to likely external factors such as climate change. Changes associated with adjacent developments that have planning approval have also been taken into account where known. The limitations associated with this prediction will be detailed for each site.

Assessment areas

5.4.20 The assessment areas follow the general guidance in Section 2. Within the terrestrial ecology realm, habitats and structures (river walls) from above the mean high water level are included in the assessment. The specific areas included within the desk study and field surveys are detailed in Section 5.3.

5.4.21 It is anticipated that the construction effects of the individual site elements will largely be contained within the site and immediate vicinity. This is based on the relatively localised nature of the proposed activities. The assessment area has been deemed as the individual sites (including features such as construction access roads) and their immediate surrounds that are considered (using professional judgement) to be potentially affected by the project. Where standard guidance exists for distances these are applied as follows:
a. within 500m of waterbodies with the potential for great crested newts to be present
b. trees with their root zones within the development site boundary
c. designated sites within 500m that could be affected by the works.

**Defining resource value**

5.4.22 The ecological resource is valued using a geographical frame of reference in line with the IEEM Guidelines\textsuperscript{64}. To allow for project-wide compatibility, the terminology described in Section 2 has been provided as shown underlined here:

a. International – high
b. National – high
c. Regional (South East UK) – high
d. County (Greater London) – medium
e. District (LB) – medium
f. Local (Town) – low
g. Site – low
h. No significant resource – negligible.

5.4.23 The value of each ecological resource or feature has been determined by considering the following factors based on the IEEM Guidelines\textsuperscript{65}:

a. statutory and non-statutory site designations (see para. 5.4.12 for full list)

b. biodiversity value:
   i. Protected species status (European Protected Species, species listed in the Wildlife and Countryside Act etc.)
   ii. Biodiversity Action Plan status (Priority Habitat or Species on Borough, Greater London and/or UK BAPs)
   iii. Population status of birds in the UK (red, amber and green list species)\textsuperscript{66}
   iv. British Red Data Books status (specific books are referenced in the relevant assessment volumes (Volumes 7 - 28))
   v. National/County Flora status

c. potential value, such as a site that would increase in value if managed in a certain way
d. secondary and supporting value, such as a non-designated site supporting protected species
e. social value (those sites that, irrespective of biodiversity value, contribute to ecological conservation, eg, through environmental education)

f. legal status (see para. 5.4.5 for legal context)
5.4.24 A table detailing the criteria is provided below.
### Vol 5 Table 5.4.1 Terrestrial ecology - valuing ecological resources

<table>
<thead>
<tr>
<th>Value</th>
<th>Ecological features</th>
</tr>
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</table>
| **International (high)** | A habitat or species cited as a reason for the designation or proposed designation of a World Heritage Site, Biosphere Reserve, Biogenetic Reserve, Ramsar Site, Special Protection Area (SPA) or Special Area of Conservation (SAC).  
A large extent of habitat that is listed as a Priority Habitat Type in Annex 1 of the EC Habitats Directive in good condition with typical species diversity.  
A large and viable population of a regularly occurring species that is rare within an international context. |
| **National (high)**   | A habitat or species cited as a reason for the designation or proposed designation of a National Nature Reserve (NNR), Marine Nature Reserve (MNR), National Park, Site of Special Scientific Interest (SSSI) or Area of Special Scientific Interest (ASSI).  
Any area of habitat listed as a Priority Habitat Type in Annex 1 of the EC Habitats Directive that has potential to support typical species diversity.  
A large extent of habitat listed as a Priority Habitat in the UK BAP in good condition that supports an abundance of typical species.  
A large and viable population of a regularly occurring species that is scarce within an international context.  
A very large and viable population of a regularly occurring species that is listed as a Priority Species in the UK BAP.  
A large and viable population of a regularly occurring rare species that occurs in 15 or fewer 10km squares of the National Grid (eg, a species that is listed in UK Red Data Books).  
A bird species with a British breeding population of <1,000 pairs. |
| **Regional (high)**   | A large extent of habitat listed as a Priority Habitat in the UK BAP that supports typical species diversity and is in good condition.  
A large and viable population of a regularly occurring species that is listed as a Priority Species in the UK BAP.  
A large and viable population of a regularly occurring plant species that is known to occur in 16 to 100 10km squares of National Grid (Stewart, Preston and Pearman 1994).  
A large and viable population of a regularly occurring insect species (Nationally Notable categories Na and |
<table>
<thead>
<tr>
<th>Value</th>
<th>Ecological features</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>Nb) that is known to occur in 16 to 100 10km squares of the National Grid (Ball, 1986). A bird species with a British breeding population of 1,000 to 10,000 pairs.</td>
</tr>
</tbody>
</table>
| County (medium)      | A habitat or species cited as a reason for the designation or proposed designation of a Local Site (known locally as a Wildlife Site (WS), Site of Importance for Nature Conservation (SINC), Ecology Database Site (EDS) etc.), a Local Nature Reserve (LNR), a Nature Reserve (owned or managed by: The Wildlife Trusts, The Woodland Trust or equivalent body) or an Ancient Woodland in good condition with a typical plant community.  
A habitat listed as a Priority Habitat in the UK BAP which is large in extent and supports typical species diversity.  
A medium and viable population of a regularly occurring species that is listed as a Priority Species in the UK BAP.  
A viable population of a regularly occurring species listed in a County Red Data Book, County Flora or found in less than 10% of 1km squares of the National Grid within the count.  
A small population of a plant species that is known to occur in 16 to 100 10km squares of National Grid.  
A small population of an insect species (Nationally Notable categories Na and Nb) that is known to occur in 16 to 100 10km squares of the National Grid.  
A bird species with a British breeding population of 10,000 to 100,000 pairs. |
| Borough (medium)     | A habitat or species cited as a reason for the designation or proposed designation of a Local Site (known locally as a Wildlife Site (WS), Site of Importance for Nature Conservation (SINC), Ecology Database Site (EDS) etc.), a Local Nature Reserve (LNR), a Nature Reserve (owned or managed by: The Wildlife Trusts, The Woodland Trust or equivalent body etc) or an Ancient Woodland in an unfavourable condition.  
A habitat listed as a Priority Habitat in the UK BAP which is small in extent, supports typical species diversity or is in an unfavourable condition.  
A small and viable population of a species that is listed in the UK BAP or LBAP.  
A bird species with a British breeding population of 100,000 to 500,000 pairs. |
<table>
<thead>
<tr>
<th>Value</th>
<th>Ecological features</th>
</tr>
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</table>
| Town (low)                    | A habitat or species cited as a reason for the designation or proposed designation of a site which is officially listed eg, on a Parish Register.  
A semi-natural habitat that is listed in the UK BAP or LBAP, which is either small in extent and/or is in an unfavourable condition.  
A species which occurs occasionally that is listed in the UK BAP or LBAP.  
A bird species with a British breeding population of >500,000 pairs. |
| Site (low)                    | An artificial habitat or habitat that has readily established eg, amenity grassland.  
A species which is common and not listed on the UK BAP or LBAP eg, Badger.                                                                 |
| No significant resource (negligible) | No semi-natural habitat.                                                                                                                                  |
| Within immediate zone of influence | An invasive or deleterious species, affecting an ecological merit eg, the removal Japanese knotweed to enable native plants to flourish.                                      |

* (based on IEEM [2006]*)
Determining the magnitude of effects

5.4.25 The magnitude of effects is determined by describing the following features of the effects based on the IEEM Guidelines68:

a. extent of effects, eg, area of habitat loss, number of individuals of species that will be affected
b. location of effects, eg, on-site or surrounding the site
c. the duration of the effect, ie, permanent or temporary
d. timing and frequency of effect – 24 hours a day, night time only, for the duration of construction etc
e. positive or negative effect
f. direct effect (eg, disturbance to birds) or indirect effects (eg, loss of bird foraging resource).

5.4.26 The terrestrial ecology assessment does not apply a ranking of low, medium or high to the magnitude of the effects. Therefore, the terminology differs to that of the general approach to the EIA as detailed in Section 2. The magnitudes of the effects are described but no ranking will be given, in line with the IEEM Guidelines69.

Determining the significance of effects

5.4.27 The significance criteria used for the ecological impact assessment differ from those detailed in Volume 5 in order to conform to the IEEM Guidelines. The assessment has used professional judgement supported by academic literature, where available, to assess the ecological response of receptors to the impacts (ie, the effects), and to assess whether these effects would be significant under the following definitions (ie, EM Guidelines70)

a. Ecologically significant effect - ‘an effect (either adverse or beneficial) on the integrity of a defined site or ecosystem and/or the conservation status of habitats or species within a given geographical area’

b. Site integrity - ‘the coherence of its ecological structure and function, across its whole area, which enables it to sustain the habitat, complex of habitats and/or levels of populations of the species for which it was classified.”.

c. Effects on conservation status:
   i. effects that may affect the habitats’ long-term distribution, structure and functions
   ii. effects that may affect the long-term distribution and abundance of the species’ populations.

5.4.28 Using the definitions above, an effect is considered to be significant or not significant. The level of significance will depend on the value (from site to international value as described in para. 1.4.20) of the affected feature and in the way in which the conversation status or site integrity has been affected. The IEEM geographical scale of significance has been used
alongside the general terminology described in Volume 5 to allow for project-wide compatibility (underlined) below:

a. International – Major effect
b. National – Major effect
c. Regional (South East UK) – Major effect
d. County (Greater London) – Moderate effect
e. District (LB) – Moderate effect
f. Local (Town) – Minor effect
g. Site – Minor effect
h. Not significant – Negligible effect

5.4.29 The level of confidence in the assessment of the significance of effects is determined using professional judgement and according to the criteria shown in the table below, as defined within the IEEM Guidelines.

Vol 5 Table 5.4.2 Terrestrial ecology - significance confidence criteria

<table>
<thead>
<tr>
<th>Confidence</th>
<th>Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Certain/near certain</td>
<td>Probability estimated at 95% chance or higher.</td>
</tr>
<tr>
<td>Probable</td>
<td>Probability estimated above 50% but below 95%.</td>
</tr>
<tr>
<td>Unlikely</td>
<td>Probability estimated above 5% but below 50%.</td>
</tr>
<tr>
<td>Extremely unlikely</td>
<td>Probability estimated below 5%.</td>
</tr>
</tbody>
</table>

* (from IEEM Guidelines)

Project-wide effects

5.4.30 At this stage, there is insufficient data to determine whether there are likely to be significant project-wide effects and these effects are not considered any further in the PEIR.

Assessment assumptions and limitations

5.4.31 An overview of assessment assumptions and limitations are provided in Section 2. Assumptions and limitations associated with the EcIA are as follows.

a. Limitation: determining species presence or likely absence:
   i. Survey methodologies follow standard guidance unless specific deviations from these have been described. However, a survey can only determine presence and likely absence. A species may be found on site at a later date.

b. Limitation: survey timings:
   i. Surveys have been undertaken within optimal survey periods wherever practicable. Where this has not occurred the site specific limitations are described within Volumes 7 to 28.
5.5 **Approach to mitigation**

5.5.1 The general approach to mitigation is described in Appendix A.

5.5.2 Mitigation, compensation and enhancement measures will be developed in response to significant effects on the integrity or conservation status of the relevant ecological feature to which it is being applied, consistent with the IEEM Guidelines. Following baseline data gathering and assessment of significance of effects, mitigation measures will continue to be developed and will be reported in the ES. The approach to mitigation will be informed by the ‘Mitigation and Compensation Hierarchy’ discussed with the Thames Tunnel Biodiversity Forum as a systematic and transparent decision making process, as outlined in Appendix A. The hierarchy is sequential and seeks to avoid adverse environmental effects. Where adverse effects are unavoidable the mitigation and compensation is provided. Where practicable, measures to enhance terrestrial ecology will be integrated into the design of the project. These measures could include but are not limited to the following:

a. Creation of ‘vertical beaches’ using fenders attached to the river wall
b. Brown/green roofs
c. Bird, bat and invertebrate habitat boxes
d. Replacement planting/habitat creation, eg, trees, foreshore habitat.

**Construction**

5.5.3 The draft CoCP is not mitigation but is part of the project development process to minimise the potential for significant adverse effects. The draft CoCP will be developed as the project design progresses. Mitigation measures will be detailed in the CoCP where appropriate, as detailed in Volume 2 (Proposed Development). Avoidance measures will be documented in an Ecological Management Plan, which forms part of the CoCP including but not limited to the following:

a. lighting, noise and vibration strategies to minimise disturbance effects to birds and bats
b. screening of construction activities from sensitive receptors such as birds
c. tree protection zones.

5.5.4 Long-term monitoring will ensure measures are effective and will be addressed through an Ecological Management Plan.

5.5.5 Whilst the assessment of construction effects is underway it is not suitably advanced for a full consideration of mitigation in this report. The ES will include full details of the assessment outcomes, and the approach to mitigation required.

**Operation**

5.5.6 Residual effects will be documented once the full assessment has been undertaken and reported in the ES.
6 Historic environment

6.1 Introduction

6.1.1 This section sets out the full EIA methodology for the assessment of effects on the historic environment. Work which has not been fully completed for the PEIR will be completed for the ES, and this is also noted within each site specific assessment volume.

6.1.2 The assessment of effects on the historic environment covers those parts of the historic environment considered to have significance because of historic, evidential, aesthetic or communal value. Consideration is given to below and above ground archaeological remains, buildings, structures, monuments and heritage landscapes (whether designated or not) within or immediately around each site and the tunnel itself, and within the visual envelope of the proposals, in order to consider indirect effects on the setting of heritage assets.

6.1.3 The historic environment resource falls into two broad categories:

a. Buried heritage assets (archaeological remains). This comprises known assets and the potential for previously unrecorded archaeological remains, including the setting/context of assets within buried ancient settlements and landscapes that are not currently visible. The assessment considers the likely nature, date, extent, survival and significance of such assets.

b. Above ground heritage assets (built heritage). This largely comprises standing buildings of historic interest, including statutorily and locally listed buildings, conservation areas and townscapes/landscapes of heritage value. It also includes built heritage that has not been designated but which has been identified during the course of the assessment as having heritage interest. The setting of assets, including those aspects of their surroundings which contribute to their coherence is also included.

6.1.4 The methodological approach set out here covers the construction and operation phases of the project. Potential effects on the historic environment could arise in the construction or operational phases of the project. Construction effects will be concerned principally with activities likely to directly remove, disturb or alter above ground or buried heritage assets, as a result of enabling or construction works. Such construction effects on the historic environment are likely to be permanent. Construction works may also give rise to effects on the historic setting of heritage assets, for example due to the visual presence of machinery or other effects such as noise, dust and traffic within the area deemed to represent the setting of an asset.

6.1.5 Potential effects on the historic environment during the operational phase of the project may derive from:

a. change to the historic environment setting of above ground heritage assets, due to the presence of permanent, visible, structures or modifications to existing structures
b. ground settlement along the line of the Thames Tunnel and from any deep constructions at each site

c. changes in the fluvial regime and subsequent scouring and/or deposition due to permanent works on the foreshore of the River Thames and in the river channel.

6.2 Scoping Opinions and technical engagement

6.2.1 A summary of scoping and stakeholder engagement undertaken in relation to the historic environment is contained in Volume 4, Sections 3.6 and 4.6. The engagement and consultation on the PEIR will continue to inform the methodology for this topic during the ongoing EIA process.

6.3 Baseline data collection methodology

Desk based baseline data

6.3.1 Each site specific assessment draws upon detailed baseline information in a study area around each site. Where relevant, site specific assessments also consider certain broad themes which recur at a number of sites across the project, providing historic environment setting and broader context (eg, human interaction on the floodplain marshes, flooding, reclamation and water management, use of the river, the work of Bazalgette etc.). Such themes are pulled together in a route overview in Volume 6.

6.3.2 For the purposes of each site specific assessment, documentary and cartographic sources, including results from any archaeological investigations within the site and a study area around it were examined in order to determine the likely nature, extent, preservation and significance of any heritage assets that may be present.

6.3.3 Identified historic environment features within the study area around each site have been allocated a unique historic environment assessment reference number (HEA 1, 2, etc), which are listed in a gazetteer in an appendix to each site specific assessment, and shown on a historic environment features map. Along with historic maps and information on the geology and geoarchaeology of the sites, this formed the baseline for each site, and has been used to identify known heritage assets within the site and in the immediate vicinity. This information has also been used to determine the potential for previously unrecorded heritage assets of any specific chronological period to be present within the site.

6.3.4 The primary sources of information used are the Greater London Historic Environment Record (GLHER) and the London Archaeological Archive and Research Centre (LAARC). The GLHER is managed by English Heritage and includes information from past investigations, local knowledge, find spots, and documentary and cartographic sources. LAARC includes a public archive of past investigations and is managed by the Museum of London. Vol 5 Table 6.3.1 lists the main data sources used.

6.3.5 The following paras. summarise further which data will be obtained as the EIA progresses (which was not available at the time of writing the PEIR).
Heritage assets within the foreshore and channel

6.3.6 The site specific baseline sections of the PEIR incorporate information from the Greater London Historic Environment Record GLHER and the Thames Discovery Programme (TDP) on structures of heritage interest on the foreshore, and from Seazone on recorded wrecks and obstructions (of potential archaeological interest) compiled from the UKHO database. The PLA may hold additional information on wrecks from its own surveys, and the intention is to clarify what is held, obtain any additional datasets that are relevant and include them in the baseline for the EIA.

6.3.7 The TDP hold additional data derived from detailed surveys that are not currently in the public domain and it is hoped that this data will be made available for the EIA, in particular to inform any foreshore surveys and mitigation proposals.

Past dredging

6.3.8 Where substantial capital dredging has been carried out in order to deepen the channel for large barges/vessels, any earlier archaeological remains present may already have been entirely removed from the dredging footprint.

6.3.9 It is understood that the PLA holds data on the channel and foreshore, which may include records of past dredging, which would assist in assessing archaeological potential within each site, where it extends into these areas. Sourcing of data is currently under discussion with the PLA.

Existing hydrological regimes

6.3.10 HR Wallingford (HRW) has prepared a report on the hydrological regimes of the River Thames and this will be evaluated for its potential to contribute material information to the historic environment assessment, eg, regarding existing and proposed scour and dredging profiles. The baseline assessment for each site will note where active scouring or deposition is currently taking place at a site. This will enable informed judgements about the appropriate mitigation strategy at that site (eg, where preservation in situ, whilst desired, may not be achievable due to existing erosion processes that will reduce or remove entirely the significance of an asset over time).

Subsurface modelling of terrestrial and channel areas

6.3.11 Once the geotechnical work, comprising borehole monitoring, has been completed, it is intended to augment the topography/geology sections of sites where substantial alluvial deposits or evidence of past topography and geology may be present, with geoarchaeological subsurface deposit models. Rockworks subsurface modelling software will then be used to construct a three dimensional model of the deposits and determine the nature of the ancient landscape. Understanding the nature and depth of subsurface deposits is a valuable predictive tool which can assist in clarifying archaeological and palaeoenvironmental potential, the extent of potential impacts, and guide an appropriate mitigation strategy.

6.3.12 The present terrestrial and riverine environments of the Thames floodplain and its tributaries are part of a single, evolving, heritage landscape. It is
intended as part of the EIA to ensure that any subsurface modelling takes an integrated approach that spans all aspects of such landscape, e.g., the present channel and foreshore together with former riverine environments now buried within the reclaimed land adjacent to the river. All the various river-related datasets described above will be fed into an integrated multi-dimensional subsurface model.
<table>
<thead>
<tr>
<th><strong>Source</strong></th>
<th><strong>Data</strong></th>
<th><strong>Notes</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>English Heritage National Monuments Record (NMR)</td>
<td>Statutorily designated heritage assets, comprising: world heritage sites; scheduled monuments; statutorily listed buildings; registered parks and gardens; historic battlefields.</td>
<td>Any potential impacts upon statutorily designated assets are likely to require particularly detailed assessment, consultation with consultees and stakeholders and detailed consideration of potential mitigation strategies.</td>
</tr>
<tr>
<td>Greater London Historic Environment Record (GLHER)</td>
<td>Historic Environment Record database search within a defined study area around each site.</td>
<td>One of the primary repositories of archaeological information within the Greater London. Includes information from past investigations, local knowledge, find spots, and documentary and cartographic sources.</td>
</tr>
<tr>
<td>Local authorities</td>
<td>Conservation areas, archaeological priority areas/zones, locally listed buildings, planning policy information.</td>
<td>Assets or areas considered to be locally significant and designated by the local planning authority. Such resources may be afforded protection under local planning policy.</td>
</tr>
<tr>
<td>Landmark Information Group</td>
<td>Ordnance Survey maps from 1st edition (1860–70s) to present day.</td>
<td>Provides an indication of the possible date of any buildings on the site. Past land use and impacts may have compromised archaeological survival.</td>
</tr>
<tr>
<td>London Archaeological Archive and Research Centre (LAARC)</td>
<td>Public archive of past archaeological investigations managed by the Museum of London.</td>
<td>Contains summary information of findings. The paper archive held at LAARC was also consulted in detail where more detailed information was required.</td>
</tr>
<tr>
<td>Museum of London Archaeology</td>
<td>GIS data sets include digitally plotted burial grounds</td>
<td></td>
</tr>
<tr>
<td>Source</td>
<td>Data</td>
<td>Notes</td>
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</tr>
<tr>
<td>(MOLA)</td>
<td>from the Basil Holmes late 19th century survey, georeferenced historic maps and digitised features (eg, projected lines of Roman roads, Civil War defences), extensive range of archaeological reports and geoarchaeological data, and the MOLA archaeological deposit survival archive.</td>
<td></td>
</tr>
<tr>
<td>Thames Discovery Programme (TDP)</td>
<td>Thames GIS database with information from the 1990s Thames Foreshore Survey (the ‘Alpha Survey’). Most of the data (over 2,000 records) has not yet been incorporated into the GLHER.</td>
<td>Survey of visible remains on the Thames foreshore, such as old wharves, jetties, barge beds and other structures. The TDP hold additional data derived from subsequent detailed surveys. This is not currently in the public domain but it is hoped that this data will be made available for the EIA.</td>
</tr>
<tr>
<td>Museum of London: Museum in Docklands</td>
<td>Archived Port of London Authority records on post-war dredging.</td>
<td>Dredging is likely to have removed any heritage assets from the river channel.</td>
</tr>
<tr>
<td>Libraries and record offices including the British Library, the London Society Library, the London Metropolitan Archives and Local authority Record Offices</td>
<td>Historic maps and published histories.</td>
<td>Information for the historic environment baseline, including information on past land use, past disturbance (factors which may have compromised asset survival) and assets which are not currently on the GLHER.</td>
</tr>
<tr>
<td>Seazone</td>
<td>Information on recorded wrecks along the Thames Tideway</td>
<td>UK Hydrographic Office data in GIS format. Wrecks may be of archaeological interest.</td>
</tr>
<tr>
<td>Port of London Authority</td>
<td>It is hoped to acquire information on obstructions along the Thames Tideway and available information</td>
<td>Wrecks and obstructions may be of archaeological interest.</td>
</tr>
<tr>
<td>Source</td>
<td>Data</td>
<td>Notes</td>
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<tr>
<td>--------------------------------------------</td>
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</tr>
<tr>
<td></td>
<td>on past dredging within the Thames channel.</td>
<td>Dredging is likely to have removed any heritage assets from the river channel.</td>
</tr>
<tr>
<td>HR Wallingford</td>
<td>Information on the existing water regime (scour/deposition) will be reviewed for the ES.</td>
<td>Riverine scour and deposition may have had an impact upon assets on the foreshore and in the Thames channel.</td>
</tr>
<tr>
<td>British Geological Survey (BGS)</td>
<td>Digital geology data.</td>
<td>Subsurface deposition, including buried geology and topography, can provide an indication of suitability for early settlement, and potential depth of remains.</td>
</tr>
<tr>
<td>Thames Water</td>
<td>Geotechnical data (historic and proposed borehole data), existing site surveys (topography and services/drainage).</td>
<td>Geotechnical data can provide an indication of the nature and depth of subsurface deposits and potential archaeological remains.</td>
</tr>
<tr>
<td>Thames Water</td>
<td>Historic ‘works as executed’ drawings relating to various Thames Water sites, including Abbey Mills, Falconbrook and Hammersmith Pumping Stations and other Thames Water sewerage infrastructure. These drawings date from the 1860s up to the 1920s.</td>
<td>These drawings can provide information on the nature and historic significance of assets. They can also provide information on existing foundations, which may have removed archaeological remains. They will be reviewed for the ES.</td>
</tr>
<tr>
<td>Thames Tunnel</td>
<td>Bathymetric data for the River Thames channel.</td>
<td>The data provides a contour of the riverbed and can provide an indication of the depth of alluvium and any archaeological remains within channel silts, or conversely, evidence of past scour and dredging effects.</td>
</tr>
</tbody>
</table>
Field survey baseline data

Phase 1 site visits

6.3.13 Reconnaissance inspections were made of each site in January and February 2011 to inform the Scoping Report. This entailed viewing each site from publicly accessible land, and taking photographs and notes.

Site walkovers

6.3.14 Detailed site walkover inspections were carried out of land-based and foreshore sites in Spring 2011. For most sites, a Senior Archaeologist and a Buildings Archaeologist were present. On the foreshore sites, a specialist from the TDP also attended the site walkover. The site walkover inspection has yet to be carried out at Chambers Wharf, and parts of Dormay Street, Carnwath Road Riverside and Kirtling Street. This will be carried out as part of the ongoing EIA for presentation in the ES. The site-specific assessments note where the site walkover inspection has yet to be completed.

6.3.15 The site walkover comprised a visual inspection (with associated notes and photography, but not a measured survey) to identify heritage assets visible above ground, and to note site configuration and formation levels (for basements and other subterranean features) which could have altered the potential for the survival of buried heritage assets. The heritage significance of above ground assets was assessed, the condition in which they currently survive was noted and, where feasible and necessary, an inspection was made of the interior of any buildings of historical interest. Also considered on the walkover was the setting/context of heritage assets within and around the site, in terms of the historical, evidential, aesthetic and apparent communal values which form the basis for the assessment of significance in English Heritage guidance (English Heritage Conservation principles, policies and guidance (2008)).

6.3.16 The site walkovers did not involve intrusive site investigation fieldwork or associated measured survey of built or buried assets. Only those areas for which access permission for the site walkover inspection had been granted (including the inside of buildings) were included, along with publicly accessible areas.

Geoarchaeological monitoring of geotechnical investigations

6.3.17 Geotechnical investigations have been carried out (boreholes and trial pits – and are ongoing) for the project for engineering design purposes. In consultation with English Heritage, locations were identified where boreholes could have a potential impact upon archaeological remains. In these cases, boreholes were either moved or archaeologically monitored. Additional boreholes were also identified for monitoring where they may provide useful baseline data. This early element of site based assessment may provide key archaeological information to inform and support the ongoing EIA and will be presented in the ES.

6.3.18 Geotechnical boreholes were selected for archaeological monitoring in order to provide information on the nature and depth of subsurface
deposits (and associated archaeological/palaeoenvironmental potential), particularly in areas where there is a little or no existing information.

6.3.19 The results of the archaeological monitoring of geotechnical investigations, are not available for the PEIR, but will inform the ongoing EIA. At that stage, the results of the archaeological monitoring will be combined with bathymetry, wrecks, dredging records and the HRW report on hydrological regimes, to provide data for modelling the river and surrounding terrain of foreshore and channel areas. This predictive modelling will inform both the desk based EIA and any further investigative site based assessment (field evaluation) that may be required in the future, as part of a post-consent mitigation strategy.

6.4 Assessment methodology

General

6.4.1 Section 2 sets out the generic EIA methodology. This section describes specific methodological approaches employed in the assessment of impact on the historic environment.

6.4.2 The assessment considers:

- a. statutorily designated resources (including scheduled monuments and listed buildings)
- b. local planning authority designations (including archaeological priority areas)
- c. conservation areas, and locally listed buildings)
- d. human remains
- e. undesignated heritage assets (known and possible).

6.4.3 In accordance with the EIA project terminology, the term ‘impact’ is used to describe actions or processes which exert an influence on a heritage asset, whilst ‘effects’ are the response of an asset to an impact. For example, the construction of a CSO drop shaft would have an impact upon heritage assets, comprising the removal of all archaeological remains within its footprint. The effect of this impact would be the reduction of any assets within the footprint of the CSO drop shaft.

6.4.4 Although the PEIR defines effects as short term (less than 12 months), medium term (1–5 years) and long-term (+ 5 years), and as either permanent or temporary effects, for the historic environment almost all impacts on built and buried heritage assets result in permanent, long-term effects. These effects occur either via partial or total physical removal of the resource during the construction phase, or permanent modification to the setting of the assets resulting from the changes to its environment, in the operational phase. Temporary effects might arise from temporary change in the historic environment setting of heritage assets during the construction phase (e.g., due to the presence of hoarding, plant and construction activities), including loss of amenity/public appreciation, historic views, etc.
6.4.5 The historic environment assessment makes clear the distinction between the importance of the resource - ‘asset significance’ in PPS5 terminology (rated from very low, low, medium, high, to very high) - and ‘significance of the environmental effect’ (rated from negligible, minor, moderate to major). In line with the generic methodology presented in Section 2, for the purposes of this report the term ‘significance’ has been replaced with ‘importance’ to avoid confusion with overall significance of effects assessment approach.

6.4.6 In accordance with national policy set out in PPS5, the approach has been to consider the impact of the proposed development on the ‘importance’ of heritage assets (described further below under ‘defining resource value/receptor sensitivity’). Each site specific assessment includes a ‘statement of importance’ outlining the expert opinion on asset importance, and highlighting where current information is insufficient to do this with certainty.

6.4.7 As part of this process the assessment has considered heritage assets and their importance, not in isolation, but within a broader historic environment context, examining the setting and ‘group value’ of the assets, and how individual assets formed part of both past and present contemporary landscapes.

6.4.8 The local, site based context of assets is also supported by consideration of broader route-wide settings, which are set out in a tunnel route overview contained in Volume 6. The route overview sets out the collective topographic, geological and cultural heritage themes for the whole scheme; forming a conceptual model that will inform the continuing desk- and site based assessments that constitute the PEIR/EIA process. The main theme that links all the sites is the past and present fluvial regimes of the River Thames, and its various tributaries (including the Fleet, the Lea and the Wandle). These regimes are linked to changes in sea and river levels since the end of the last glaciation, approximately 10,000 years ago. Water levels in turn influence the natural river regimes; the associated topography and landscapes and the resulting patterns of human settlement and land use. These factors are dynamic, evolving over time. Terrain and river modelling of these changing landscapes, and of the subsurface deposits within them, will be carried out as part of the EIA, once all the baseline data has been acquired.

**Legislation and guidance**

6.4.9 The assessment methodology conforms to the requirements of local and national guidance and planning policy, including the following planning policy:

a. PPS5 (Department of Communities and Local Government. *Planning Policy Statement 5: Planning for the Historic Environment* (March 2010))

b. The Planning (Listed Buildings and Conservations Areas) Act 1990


d. UDPs and Local Development Frameworks of the relevant Local authorities.

6.4.10 The assessment methodology also adheres to the following guidance:


f. DCMS (Department of Communities and Local Government, English Heritage & Department for Culture, Media and Sport), *PPS5 Planning for the Historic Environment: Historic Environment Planning Practice Guide* (March 2010)

g. Department for Communities and Local Government and Department for Culture, Media and Sport, *Revisions to principles of selection for listed buildings* (March 2007)


j. City of London Corporation of London Department of Planning and Transportation. *Planning Advice Note 3: Archaeology in the City of London, Archaeology Guidance* (2004);


l. English Heritage, *The setting of heritage assets. Consultation draft* (July 2010).

6.4.11 Legislation including the Planning (Listed Buildings and Conservation Areas) Act 1990, has informed the methodology.

**Construction and operational effects**

**Assessment cases and years**

6.4.12 The generic assessment cases are described in Section 2. The following section describes the specific approach for the historic environment.
6.4.13 The base case for assessment will be a future case, without the project, in any particular assessment year.

6.4.14 The existing baseline as at the time of data collection forms a ‘current baseline’. In terms of buried heritage assets, the only aspect of the resource that is likely to change, without the project in any particular assessment year is the condition of the assets due to ongoing fluvial processes (scouring and sediment deposition) on the foreshore, along with other unrelated proposed development schemes, on land or within the river.

6.4.15 For above ground heritage assets within and outside the site, their historic environment setting may change in the year of assessment, in light of adjacent non-Thames Tunnel development schemes. Relevant project developments are detailed in the site specific assessment volumes and any such change will be considered in the assessment of setting in the ongoing EIA.

6.4.16 A development case is a future case during either the construction or operation of the project in the same assessment year as the equivalent base case. The assessment typically considers the ‘development case’ compared with the ‘base case’ in any particular assessment year (see below).

6.4.17 The assessment years for the assessment of construction impacts will vary since the peak in construction activities will vary from site to site. These are defined in each site specific assessment volume for the historic environment, along with the particular aspects of the project which could impact on the historic environment (the development case). Operational impacts on setting will be assessed for Year 1 of operation (the development case). The site specific assessment volumes for each site identify the above ground infrastructure, which due to its visual presence, could impact upon historic environment receptors.

6.4.18 The study area assessed in the PEIR site specific assessments is defined by the site boundary line and a wider area around this. The study area is typically 250m in radius, but in some cases professional judgment may indicate that a larger or smaller study area is appropriate. For the purposes of the PEIR the study area is largely driven by the extent of archaeological understanding of the site and its surrounding. Where archaeological understanding is more limited a wider study area may be appropriate in order to source sufficient information to augment understanding of known and likely historic environment assets with the site. Conversely a smaller study area may be appropriate where there is generally a good understanding of the archaeology of the site. In some cases, reference is made in the site-specific baseline conditions to heritage assets outside the defined study area, where such assets are
6.4.19 Typically buried heritage assets within the study area, but outside the site, are not included in the assessment unless there is good evidence that they are likely to extend into or be present within the site.

6.4.20 Indirect effects on above ground heritage assets outside the site boundary will be assessed in the ongoing EIA for presentation in the ES. This assessment is not presented in the PEIR as the methodology for assessing effects on setting is subject to further development, in consultation with English Heritage and other consultees, in light of new planning guidance in PPS5 and draft English Heritage guidance. Above ground heritage assets will be covered in the assessment where they have some relationship with the site, either in terms of their group value, association with assets on the site, or where there may be significant effects on their setting. The study area for the assessment of indirect impacts on assets outside the site boundary will be defined in the final ES, with input from the townscape and visual specialists (since the extent of intervisibility between the above ground built structures of the project and offsite heritage assets will be a factor in defining the extent of the assessment of impacts on the setting of historic assets).

Assessment of effects on setting of heritage assets

6.4.21 As noted above (under ‘Assessment areas’) the assessment of effects on the setting of heritage assets is not presented in the PEIR and will be completed for the final ES, as the methodology is subject to further development in light of ongoing consultation and emerging guidance.

6.4.22 The heritage significance of the setting/context of heritage assets, within and close to each site, is an important component of the assessment. The Townscape/Visual assessment concentrates on the townscape character and aesthetic values of views, skylines and massing in general, but not the specific setting of heritage assets. The assessment of effects on the setting of listed/protected heritage assets (including Listed Buildings and conservation areas) to be presented in the final ES will include consideration of the setting of specific heritage assets in terms of the aesthetic, historic, communal and evidential values of their setting as defined in the English Heritage Conservation Principles (English Heritage. Conservation principles, policies and guidance. Swindon (2008)).

6.4.23 The two disciplines are working closely together, ensuring an integrated approach, as required under PPS5 (Department of Communities and Local Government. Planning Policy Statement 5: Planning for the Historic Environment (March 2010)).

Significance criteria

6.4.24 The significance of environmental effect is determined by combining the asset significance (i.e., receptor value) of heritage assets with the magnitude of impact (change) on the asset from the development. Effects may be either negative (adverse) or positive (beneficial) and are determined in accordance with a topic specific significance matrix presented in Vol 5 Table 6.4.3. Where information is insufficient to be able
to quantify either the asset significance or magnitude of impact with any
degree of certainty, significance of environmental effect is given as
uncertain.

**Defining receptor value**

6.4.25 For the historic environment, the value or sensitivity of the receptor (the
heritage ‘asset’) lies in its ‘asset significance’, comprising the value of a
heritage asset to this and future generations resulting from its heritage
interest, which may be derived from evidential, historic, aesthetic and/or
communal value. The historic environment assessment makes clear the
distinction between the significance of the resource - ‘asset significance’ in
PPS5 terminology (rated from very low, low, medium, high, to very high) -
and ‘significance of the environmental effect’ (rated from negligible, minor,
moderate to major). Heritage interest includes archaeological interest,
which comprises ‘an interest in carrying out an expert investigation at
some point in the future into the evidence a heritage asset may hold of
past human activity’ (Department of Communities and Local Government.
*Planning Policy Statement 5: Planning for the Historic Environment* (March
2010), 13). Archaeological interest may apply to both buried heritage
assets and standing buildings or structures.

6.4.26 The determination of the asset significance of known and potential
heritage assets is based on statutory designation and/or professional
judgement against four values set out in English Heritage conservation
principles (English Heritage. *Conservation principles, policies and
guidance*. Swindon (2008)):

a. Evidential value: the potential of the physical remains to yield evidence
of past human activity. This might take into account date; rarity; state
of preservation; diversity/complexity; contribution to published
priorities; supporting documentation; collective value and comparative
potential.

b. Aesthetic value: this derives from the ways in which people draw
sensory and intellectual stimulation from the heritage asset, taking into
account what other people have said or written.

c. Historical value: the ways in which past people, events and aspects of
life can be connected through heritage assets to the present, such a
connection often being illustrative or associative.

d. Communal value: this derives from the meanings of a heritage asset
for the people who know about it, or for whom it figures in their
collective experience or memory; communal values are closely bound
up with historical, particularly associative, and aesthetic values, along
with educational, social or economic values.

6.4.27 These values encompass the criteria of special historic, architectural,
artistic, traditional or archaeological interest used by English Heritage
when designating listed buildings or scheduled monuments. Evidential
and aesthetic values correspond most closely to architectural interest
according to listing criteria, while historic and communal values
correspond to historic interest.
6.4.28

The table below defines the asset importance (value) of designated and non-designated heritage assets.

**Vol 5 Table 6.4.1 Historic environment - value criteria for receptors**

<table>
<thead>
<tr>
<th>Asset Importance (value)</th>
<th>Definition</th>
</tr>
</thead>
</table>
| Very high (International/national) | World heritage sites  
                             Scheduled monuments  
                             Grade I and II* listed buildings  
                             English Heritage Grade I and II* registered parks and gardens  
                             Protected Wrecks  
                             Heritage assets of national importance. |
| High (National/regional/county) | English Heritage Grade II registered parks and gardens  
                             Conservation areas  
                             Designated historic battlefields  
                             Grade II listed buildings  
                             Burial grounds  
                             Protected heritage landscapes (eg, ancient woodland or historic hedgerows)  
                             Heritage assets of regional or county importance. |
| Medium (District) | Heritage assets with a district value or interest for education or cultural appreciation  
                             Locally listed buildings. |
| Low (Local) | Heritage assets with a local (ie, parish) value or interest for education or cultural appreciation |
| Very Low | Where heritage assets of otherwise low significance are known to be poorly preserved  
                             Heritage assets of local interest which are generally very common or known to survive widely in the local area. |
| Negligible | Historic environment resource with no significant value or interest. |
| Uncertain | Heritage assets that have a clear potential, but for which current knowledge is insufficient to allow significance to be determined, generally because they are buried or otherwise concealed. |

6.4.29

The above table is intended as a guide only. English Heritage considers that all statutorily listed buildings are of national significance. In the table, Grade II listed buildings and Registered Parks and Gardens have been categorised as being of ‘high’ asset significance, in order to differentiate
them from Grade I/II* buildings and Registered Parks and Gardens which are of normally considered of greater heritage value (very high significance). This is standard in EIA methodology and assists in determining an appropriate level of environmental effect.

6.4.30 Unless the nature and exact extent of archaeological remains have been determined through prior investigation, the significance of below ground heritage assets is often uncertain.

6.4.31 Built heritage and above ground archaeological remains (eg, earthworks and landscapes) are visible and tangible and, where appropriate, significance is considered in more detail. However, potentially important elements of above-ground assets may also be concealed, such as where the interiors of a historic building are obscured by later alterations and finishes such as new rendering or plaster. In such cases further clarification may be required via site based investigative survey (field evaluation).

**Determining magnitude of impacts**

6.4.32 The determination of magnitude of impact (change) upon asset importance is based on the severity of proposed impact (generally a physical impact from construction works), against the existing baseline situation and the importance of those historic environment assets affected. As the presence, nature, extent, survival, and importance of buried heritage assets within any given area is often uncertain, the magnitude of impact can be difficult to predict from solely desk based means. The table below sets out the criteria used to define impact magnitude.

**Vol 5 Table 6.4.2 Historic environment magnitude criteria for impacts**

<table>
<thead>
<tr>
<th>Impact magnitude</th>
<th>Definition</th>
</tr>
</thead>
</table>
| High             | Complete removal of asset significance  
                  | Change to the asset significance resulting in a fundamental change in our ability to understand and appreciate the resource and its historical context and setting. |
| Medium           | Change to the asset significance resulting in an appreciable change in our ability to understand and appreciate the asset and its historical context and setting. |
| Low              | Change to the asset significance resulting in a small change in our ability to understand and appreciate the asset and its historical context and setting. |
| Negligible       | Negligible change or no material change to the asset significance. No real change in our ability to understand and appreciate the asset and its historical context and setting. |
| Uncertain        | Level of survival/condition of asset in specific locations is not known: therefore, magnitude of impact is not known. |
**Determining the significance of effect**

6.4.33 The significance of environmental effect is determined by combining the asset significance of baseline assets (value) with the magnitude of impact on the asset value as shown in the matrix in Vol 5 Table 6.4.3. Impacts may be either adverse (negative) or beneficial (positive). Where information is insufficient to be able to quantify either the asset value or magnitude of impact with any degree of certainty, the significance of the environmental effect is given as ‘uncertain’.

6.4.34 As noted previously, information on known heritage assets in the wider study area identified through baseline data collection has been used to determine the potential for previously unrecorded heritage assets of any specific chronological period to be present within the site. Where the likelihood of such assets being present is considered to be low, the probability of the predicted effect occurring is therefore low. The effect is noted as being ‘unlikely’ in the assessment volumes, since the purpose of EIA is to identify ‘likely’ significant effects.

6.4.35 Section 2 provides the generic methodology information and the generic significance matrix.
### Vol 5 Table 6.4.3 Historic environmental significance of effect criteria

<table>
<thead>
<tr>
<th>Magnitude of impact</th>
<th>Asset significance (value)</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Very high</td>
<td>High</td>
<td>Medium</td>
<td>Low</td>
<td>Very low</td>
<td>Uncertain</td>
</tr>
<tr>
<td>High</td>
<td>Major</td>
<td>Major</td>
<td>Major/</td>
<td>Moderate/</td>
<td>Minor</td>
<td>Uncertain</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>moderate*</td>
<td>/Minor*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Medium</td>
<td>Major</td>
<td>Major/</td>
<td>Moderate</td>
<td>Minor</td>
<td>Negligible</td>
<td>Uncertain</td>
</tr>
<tr>
<td></td>
<td>moderate*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low</td>
<td>Moderate</td>
<td>Moderate/</td>
<td>Minor</td>
<td>Minor</td>
<td>Negligible</td>
<td>Uncertain</td>
</tr>
<tr>
<td></td>
<td>minor*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Negligible</td>
<td>Minor</td>
<td>Minor/</td>
<td>Negligible</td>
<td>Negligible</td>
<td>Negligible</td>
<td>Uncertain</td>
</tr>
<tr>
<td></td>
<td>negligible*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Uncertain</td>
<td>Uncertain</td>
<td>Uncertain</td>
<td>Uncertain</td>
<td>Uncertain</td>
<td>Uncertain</td>
<td>Uncertain</td>
</tr>
</tbody>
</table>

* The matrix is intended to provide transparency in the assessment process, but is intended as a guide only and rather than presenting a rigid set of values, allowing the flexibility to apply professional judgement depending on the nature of the asset and the impact upon it. Where the environmental effect shown has more than one value (moderate/minor or major/moderate) the significance of effect will be identified through professional judgement. For example, where a high magnitude of impact is only likely to affect certain localised areas it may be appropriate to judge that the significance of effect is minor rather than moderate.
6.4.36 The table below defines each significance rating. In EIA terms, Major and Moderate effects are considered to be ‘significant’.

**Vol 5 Table 6.4.4 Historic environment significance criteria**

<table>
<thead>
<tr>
<th>Significance of effect</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Major adverse</td>
<td>Negative effect that would be an important consideration, possibly at a national level.</td>
</tr>
<tr>
<td>Moderate adverse</td>
<td>Negative effect that would be an important consideration at a regional or county level (i.e., at the level of Greater London or multiple LBs)</td>
</tr>
<tr>
<td>Minor adverse</td>
<td>Negative effect that would be a relevant consideration in a local (i.e., Borough) context.</td>
</tr>
<tr>
<td>Negligible</td>
<td>Effect that is nil or imperceptible and not significant.</td>
</tr>
<tr>
<td>Uncertain</td>
<td>Unquantified significance of effect due to lack of information.</td>
</tr>
<tr>
<td>Minor beneficial</td>
<td>Positive effect that would be a relevant consideration in a local context.</td>
</tr>
<tr>
<td>Moderate beneficial</td>
<td>Positive effect that would be an important consideration at a regional or county level.</td>
</tr>
<tr>
<td>Major beneficial</td>
<td>Positive effect that would be an important consideration at a national level.</td>
</tr>
</tbody>
</table>

**Cumulative, in combination and compound effects**

6.4.37 The generic approach to assessing cumulative, in combination and compound effects is described in Section 2. The specific approach to the historic environment is described below.

6.4.38 The site specific assessments will consider the cumulative effects of the works at that site, plus other non-Thames Tunnel developments in the vicinity and other Thames Tunnel sites in the vicinity (compound effects). Cumulative or compound effects on the historic setting of heritage assets, such as Listed Buildings and conservation areas, would occur where other Thames Tunnel sites or non-Thames Tunnel developments fall within and adversely affect, the setting of a heritage asset by virtue of its visual presence or due to other construction effects such as noise or dust. Cumulative or compound effects could also occur where assets within and outside the site have a group value or significance in addition to their individual significance.

**Project-wide effects**

6.4.39 Project-wide effects may arise through the cumulation of impacts on individual heritage assets at each Thames Tunnel site, with these individual assets being associated with the key heritage route-wide themes identified in the Historic Environment Route Overview (see Volume 6 Appendix B). For example, at a number of sites evidence of
prehistoric land surfaces and river use (one of the heritage themes) may be removed by temporary cofferdams and permanent foreshore structures. The compound effect of removing such remains at a number of foreshore locations across the project will be considered in the ongoing EIA for presentation in the ES, when baseline data on past dredging, along with existing fluvial scour (which would have entirely removed or truncated any prehistoric landsurfaces respectively), is available.

**Project wide baseline data collection methodology**

6.4.40 The baseline for the project wide effects comprises all the site-specific baseline data, collected as per the methodology described above, along with a 250m buffer around the line of the main tunnel and connecting tunnels which forms the study area for defining project wide heritage themes. The assessment area is considered to be appropriate to characterise the historic environment at each Thames Tunnel site, and in respect of the Route Overview, to identify the key heritage themes along the line of the tunnel. Occasionally there may be reference to assets beyond these defined areas, where appropriate, for example where such assets are particularly significant.

6.4.41 A key component of the methodology for compiling baseline data for inclusion in the Historic Environment Route Overview is a desk-based study, consulting a broad range of archaeological, documentary and cartographic sources.

6.4.42 It also includes site walkover surveys for individual sites and a review of the results of geotechnical investigations, some of which have been archaeologically monitored.

**Asset significance for project wide baseline**

6.4.43 The collective significance/group value of individual heritage assets that would be affected by the proposed scheme, and which are associated with the key route wide heritage themes is defined by professional judgement, in line with the criteria for 'Defining receptor value' outlined above (para. 6.4.25).

**Project wide assessment methodology**

6.4.44 The broad methodology for assessing likely significant project-wide effects follows the methodology, including the significance matrix, set out above for site specific assessments.

6.4.45 The assessment of project-wide effects follows the following stages:

a. Compilation of a list of heritage assets which fall within one of the key route-wide themes likely to be significantly affected during the construction or operational phase at more than one site;

b. Assessment of the magnitude and significance of the effect of construction and operation on the whole resource.

6.4.46 For example, sections of historic river wall might be removed at one site, perhaps resulting in a minor adverse effect, but across the project a number of sections of the historic river wall, part of a finite resource along the River Thames, would be removed, and the environmental effect of the
loss may be more significant. Such effects will be identified based on professional judgement, as there is no guidance to guide such an assessment.

6.4.47 Project-wide construction phase effects would include individual site-specific impacts which may, when combined, constitute a greater collective effect on a given class of asset. This applies particularly if the asset class is homogeneous, with an enhanced group value.

6.4.48 Project-wide operational phase effects could include:

a. Effects from works which may affect public appreciation of the historic character and setting of designated assets forming part of a route wide theme, e.g. changes in public appreciation of Bazalgette’s Embankment, its overall linearity and uniformity of architectural features.

b. Hydrological effects where proposed dredging and the presence of new foreshore structures within the Thames could cause altered flow regimes. Such activities could result in changes to riverine deposition or scouring, affecting groups of heritage assets along certain stretches of the river - primarily foreshore resources such as prehistoric landscapes and post-medieval industrial wharves, jetties and barge beds.

c. Settlement effects – the spatial extent of likely significant effects from ground settlement on heritage assets due to the presence of the tunnel will be identified based on settlement contour data. The assessment will consider the impact of ground settlement on statutorily designated (protected) heritage structures, comprising listed buildings and scheduled monuments. Ground settlement of deep constructions at each site, other than the tunnel itself, will be assessed within the site-specific assessments.

Assumptions and limitations

6.4.49 Section 2 sets out generic assessment assumptions and limitations. General topic specific assumptions and limitations are described below, with further consideration in Volumes 6, 7 to 28 where necessary.

Limitations

6.4.50 The primary sources of information on heritage resources are the GLHER and the LAARC, which list all known archaeological sites and finds. However, such databases are limited in their ability to identify unknown assets, and the information listed in the gazetteers within the baseline sections of each site specific assessment provide an initial indication of assets present rather than a definitive list of all potential archaeological assets.

6.4.51 Most of the sites have not been subject to archaeological investigation in the past. A few sites are in areas where archaeological understanding is further limited due to a lack of past archaeological investigation in the study area around the site. Current understanding is therefore often limited, in particular for periods not present or poorly presented in the historical record (prehistoric, Roman and early medieval periods).
Therefore, the presence/extent, date, nature, survival and significance of possible, previously unrecorded, buried heritage assets are largely uncertain.

6.4.52 Where information is not available, professional judgement has been used to assess historic environment potential. This approach is based on other relevant data, for example the nature and depth of subsurface geological deposits as noted in geotechnical surveys and BGS data (this can provide an indication of the likely nature, depth, and survival of archaeological remains, if present), and the history of past land use as shown on historic maps (useful for determining likely truncation and survival potential). Further site based archaeological field investigation is normally required to clarify archaeological potential and significance.

6.4.53 Notwithstanding these limitations, the methodology is robust, utilising reasonably available information, and conforms to the requirements of local and national guidance and planning policy. Typically appropriate standard archaeological prospection and evaluation techniques are utilised post consent to reduce the uncertainties inherent in any desk based study, as part of an overall EIA mitigation strategy.

**Assumptions**

6.4.54 The assessment relies on available data and best endeavours have been made to ensure that the data are accurate and up to date. It is assumed that data on known sites and finds as supplied by the Greater London HER is accurate. A summary of the assumptions is provided below.

a. Limitation: the nature of the archaeological resource - buried and not visible. Acknowledgement of the limitation of attempting to predict the presence of new (possible, previously unrecorded) assets, based solely on a desk based study and site visit.
   i. The information as listed in the gazetteers within the baseline section should not be seen as a definite list of all assets present on the site, but rather as a list of those which are currently known or likely to be present.

b. Assumption: information on the GLHER database is accurate.
   i. Compiling the baseline has entailed reviewing and to an extent validating the GLHER data (eg, ensuring asset national grid co-ordinates match the address, removal of errors and further research, where appropriate, into GLHER entries with little information).

6.5 **Approach to mitigation**

**Construction**

6.5.1 Mitigation requirements would be informed by selective site based assessment carried out post-consent and in advance of construction. This could include a variety of techniques, such as geotechnical investigation, geoarchaeological deposit modelling, archaeological test pits and trial trenches. This evaluation would enable a more targeted and precise mitigation strategy to be developed.
Subject to the findings of any site based investigation carried out post-consent, mitigation of the adverse effects upon both built and buried assets is likely to include one of the following:

a. preservation *in situ*. This is the preferred option for assets potentially of national significance (eg, listed buildings or scheduled monuments). The aim would be to configure the project design, where feasible, to allow such remains to be permanently safeguarded and retained in situ. At this stage the PEIR has not identified any significant impacts on such remains. In some case it may also be feasible and practicable to preserve assets of lesser significance *in situ* by attention to detailed engineering design (eg, by raising formation levels within temporary works compounds). However, other forms of mitigation would be equally acceptable for assets not of national significance.

b. Preservation by record to include advancing understanding and public appreciation of asset significance. For assets not of national significance, archaeological investigation, recording and publication ensures that the record (and public appreciation of it) is preserved even when the asset has been physically removed.

c. PPS5 indicates that the purpose of mitigation is to advance wider public appreciation of, and participation in, the historic environment. Therefore during the ongoing design process opportunities will be sought, where appropriate, to protect and enhance the condition and setting of any affected assets and to improve interpretation.

The mitigation strategy will be informed by ongoing design dialogue with the project engineers, and future site based assessment carried out post consent.

Mitigation of construction effects will in most cases consist of archaeological investigation of built and buried assets affected by the proposed scheme, to appropriate professional standards, both before and during construction. Such preservation by record will be undertaken where preservation *in situ* is not feasible or necessary. It is a standard and appropriate approach to mitigation of adverse environmental effects upon assets which are not of very high significance, thus avoiding or reducing any adverse effects.

Where desk and site based assessment indicates a need for mitigation of above ground heritage assets, preservation by record is likely to include standing building archaeological survey and recording to an appropriate English Heritage standard. This may be undertaken prior to the demolition of the asset, alteration to its fabric, or modification to allow the asset a new function as part of the project. For example, where the project entails removal or alteration to the fabric of the Thames river wall, or where sections of the wall would be permanently obscured by the permanent works, archaeological survey and recording may be required.

Mitigation for significant (eg, listed) built heritage assets would typically commence with on-site assessment in the form of an evaluation survey to further determine the overall condition, significant features and potential of the asset. This more detailed information would inform the development
of a suitable mitigation strategy. This would include any protective measures needed to remove and later reinstate heritage assets or otherwise prevent accidental damage during construction (in addition to the generic safeguards contained in the CoCP).

**Operation**

6.5.7 Operational effects will be assessed in the ongoing EIA for presentation in the ES and an appropriate mitigation strategy developed where possible to address any predicted effects on the setting of historic assets (further to the environmental design measures already developed and incorporated to date. Mitigation might include changes to cladding materials or ground surface treatments to ensure the appearance of structures is in keeping with the historic environment.
7 Land quality
7.1 Introduction
7.1.1 This section sets out the full EIA methodology for the assessment of land quality effects associated with the Thames Tunnel project. Work which has not been fully completed for the PEIR will be completed for the ES, and this is noted below and within each site specific assessment volume.

7.1.2 Both construction and operational effects are considered.

7.1.3 Land can become contaminated by previous industrial uses through activities that may result in the spillage and seepages of harmful substances. Such contamination has the potential to adversely affect site users, neighbours, site structures and the wider environment, if it is not addressed and mitigated (remediated) where necessary.

7.1.4 Contaminated land may be encountered where construction works for the Thames Tunnel project involve breaking ground, for example the construction of shafts or for the excavation of utilities. It may also be encountered where ground undergoes significant disturbance, eg, through major ground treatment or demolition.

7.1.5 It is therefore necessary to undertake a land quality assessment across the project to determine potential impacts and effects.

7.1.6 Key interfaces with the land quality topic are as follows:
   a. Water resources – groundwater
   b. Water resources – surface water
   c. Aquatic ecology
   d. Terrestrial ecology.

7.1.7 Land quality can potentially impact upon the water resources and ecology via mobilisation of pre-existing contamination, creation of new contaminant pathways and the addition of new pollution sources through construction and during operation of the project. These topics should therefore also be referred to gain a wider understanding of impacts arising from land quality on these potential receptors.

7.1.8 Contaminated and uncontaminated soils from excavations will be required to be handled and managed as part of the waste strategy for the project.

7.2 Scoping Opinions and technical engagement
7.2.1 A summary of Scoping Opinions and technical engagement undertaken in relation to land quality is contained in Volume 4, Sections 3.7 and 4.7.

7.2.2 The principal stakeholders in terms of land quality are the Environment Agency and local authority Environmental Health Departments.
7.3 **Baseline data collection methodology**

**Desk based baseline data**

7.3.1 The method for determining and appraising baseline conditions involves desk study data collection and interpretation. Survey work at each of the sites and tunnel alignment includes a review of the information presented in the table below.

**Vol 5 Table 7.3.1 Land quality - desk based baseline data sources**

<table>
<thead>
<tr>
<th>Source</th>
<th>Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thames Tunnel Ground Investigation</td>
<td>Geological profile, groundwater levels, groundwater, soil and soil gas data</td>
</tr>
<tr>
<td>Thames Tunnel GIS – sourced from Landmark Information Group</td>
<td>Historic maps</td>
</tr>
<tr>
<td></td>
<td>Source Protection Zones</td>
</tr>
<tr>
<td></td>
<td>Pollution incidents to controlled waters</td>
</tr>
<tr>
<td></td>
<td>Boreholes</td>
</tr>
<tr>
<td></td>
<td>Historic landfill sites</td>
</tr>
<tr>
<td></td>
<td>Authorised landfill sites</td>
</tr>
<tr>
<td></td>
<td>Registered landfill sites (Point)</td>
</tr>
<tr>
<td></td>
<td>Licensed Waste Management Facilities (Point)</td>
</tr>
<tr>
<td></td>
<td>Licensed Waste Management Facilities/landfill boundaries</td>
</tr>
<tr>
<td></td>
<td>Registered Waste Treatment or Disposal Sites</td>
</tr>
<tr>
<td></td>
<td>Control of Major Accident Hazards (COMAH) sites</td>
</tr>
<tr>
<td></td>
<td>Integrated Pollution Permit and Control (IPPC) Permit sites (Active)</td>
</tr>
<tr>
<td></td>
<td>Registered radioactive substances</td>
</tr>
<tr>
<td></td>
<td>Authorised radioactive substances</td>
</tr>
<tr>
<td></td>
<td>Registered waste treatment or disposal sites</td>
</tr>
<tr>
<td></td>
<td>Notification of Installations handling hazardous substances (NIHHS)</td>
</tr>
<tr>
<td></td>
<td>Past contamination - land use</td>
</tr>
<tr>
<td></td>
<td>Groundwater abstraction points</td>
</tr>
<tr>
<td>Thames Water</td>
<td>Review of Thames Water operational site records to establish list of potentially contaminating substances stored on site and whether or not any pollution incidents had taken place over the previous five years</td>
</tr>
</tbody>
</table>
Field survey baseline data

7.3.2 Land quality field surveys involved a walkover survey of each site by a land quality specialist. The surveys followed widely used guidance on the preliminary assessment of land contamination such as BS1075: Investigation of Potentially Contaminated Sites (British Standards) and CLR2: Guidance on the preliminary site inspection of contaminated land (Department of the Environment)\(^74\). In particular, the following aspects were looked at:

a. size and topography of site and surroundings
b. neighbouring site use and any sensitive receptors
c. site buildings – extent and construction
d. surfacing – extent, type and condition
e. vegetation – type, distribution and signs of distress (including invasive species)
f. presence of fuels or chemicals storage on site and extent and type of containment measures present
g. vehicle servicing or refuelling onsite
h. waste generated/stored onsite
i. surface water
j. site drainage
k. evidence of previous site investigations
l. evidence of land contamination (eg, odours or staining of ground surface).

Additional baseline data collection

7.3.3 A second phase of intrusive ground investigation (GI) is underway across the project. This will include the drilling of additional boreholes, testing of soil and groundwater samples, monitoring of groundwater levels and assessment of the soil gas regime.

7.3.4 Additionally it is specifically proposed to undertake an assessment of the sediment quality within the foreshore sites to assess the risks to aquatic organisms from construction activities within the foreshore.

7.3.5 Data from the second GI phase will be reviewed for the ES.
7.4 Assessment methodology

General

7.4.1 A key element of undertaking a contaminated land assessment is the development of a site conceptual model (SCM) that describes the environmental features of the site together with the expected interaction of potential contamination sources with the environment. This is done by undertaking a Source-Pathway-Receptor (S-P-R) analysis of the site:

a. Sources (S) are potential or known contaminant sources, eg, a former fuel storage area
b. Pathways (P) are environmental systems through which a contaminant could migrate, eg, air, soil, unsaturated zone, groundwater
c. Receptors (R) are sensitive environmental receptors that could be adversely affected by a contaminant, eg, site occupiers, construction workers, building materials, or groundwater resources.

7.4.2 Where a source, relevant pathway and receptor are present, a pollutant linkage is considered to exist whereby there is a circumstance through which environmental harm could occur to receptors.

7.4.3 Without a significant pollutant linkage being identified by the S-P-R conceptual model, the contamination may be a hazard but does not constitute a risk to human health or the environment.

7.4.4 Therefore, when assessing the potential for contamination to cause a significant effect, the extent and nature of the potential source or sources of contamination must be assessed, the pathways identified, and any sensitive receptors identified and appraised to determine their value and sensitivity to contamination related effects.

7.4.5 If a significant source has been identified and potential sensitive receptors are present, then the potential effects will be determined by considering the pathways whereby the source may affect the receptors. During the assessment it will be assumed that there will be (either during or after construction) a pathway present between the source and the receptor, unless there is a clear indication that this will not be the case.

7.4.6 The EA provides guidance on EIA with regard to contamination issues (Scoping guidelines for EIA, EA 2002). There is also a considerable body of guidance, including CLR 11 – Model Procedures for the Management of land Contamination, that has been prepared in order to assist both local authorities and practitioners in assessing the degree to which land is contaminated, and deciding whether such land is contaminated within the definition of the Part IIA of the Environmental Protection Act 1990 (as amended by the Water Act 2003) and associated guidance.

7.4.7 The Environmental Protection Act provides a statutory definition of contaminated land - “Contaminated Land is any land which appears to the Local authority in whose area it is situated to be in such a condition, by reason of substances in, on or under the land, that:

a. significant harm is being caused or there is a significant possibility of such harm being caused, or
b. significant pollution of controlled waters is being, or there is a significant possibility of such pollution being, caused.”

7.4.8 The guidance detailed above, and the definition of contaminated land, have been applied to the appraisal of land quality.

**Construction and operational effects**

**Assessment cases and years**

7.4.9 The generic assessment cases are described in Section 2. The following section describes the specific approach for land quality receptors.

**Assessment cases**

**Base case**

7.4.10 The base case for assessment will be a future case, without the project, in any particular assessment year.

7.4.11 In general terms land quality will remain relatively constant - it is unlikely that significant changes that may substantially alter the base case from the existing baseline will take place at majority of the sites. However, the following scenarios have been considered with regard the future base case:

a. Existing derelict/non-contaminating sites with no change in use – in this scenario it is possible that there may be a slight decrease in certain contaminants as natural attenuation processes take effect.

b. Existing industrial/potentially contaminating sites, no change in use- in this scenario it is possible that land quality may deteriorate slightly as continued use of the land for contaminating activities increases emissions of substances to the ground.

c. Existing derelict or industrial/potentially contaminating sites which are redeveloped – in this scenario land quality is likely to improve as remediation schemes are adopted and implemented through planning processes.

7.4.12 Having reviewed the proposed major new developments in the vicinity of each site no changes in the land quality base case are considered likely at this stage. If major development sites in the vicinity of the preferred sites for the Thames Tunnel are known to be contaminated, consideration has been given to the potential for migration of contamination between these and the preferred site (and vice versa).

**Development case**

7.4.13 A development case is a future case during either the construction or operation of the project in the same assessment year as the equivalent base case. The assessment typically considers the ‘development case’ compared with the ‘base case’ in any particular assessment year (see below).

**Assessment years**

7.4.14 The assessment year for construction is Year 1 of construction.

7.4.15 The assessment year for operation is Year 1 of operation.
Assessment areas

7.4.16 The geographical extent of the assessment will consider all locations where physical works and ground disturbance will take place through the surface soils, i.e., all the sites and 250m beyond. The spatial scope also considers the Tunnel at depth where it passes through the lower Lambeth Group, Thanet Sand and Chalk.

Significance criteria

Determining magnitude of impacts

7.4.17 The qualitative descriptions of magnitude of impact shown in Vol 5 Table 7.4.1 are based on:

a. CIRIA C552, Contaminated Land Risk Assessment– A Guide to good practice

b. the EA and Water Framework Directive classifications for surface water

c. the EA classification scheme for protection of groundwater resources that defines Source Protection Zones (SPZs)

d. published Contaminated Land Reports (CLRs) published by DEFRA/EA and its predecessors (Department of the Environment).

Vol 5 Table 7.4.1 Land quality - impact magnitude criteria

<table>
<thead>
<tr>
<th>Impact magnitude</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>Previous or ongoing activities on or near to a site where severe harm to a defined receptor is very likely. Site investigation data indicating contamination on many sites affected by current or former uses. Quantitative or qualitative risk assessment data estimating a significant likelihood of adverse effects from exposure to pollutants in the environment. Loss of the special characteristics of a water resource. Reduction in WFD grade, pollution of potable source, severe flood risk, loss of fisheries. Any pollution of a Principal Aquifer.</td>
</tr>
<tr>
<td>Medium</td>
<td>Previous or ongoing activity where harm to a defined receptor is possible but severe harm is unlikely. Site investigation data indicating moderate contamination. Quantitative or qualitative risk assessment data estimating medium risk of adverse effects from exposure to pollutants in the environment. Impact on water resources. Reduction in the production of fisheries, moderate changes insufficient to reduce water quality. Any pollution of a Secondary Aquifer.</td>
</tr>
<tr>
<td>Low</td>
<td>Greenfield site or previous or ongoing activities where harm</td>
</tr>
</tbody>
</table>
Preliminary environmental information report

Impact magnitude | Definition
--- | ---
Negligible | No impact
Site investigation data indicating significant contamination is unlikely. Quantitative or qualitative risk assessment data estimating low likelihood of adverse effects from exposure to pollutants in the environment.
Minor impact, insufficient to affect the use or characteristics of the water resource. Impacts to unproductive strata.

Note: as land quality impact magnitude is linked to potential existing contamination, the definitions above necessarily closely relate to existing baseline conditions.

Defining resource value / receptor sensitivity

7.4.18 The sensitivity criteria in Vol 5 Table 7.4.2 have been developed to take into account the nature and sensitivity of the receptor as well as the period of exposure of the receptor to contamination.

7.4.19 The sensitivity of the receptor varies based on the value of the land use or feature. This relates to the anticipated exposure of the receptor to elevated levels of contamination. The categories are based on standards and targets set by governmental authorities such as Natural England and the EA, and advisory bodies such as CIRIA.

Vol 5 Table 7.4.2 Land quality - receptor value/sensitivity

<table>
<thead>
<tr>
<th>Receptor sensitivity</th>
<th>Low</th>
<th>Moderate</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td>Future users</td>
<td>Industrial, infrastructure, warehouses, car parks</td>
<td>Commercial, forestry, agricultural</td>
<td>Residential, allotments, school ground</td>
</tr>
<tr>
<td>Surrounding land users</td>
<td>Industrial warehouses, car parks</td>
<td>Commercial, open spaces</td>
<td>Residential, allotments</td>
</tr>
<tr>
<td>Construction workers or site operatives</td>
<td>Minimal construction works</td>
<td>Limited construction works</td>
<td>Intensive construction works</td>
</tr>
<tr>
<td>Ecological sites</td>
<td>Sites of no significant ecological value</td>
<td>Viable areas of key habitat identified in the Regional Biodiversity Action Plan (BAP) or smaller areas of such habitat</td>
<td>Habitats which are essential to maintain the viability of a larger whole</td>
</tr>
</tbody>
</table>
### Receptor sensitivity

<table>
<thead>
<tr>
<th>Receptor sensitivity</th>
<th>Low</th>
<th>Moderate</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>which are essential to</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>maintain the viability of a</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>larger whole.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Local Nature Reserves</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>selected on Parish</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>ecological criteria</td>
<td></td>
</tr>
</tbody>
</table>

### Water resources

<table>
<thead>
<tr>
<th>Water resources</th>
<th>Surface water</th>
<th>Groundwater</th>
<th>Built environment</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Fish absent or sporadically present. Impoverished ecosystem WFD chemical classification Poor</td>
<td>Good cyprinid fisheries. WFD chemical classification Moderate</td>
<td>Sites with a local or district value or interest for education or cultural appreciation; locally listed buildings</td>
</tr>
<tr>
<td></td>
<td>Good salmonid and cyprinid fisheries. WFD chemical classification Good</td>
<td>Principal Aquifer</td>
<td>Sites of national and international importance; World Heritage Sites; Scheduled Monuments</td>
</tr>
</tbody>
</table>

### Groundwater

**7.4.20** Groundwater quality in the ‘upper’ aquifer (defined as the River Terrace Deposits and alluvium) has been directly compared with Environmental Quality Standards for saltwater published by the Water Research Council (this takes into account the saline nature of the tidal River Thames).

**7.4.21** Groundwater quality in the ‘lower’ aquifer (defined as the Lambeth Group, Thanet Sand Formation and Chalk) has been directly compared to concentrations set out in the Water Supply (Water Quality) Regulations.
due to the potential for this groundwater resource to be exploited for potable water supply.

**Soils – risk to human health**

7.4.22 In order to provide a preliminary assessment on the levels of contamination present, soil quality data from the Thames Tunnel ground investigations have been compared to widely used UK specific assessment criteria, namely:

a. Soil Guidance Values published by the EA

b. generic assessment criteria (GAC) published by the Chartered Institute of Environmental Health and Land Quality Management (2nd Edition)\(^{77}\)

c. generic assessment criteria published by Contaminated Land: Application in Real Environments (CL:AIRE).

7.4.23 In view of the proposed development and for the purpose of the ES, the data will initially be compared to industrial/commercial screening values. The assessment criteria provide generic screening values to assess the potential for the long term risks to human health; and in this scenario the most sensitive receptor is considered to be a 17 year old female worker in a completed commercial/light industrial development where some exposure to the underlying soils is anticipated.

7.4.24 The values are not designed to provide comment on immediate (short term) risks to construction workers.

7.4.25 Further risk assessments will be undertaken as part of the EIA and reported in the ES. These will take into account the specific end use of permanent works area (for instance where the shaft area is incorporated into a residential development).

**Sediments – risk to aquatic organism**

7.4.26 The results of laboratory testing on samples of soils/sediment retrieved from boreholes located in the river will be compared to Threshold Effect Levels (TEL) and Probable Effect Levels (PEL). These levels identify biological effects attributed to certain contaminant concentrations in the Canadian Sediment Quality Guidelines, which are used for assessment as currently the UK does not have any published sediment quality guidelines. These guidelines are endorsed by the Port of London Authority.

7.4.27 In accordance with the Canadian Sediment Quality Guidelines\(^{78}\), concentration below the TEL is defined as the minimal effect range within which adverse effects rarely occur. Between the TEL and PEL, is the possible effect range within which adverse effects occasionally occur and Above the PEL is the probable effect range within which adverse effects frequently occur.

**Determining the significance of effects**

7.4.28 The likely severity of the effects will be assessed using the matrix given in Vol 5 Table 2.4.1 in conjunction with professional judgement to consider site-specific factors that may be of relevance.
7.4.29 A descriptive meaning for the five points on the severity of effects scale, and the corresponding significance of the effect is detailed in Vol 5 Table 7.4.3.

7.4.30 The five point scale given in Vol 5 Table 7.4.3 is judged to be appropriate for land quality as it is compatible with common land quality risk assessment process and industry standards (eg, CIRIA C552).

7.4.31 This methodology is also consistent with that adopted by other major infrastructure schemes within London.

**Vol 5 Table 7.4.3 Land quality - significance criteria**

<table>
<thead>
<tr>
<th>Significance of effect</th>
<th>Description</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Negligible</td>
<td>No discernable negative effects</td>
<td>Not significant</td>
</tr>
<tr>
<td>Slight</td>
<td>Non-permanent short term health effects on humans that are easily preventable</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Minor, low-level and localised contamination of on-site soils</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Easily repairable damage to crops/buildings/infrastructure</td>
<td></td>
</tr>
<tr>
<td>Minor</td>
<td>Non-permanent medium term health effects on humans that are easily preventable and treatable</td>
<td>Significant</td>
</tr>
<tr>
<td></td>
<td>Pollution of non-sensitive water resources</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Localised damage to crops/buildings/infrastructure (on or off site)</td>
<td></td>
</tr>
<tr>
<td>Moderate</td>
<td>Medium/long term (chronic) risk to human health from continued exposure</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Medium long term risk of pollution of sensitive water resource or ecosystem</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Significant damage to crops/buildings/infrastructure (on or off site)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Contamination of off-site soils</td>
<td></td>
</tr>
<tr>
<td>Major</td>
<td>Immediate (acute) risk to human health eg exposure to asphyxiant or explosive</td>
<td></td>
</tr>
</tbody>
</table>
### Cumulative and in combination effects

7.4.32 The general approach to assessing cumulative, in combination and compound effects is described in Section 2. It is not anticipated that there will be any cumulative or in combination effects associated with land quality.

### Project-wide effects

7.4.33 It is not anticipated that there will be any project-wide effects associated with land quality.

### Assessment assumptions and limitations

#### Baseline

7.4.34 The baseline data and assessment contains the following assumptions and limitations as summarised below.

7.4.35 Baseline conditions have been established in part from historical data. Where no ground investigation has been carried out, the assessment is entirely qualitative in nature.

7.4.36 Potentially contaminating land uses, which may have existed between the dates of the Ordnance Survey mapping, may have been omitted from the maps. As a result, Ordnance Survey mapping may not reveal all historic contamination sources.

7.4.37 Access to Chambers Wharf and Carnwarth Road has been constrained. At these sites field surveys were conducted from publicly accessible areas only.

#### Assessment

7.4.38 The project includes a comprehensive draft Code of Construction Practice (CoCP) which in terms of land quality assumes that a variety of design measures are already incorporated into the project in order to manage risks and reduce impacts and effects. These are summarised further in paras. 7.5.1 to 7.5.8, below.
7.5 **Approach to mitigation**

**Construction**

**Ground investigation and remediation**

7.5.1 As part of the draft CoCP, prior to construction, a ground investigation will be undertaken to determine ground conditions and characterise the contamination status of the site in terms of:

a. soil quality  
b. groundwater quality  
c. groundwater flow regime  
d. land gas regime  
e. buried unexploded ordnance (UXOs).

7.5.2 The ground investigation will be suitable to determine physical and chemical ground conditions which in turn can provide information for detailed risk assessments to identified receptors, eg, human health, plant and animal life, groundwater and construction materials.

7.5.3 During the investigation, UXO surveys will be carried out to ensure the identification and appropriate removal of potential UXO avoiding potential harm to human health, damage to the built environment and delays to the project.

**Construction phase**

7.5.4 Where potential risks to the project have been identified by the investigation and risk assessments, remedial measures can be drawn up to mitigate against such risks, for instance: schemes designed to remove or isolate contamination; schemes to remove/treat contaminants in groundwater; design of gas protection measures in permanent structures. This action will mitigate the minor to major effects identified to potentially impact upon human health, controlled waters, and the built environment during the construction phase. Following these, it is anticipated there will be no significant residual effects during the operational phase of the project.

7.5.5 The draft CoCP will set out procedures for the protection of human health, controlled waters and flora and fauna. Where highly contaminated material is encountered, it will be treated for potential re-use at the site or disposed of as a controlled waste, eg, as hazardous waste to a designated landfill. The plan will set out the necessary safe storage and handling of hazardous materials (eg, fuels) during demolition, remediation and construction phases.

7.5.6 To mitigate the effects from the migration of contaminants from site to the surrounding areas, the CoCP provided by the contractor will set out procedures for the protection of adjacent sites including dust suppression activities.

7.5.7 As standard design measures to protect human receptors (site investigation staff, remediation operatives and construction workers), best
practice construction methods will be utilised for working in structures and confined spaces as detailed in the draft CoCP. Appropriate PPE will be supplied and used at all times including gas monitoring equipment and breathing apparatus where necessary, resulting in no significant residual effects to human receptors.

7.5.8 The draft CoCP will effectively mitigate otherwise potentially minor effects during the demolition/ remediation / construction phases that may be identified and it is expected there will be no significant residual effects experienced during the construction and operational phase.

7.5.9 With the inclusion of the environmental design measures to be adopted within the draft CoCP (Volume 2, Appendix A), it is anticipated that there will be no need for mitigation measures during construction.

**Operation**

7.5.10 With the incorporation of environmental design measures within the construction phase and operational management through regulatory controls, it is not anticipated that there will a need for mitigation during the operational phase; however, this will be confirmed on a site by site basis through the assessment of each of the sites.
8 Noise and vibration

8.1 Introduction

8.1.1 This section sets out the full EIA methodology for the assessment of townscape and visual effects associated with the Thames Tunnel project. Work which has not been fully completed for the PEIR will be completed for the ES, and this is noted below and within each site specific assessment volume. Both construction and operational effects are considered.

8.1.2 Although much of the construction works would take place at some depth below ground, there are noise implications for areas surrounding the surface construction sites. Vibration from the tunnelling works could potentially cause groundborne noise and vibration impacts at shallower depths, and vibration from surface site construction activities could also affect areas closest to the sites.

8.1.3 The following types of noise and vibration source are identified as having the potential to result in significant effects during the construction phase:

a. noise from surface construction activities
b. vibration from surface construction activities
c. noise from construction road traffic on neighbouring roads
d. Noise from loading and unloading operations from river barges
e. groundborne noise from the operation of the Tunnel Boring Machine (TBMs)
f. groundborne vibration from the operation of the Tunnel Boring Machine (TBMs)
g. groundborne noise from the operation of the temporary below ground construction railway servicing the Tunnel Boring Machine (TBMs)
h. groundborne vibration from the operation of the temporary below ground construction railway servicing the Tunnel Boring Machine (TBMs).

8.1.4 Operational noise would potentially occur during tunnel filling events (water cascade) and during the release of air through the vent stacks. Although not typically an issue at other installations, the possibility of significant effects cannot be ruled-out for sensitive receptors very close to drop shafts, given the volumes of water during filling events. For any given receiver the potential for noise effects is related to the distance from the drop shaft and the existing noise level; ie, water cascade noise would be less noticeable at receptors already subject to higher ambient noise levels.

8.1.5 At times other than tunnel filling events there would be some low pressure flow of air through the ventilation shafts aided by fans. Given the low pressure flow, the noise emission is not expected to be noticeable at receptors surrounding many of the sites relative to existing noise levels. To some extent this will depend of the design of fans that would be used and it would be necessary to provide adequate noise attenuation to avoid
significant effects where there is a possibility that significant noise could occur. The incorporation of noise controls is currently being reviewed by the Thames Tunnel engineering team.

8.1.6 Routine inspections would be every 3 to 6 months and a maintenance check would take place every 10 years. Given the infrequent nature of these activities, noise and vibration from these short-term occasional activities have been scoped out of the assessment.

8.2 Scoping Opinions and technical engagement

8.2.1 A summary of the scoping and technical engagement undertaken in relation to noise and vibration is contained in Volume 4, Sections 3.8 and 4.8.

8.2.2 The Scoping Opinion and Position Paper comments shown in Volume 4 describe a number of points raised during the consultation process concerning the assessment method. There is an on-going process to review and discuss these methods. In some cases these points have been clarified in the responses to comment made in Volume 4. Where further work is required these issues will be dealt with in the EIA.

8.3 Baseline data collection methodology

8.3.1 For the purposes of the noise and vibration baseline, data describing the baseline situation are taken from a desk based review of site information and also surveys of noise around the surface sites to represent the noise climate.

8.3.2 Noise sensitive locations at which measurements have been taken include residential areas, other noise sensitive buildings and/or public amenities around the project at locations that could be exposed to construction or operational noise. Baseline locations have been selected to represent noise sensitive locations closest to the project surface sites which would be most affected. The baseline results have been used to compare against the estimated noise levels associated with the construction and operation of the development. It has not been possible to obtain baseline noise measurements for all of the sites for the PEIR although this data will be available for the ES.

8.3.3 Based on the Scoping Report, baseline noise surveys were designed to cover site construction hours for daytime working and in some cases 24 hour working. There have since been a number of sites where the potential for extended working in the evening has been identified for certain limited periods (eg, concrete pours). This information was not available at the time of the Scoping Report. In response to this, the individual boroughs have been consulted to find locations for continuous logging, where possible, over a number of days during the week and weekend. This data will be available in time for the EIA.

8.3.4 For some of the non-residential receptors assessed for the PEIR, comparison has been made to the noise levels reported from road traffic in the DEFRA London Noise Maps (2007)\textsuperscript{79}. The results reported in these maps is based on an average over a longer period (7am to 11pm) than the construction hours at most sites, which is therefore likely to be lower than
the actual, typical daytime noise level. The baseline level has been assumed to be the lowest value in the range given in the noise maps (with a facade correction added). The noise levels reported are indicative of the noise climate in an area rather than a specific receptor. However, using this data has enabled some indicative assessment of the noise change for those non-residential receptors where measurement is, as yet, unavailable. The baseline noise data will be updated with the measured data during preparation of the ES.

8.3.5 The sensitivity of a receptor to noise and vibration impacts is generally considered in terms of the potential effects on people occupying the buildings or areas in question. There is also the potential for vibration impacts on building structures themselves at very high levels of exposure, or on particular types of highly sensitive equipment. Vol 5 Table 8.3.1 describes the potential impacts of noise and vibration in terms of human occupants primarily for residential uses which would generally be considered the most sensitive use, i.e., as permanent living and sleeping spaces. However, the occupants of other buildings such as community halls, educational buildings, places of worship, hospitals would be sensitive to noise and vibration and Vol 5 Table 8.3.1 notes different levels of sensitivity to noise according to the particular use. The sensitivity of specialist equipment to vibration would depend on the particular type and would need to be assessed on the manufacturer’s specification for vibration tolerance. The impacts of vibration on building structures is unlikely except in the case of exceptionally high levels and is assessed against the criteria defined in the table below describes typical sensitivities for a range of receptor types.

Vol 5 Table 8.3.1 Noise and vibration sensitive receptors

<table>
<thead>
<tr>
<th>Receptor value and/or sensitivity¹</th>
<th>Receptor type</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>Residential properties, hospitals, special schools, TV/music, recording studios, recital rooms (or other sensitive performance auditoria, (particular vibration sensitivity for receptors making use of highly vibration sensitive equipment, eg microscopy, nanotechnology laboratories)</td>
</tr>
<tr>
<td>Medium</td>
<td>Schools/colleges, community halls, clinics/surgeries, libraries places of worship, offices, conference facilities, parks, conference, hotels</td>
</tr>
<tr>
<td>Low</td>
<td>Commercial, retail</td>
</tr>
</tbody>
</table>

¹The sensitivity categories shown are considered typical for the uses described, however, each must be assessed on its particular use and times of operation. Assigned sensitivities for particular receptors described in the individual site assessments may vary from that shown above.

Desk based baseline data

8.3.6 Baseline data on existing land uses and receptors were collated from mapping resources including ordnance survey and aerial photography, as
detailed in the table below. Findings were then later confirmed by site visits, photographs and advice from the project team.

**Vol 5 Table 8.3.2 Noise and vibration desk based baseline data sources**

<table>
<thead>
<tr>
<th>Source</th>
<th>Data</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ordnance survey</td>
<td>Location of potential noise sensitive receptors and land uses surrounding the sites.</td>
<td>Noise sensitive receptors include (but are not restricted to) dwellings, community buildings, hospitals/healthcare buildings, hotels/hostels, offices, open/public amenity space, premises with noise/vibration sensitive equipment, places of worship; recording studios, and schools/educational institutions.</td>
</tr>
<tr>
<td>Google Earth aerial imagery</td>
<td>Location of potential noise sensitive receptors.</td>
<td>-</td>
</tr>
<tr>
<td>Thames Tunnels GIS</td>
<td>Location of potential noise sensitive receptors and land uses surrounding the site</td>
<td>-</td>
</tr>
</tbody>
</table>

**Field survey baseline data**

8.3.7 Noise surveys were undertaken for some of the project sites between March and July 2011. Although not all sites have been surveyed at this stage, the surveys will be complete for the ES.

8.3.8 Measurements have been taken at locations considered to be representative of the noise climate of the nearest noise sensitive receptors to the proposed construction areas for each site. This was usually the nearest noise sensitive building/use, unless this was very close to a dominant noise source (e.g., from passing traffic) and it was considered other receptors could potentially be subject to larger changes in noise levels from the construction works.

8.3.9 On foreshore sites where dredging or foreshore works are proposed, a measurement was also taken close to sensitive receptors on the opposite bank to the proposed works.

8.3.10 For the majority of sites it was not possible to identify a suitable location for continuous unattended monitoring and therefore short sample attended measurements were completed instead. Each measurement was 15 minutes in duration, and measurements were completed in circuits so as to ensure that each successive sample at any location was taken during a later period (i.e., measurements at a given location were not consecutive but spread out over the full monitoring period).
8.3.11 The measured noise parameters and time periods for the short sample measurements are detailed in Vol 5 Table 8.3.3 and Vol 5 Table 8.3.4. These were agreed with the Boroughs in order to avoid busy peak periods and be representative of the quietest periods when noise from construction is likely to be most noticeable. All measurement periods were considered by the survey engineers to be typical of the noise climate of the sites during the inter-peak period. Specifically, there were no unusual noise sources operating to increase the baseline noise level, and traffic was considered to be flowing typically for the area.

8.3.12 A limited number of sites proposed for 24 hour working provided a suitable location for an unattended continuous measurement and these were monitored where available. Discussions are on-going with individual Boroughs to find locations for continuous logging, where possible, over a number of days during the week and weekend. This data will be available in time for the ES but not for the PEIR.

8.3.13 All measurements were made using a sound level meter complying with BS EN 60804, 1991, Specification for Integrating Sound Level Meters (if manufactured prior to 2003), or to BS EN 61672, Part 1, 2003 Electroacoustics – sound level meters – specification (if manufactured after 2003).

8.3.14 All sound level meters were checked with a sound level calibrator conforming to BS 7189: 1989 (if manufactured prior to 2003) or to BS EN 60942: 2003 (if manufactured after 2003) before and after each measurement, and the result of the check recorded.

8.3.15 All sound level meter kits (sound level meter and sound level calibrator) hold a valid calibration certificate issued by a United Kingdom Accreditation Service (UKAS) accredited calibration laboratory (or equivalent European accreditation body). All sound level meters are periodically calibrated in accordance with BS 7580: 1997: Parts 1 and 2 as appropriate.

8.3.16 The microphone was located 1.2 to 1.5m from the ground and at least 3.5m from any reflective surfaces. Where this was not possible, measurements were taken 1m from the façade of a building such that it would be clear that the measurement was affected by façade reflection and could be corrected if necessary.

8.3.17 The measurements were undertaken when weather conditions would not affect the ambient and background noise levels. Any precipitation was avoided and the wind speed in any direction did not exceed 5m/s. Where it was considered that conditions were not appropriate the survey was abandoned and recommenced at a later date.

Vol 5 Table 8.3.3 Noise and vibration field survey baseline data sources

<table>
<thead>
<tr>
<th>Source</th>
<th>Data</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Measured data for daytime</td>
<td>$L_{Aeq,T}; L_{A90,T}; L_{Amax}$</td>
<td>Time periods for noise surveys are shown in Vol 5 Table 8.3.4</td>
</tr>
<tr>
<td></td>
<td>Data collected over minimum of 15 minutes, at</td>
<td></td>
</tr>
</tbody>
</table>
### Source | Data | Notes
--- | --- | ---
| | least two sets of data in each two hour period. |  

**Measured data for night-time (where 24-hour working proposed) or operational noise if required**

- $L_{A_{eq,T}}$; $L_{A_{90,T}}$; $L_{A_{max}}$
- Data collected over minimum of 15 minutes, at least two sets of data in each two hour period.
- Time periods for noise surveys are shown in Vol 5 Table 8.3.4

**Measured data for weekends (where 24-hour working proposed)**

- $L_{A_{eq,T}}$; $L_{A_{90,T}}$; $L_{A_{max}}$
- Data collected over minimum of 15 minutes, at least two sets of data in each two hour period.
- Time periods for noise surveys are shown in Vol 5 Table 8.3.4

---

**Vol 5 Table 8.3.4 Noise and vibration field survey baseline data collection**

<table>
<thead>
<tr>
<th>Data collection</th>
<th>24 hour sites</th>
<th>Standard hour sites</th>
<th>Operational ventilation (if required)</th>
</tr>
</thead>
</table>
| **Time periods for measurements** | Weekday | 10am to 12pm  
2pm to 4pm  
8pm to 10pm  
Midnight to 4am | 10am to 12pm  
2pm to 4pm | Midnight to 4am |
|  | Weekends (Sunday) | 2pm to 6pm  
Midnight to 4am | N/A | N/A |
| **Duration of measurements** | Minimum of two measurements each of 15 minutes duration logging the $L_{A_{eq}}$ and $L_{A_{90}}$ for the whole period and at every 5 minutes so that shorter periods can be reported if required. Measurements for each site completed in circuits and not completed consecutively at any location. | **Parameters** | $L_{A_{eq,T}}$; $L_{A_{90,T}}$; $L_{A_{max}}$ |
### 8.4 Assessment methodology

**General**

**Legislation and guidance**

8.4.1 The highest level noise guidance document from which most other relevant documents stem is Planning Policy Guidance 24 (PPG24)\(^81\). This document describes the assessment of environmental noise sources in the planning context and refers to the required prediction and assessment guidance.

8.4.2 The effect of construction noise and vibration is usually assessed with reference to policy and guidance detailed below.

8.4.3 British Standard 5228: 2009\(^82\) provides guidance on the assessment of noise from construction operations and describes methods for evaluation of the significance of noise effects. The Standard contains detailed information on noise reduction measures and promotes the 'best practicable means' approach to control noise and minimise the effect on local residents and construction workers.

8.4.4 The Control of Pollution Act\(^83\) gives the local authority powers requiring the control of site noise under Section 60 of the Act. Under Section 61, the developer or contractor intending to carry out the works may apply in advance for a consent as to the methods by which the works are to be carried out. This may include specific controls to restrict certain activities identified as causing particular problems. Conditions regarding hours of operation will generally be specified and noise and vibration limits at certain locations may be applied in some cases. All requirements must adhere to established guidance and be consistent with best practicable means to control noise only as far as is necessary to prevent undue disturbance.

8.4.5 The Environmental Protection Act\(^84\) describes the duty of the local authority to take steps to abate any noise effect, including that from a construction site, deemed to be causing a statutory nuisance.

8.4.6 The Mayor's Ambient Noise Strategy\(^85\) does not contain any specific policy relating to construction noise. However, it notes that in 2002, 4% of London householders considered that roadwork / demolition / construction noise was a "serious problem" (compared with 13% for traffic noise), and states that the Mayor's aim is to secure the benefits from growth, while keeping construction noise under control. Construction noise is dealt with by individual LBs.

8.4.7 Many LBs have individual CoCPs and it is understood that a London-wide code of practice is being developed although is not yet publicly available. The individual Borough codes have been considered in developing the assessment methodology and mitigation approach.

8.4.8 Operational noise effects will depend on whether it is shown that operational noise from tunnel filling events or ventilation fans cause noise effects at nearby receptors. The methodology described in BS 4142 would be used to determine the likelihood or not of complaint according to
the relative level (and character) of the introduced noise source relative to the background noise level. If necessary, the operational noise will be mitigated relative to the local background noise levels (as defined by BS 4142) so as to prevent significant effects. These limits would be set appropriately in agreement with the local authority relative to the background noise levels at each receptor (as defined by BS 4142).

8.4.9 A quantitative assessment of the operational plant noise emission (and appropriate limit values) will be carried out as part of the EIA when more detail regarding plant design and noise control measures are available.

Construction and operational effects

8.4.10 The assessment of noise effects is made by comparing predicted noise levels during construction or operation against the future base case. The impact associated with change in noise level is evaluated along with other parameters, such as the number of receptors and their sensitivity, to assess the significance of the effect. In the case of vibration the effects are assessed in terms exceedance of particular threshold levels associated with disturbance or building damage, rather than by change relative to baseline level.

Assessment cases and years

8.4.11 The generic assessment cases are described in Section 2. The following section describes the specific approach for noise and vibration receptors.

Assessment cases

Base case

8.4.12 The base case for assessment will be a future case, without the project, in any particular assessment year.

8.4.13 The future base case, for most sites, has been taken as the existing baseline situation, ie, the various noise sources and receptors which characterise the locality and are relevant to the assessment. The baseline noise measurement surveys are generally considered to represent the future base case noise climate if there are no particular changes expected. However, the change in traffic flows between the current and future base case years has been examined to verify that traffic noise is unlikely to alter. Changes over the intervening period would be expected to be negligible unless major changes in the local road network are anticipated.

8.4.14 For a number of sites, it is known that other committed development in the locality will be built before or during Thames Tunnel construction works, or before the operation of surface sites. This committed development forms part of the base case and where the future base case is expected to change, any additional receptors have been included in the assessment of impacts. The existing measured baseline noise levels around the site have been used to represent the future base case noise climate where possible. If the expected committed development would, itself, alter the noise climate, for example by screening receptors from existing highways, the future base case noise levels has been estimated accordingly, by applying suitable corrections to the measured noise levels.
Development case
8.4.15 A development case is a future case during either the construction or operation of the project in the same assessment year as the equivalent base case. The assessment typically considers the ‘development case’ compared with the ‘base case’ in any particular assessment year (see below).

8.4.16 With regard to the development case, various assessment periods for construction have been considered in order to span the overall duration of the works. For the purposes of the PEIR, the estimated worst case construction noise has been assessed for each major stage of activity at each site, as defined in Volume 2, and Section 3 of each site specific volume (e.g., enabling works, foreshore works etc.). Rather than using a single assessment year, this provides more information as to how the effects of construction noise on the surrounding community would vary during the works and across the assessment period. This will be of most importance for sites with longer programmes of work.

Assessment years
8.4.17 The base case assessment year for construction works have been taken to be the start year minus 1 (before enabling works commence). As described, changes in noise climate between the current baseline noise monitoring and the base case assessment year would be very small but any increase in the intervening period would tend to make the assessment conservative.

8.4.18 It has been assumed that the plant would be operational from Year 1 of the operational phase.

Assessment areas
8.4.19 The study area is dependent upon the type of noise or vibration source being considered.

8.4.20 The assessment has considered construction noise from surface sites at receptors within approximately 300m of the site boundary. However, in built-up areas, it would be expected that effects would be limited to a smaller radius where there are two or more intervening rows of buildings screening the works from noise sensitive receptors.

8.4.21 Only a small number of specific types of surface construction activities give rise to significant levels of vibration from surface works and then only where they are employed close to sensitive receptors. These are therefore considered on an activity-by-activity basis.

8.4.22 Construction traffic routes, diversion or road closures as a result of the construction works which result in changes to the traffic flow have been considered within the assessment where any of the following criteria apply:

a. the flow changes are estimated to be greater than +25% or -20%
b. HGV composition could change by +/-5%
c. mean speeds could change by 10kmh.
8.4.23 For the purposes of the PEIR, the baseline traffic information is not yet available for all the sites, hence those areas where it is considered there is potential for construction traffic to give rise to the above traffic changes have been included in the study area.

8.4.24 Groundborne noise and vibration from the tunnel construction works, including the operation of the TBMs and supply trains would potentially affect receptors in a corridor above the tunnel, depending upon the tunnel depth at that particular location.

8.4.25 The operation of the TBM would result in the highest level of groundborne noise and vibration from the tunnelling works. Using the methodology stipulated in BS5228: Part 2: 2009, the 'low' impact classification for groundborne noise at residential receptors occurs at a distance of approximately 65m. This takes into consideration the worse case potential amplification as a result of the building construction and assumes the prediction of the upper-bound groundborne noise from the operation of tunnelling equipment.

8.4.26 At this distance, again using the prediction methodology stipulated in BS5228: Part 2: 2009, the predicted resultant vibration level is less than 1mm/s. Furthermore, the prediction methodology states that, in soft ground, this is likely to be excessively conservative and the constant term could reasonably be reduced by an order of magnitude.

8.4.27 Therefore the study area for the groundborne noise and vibration assessment for residential receptors is limited to within 65m radial distance of the tunnel crown.

8.4.28 Land uses where low ambient vibration is critical to operations include vibration sensitive research and manufacturing; hospitals with vibration sensitive equipment and procedures; and some university research operations. The degree of sensitivity to vibration will be dependent on the specific equipment and operations in the building. Equipment such as electron microscopes and high resolution lithographic equipment can be sensitive to vibration. Manufacturing of computer chips is an example of a vibration sensitive process.

8.4.29 Buildings with such equipment and processes are generally be located outside urban areas away from sources of environmental vibration. Where they are located in urban areas (eg, hospitals) then mitigation measures will generally be in place to protect the sensitive equipment and operations from external sources of environmental vibration. In all cases, such equipment and processes will be protected from internal occupational vibration (eg, footfalls and door slams) which means that sensitivity of such facilities to new external sources of environmental vibration is less than might be anticipated based on the sensitivity of the equipment itself.

8.4.30 Nonetheless, using a precautionary approach, mapping and datasets have been used to identify potentially vibration sensitive land uses that are within 250m of the tunnels. Following review of these data, any land uses where low ambient vibration could be critical to operations will be investigated further by contacting the owner to confirm the exact type of
use. This more detailed investigation of highly sensitive receptors will be carried out as part of the EIA.

8.4.31 The operational effects of plant machinery noise associated with ventilation of the tunnel have been considered for sensitive receptors around the sites. Noise would be controlled to within appropriate target levels agreed with the local authorities at the closest sensitive receptors. The position of the closest receptors therefore defines the study area for each site. Operational effects will also include consideration of tunnel filling events and any associated noise break out. It is expected that it will only be necessary to consider receptors within a short distance of the drop shafts and no further than the front row of properties, ie, not those screened by others from the drop shaft location.

Significance criteria

Determining magnitude of surface construction noise impacts

8.4.32 Noise from surface construction activities has been calculated using the approach presented in BS5228: Part 1: 2009 *Code of practice for noise and vibration control on construction and open sites: Noise*, which has been adapted in consultation with the British Standards Institute.

8.4.33 An adverse impact which could potentially cause disturbance is defined using the proven approach used to assess construction noise from the High Speed 1 project (formerly Channel Tunnel Rail Link) and Thameslink 2000. This method has also been adopted as part of BS5228: Part 1. Under this approach the adverse impact threshold is determined at a dwelling using the existing ambient noise level, rounded to the nearest 5dB for the appropriate period, which is then used to determine the appropriate assessment category. The predicted construction noise level is then compared to the assessment category value.

8.4.34 The criteria at residences for determining the significance of noise effects from construction sources are dependent upon the existing ambient noise levels. For some sites measured data is not available for the PEIR. In these cases the lowest assessment category has been assumed for all residential receptors (ie, worst case sensitivity category has been assumed with regard to the baseline noise climate).

8.4.35 If the construction noise level exceeds the appropriate category value, then an adverse impact with the potential to cause disturbance is identified. It should be noted that the wording of the Standard reproduced below in Vol 5 Table 8.4.1 uses the term significant effect rather than simply assessing impact. For the purpose of this assessment the BS5228 derived criteria is used to identify impacts that could potentially cause disturbance to residents. The significance of the effect is assessed using professional judgement by considering not only the criteria below but also other factors such as the duration of the noise exposure. This approach to the determination of significant effects for all noise and vibration impacts is described later in this section at para. 8.4.55.
### Vol 5 Table 8.4.1 Noise and vibration assessment criteria - construction

<table>
<thead>
<tr>
<th>Assessment period</th>
<th>Category and threshold values (dBL_{Aeq})</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Category A(^{(A)})</td>
</tr>
<tr>
<td>Daytime (0700-1900) and Saturdays (0700-1300)</td>
<td>65</td>
</tr>
<tr>
<td>Evenings and weekends(^{(D)})</td>
<td>55</td>
</tr>
<tr>
<td>Night-time (2300-0700)</td>
<td>45</td>
</tr>
</tbody>
</table>

*based on BS5228

**NOTE 1** If the ambient noise level exceeds the threshold values given in the table (i.e., the ambient noise level is higher than the above values), then a significant effect is deemed to occur if the construction L_{Aeq} noise level is greater than the ambient noise level.

**NOTE 2** If the ambient noise level exceeds the threshold values given in the table (i.e., the ambient noise level is higher than the above values), then a significant effect is deemed to occur if the total L_{Aeq} noise level for the period increases by more than 3 dB due to construction activity.

**NOTE 3** Applied to residential receptors only.

---

**Determining magnitude of surface construction vibration impacts**

8.4.36 Where applicable, prediction of vibration from construction sources has been carried out following the procedure identified in Transport Research Laboratory Report 429\(^{37}\) on groundborne vibration caused by mechanised construction works, which is specified in BS5228: Part 2: 2009 *Code of practice for noise and vibration control on construction and open sites: Vibration*.

8.4.37 The vibration levels affecting building occupants arising from surface construction activities can be compared to the criteria defined in the table below. These VDV (vibration dose values) are based upon guidance from BS6472: 2008, Part 1 Guide to evaluation of human exposure to vibration in buildings (Vibration sources other than blasting).
**Vol 5 Table 8.4.2 Vibration criteria for building occupants – construction**

<table>
<thead>
<tr>
<th>Place and time</th>
<th>Low probability of adverse comment – VDV ms(^{-1.75})</th>
<th>Adverse comment possible – VDV ms(^{-1.75})</th>
<th>Adverse comment probable – VDV ms(^{-1.75})</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residential buildings – 16 hour day</td>
<td>0.2 - 0.4</td>
<td>0.4 - 0.8</td>
<td>0.8 - 1.6</td>
</tr>
<tr>
<td>Residential buildings – 8 hour night</td>
<td>0.1 – 0.2</td>
<td>0.2 - 0.4</td>
<td>0.4 - 0.8</td>
</tr>
</tbody>
</table>

*(ie, potential for adverse comment – BS6472)*

*8.4.38 Where it is not possible from the available information to determine the VDV levels, an alternative is to at least consider if the vibration would be perceptible. The threshold of perception in residential environments is identified as 0.3mm/s Peak Particle Velocity (PPV) in accordance with BS 5228: Code of practice for noise and vibration control on construction and open sites – Part 2: Vibration. Complaint is likely above 1.0mm/s PPV at residential properties. For the purposes of the PEIR this approach has been adopted for some sites to consider the potential for vibration disturbance.*

*8.4.39 The assessment criteria for building damage are based upon guidance within BS7385: Part 2 (1993) Evaluation and measurement for vibration in buildings: Guide to damage levels from groundborne vibration\(^{88}\). The Standard differentiates between transient and continuous vibration. For transient vibration the standard notes that the risk of cosmetic damage to residential buildings starts at a PPV of 15mm/s at 4Hz. The Standard also notes that below 12.5mm/s PPV the risk of damage tends to zero. When considering continuous vibration, the standard recommends the guide values are reduced by 50%.*

*8.4.40 The Standard highlights that the criteria for very old buildings may need to be lower if the buildings are structurally unsound. However, the Standard also notes that criteria should not be set lower simply because a building is important or historic. Given that at this stage structural defect surveys have not been undertaken for buildings where there is any evidence of existing damage, and given that the risk of existing damage is greater in the historic and protected buildings along the length of the tunnels, the evaluation criteria for these receptors has been set at a lower level on a precautionary basis.*

*8.4.41 The table below presents the quantitative evaluation criteria for the effect of transient and continuous vibration on buildings arising from tunnelling activities.*
Vol 5 Table 8.4.3 Noise and vibration building damage - assessment criteria

<table>
<thead>
<tr>
<th>Category of Building</th>
<th>Threshold of potential cosmetic damage (Peak Particle Velocity - PPV - at building foundation)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Transient Vibration mm/s</td>
</tr>
<tr>
<td>Structurally sound and non-protected buildings</td>
<td>12</td>
</tr>
<tr>
<td>Protected or potentially vulnerable buildings</td>
<td>6</td>
</tr>
</tbody>
</table>

Determining magnitude of construction road traffic noise impacts

8.4.42 Department of Transport Memorandum: Calculation of Road Traffic Noise, 1988 presents a procedure for the prediction of road traffic noise. The relevant parts of this procedure have been used to predict, for a given road at a reference distance, the change in noise level resulting from the change in road traffic between the base and development cases.

8.4.43 The change in road traffic noise between the base and development cases has been rated as an impact where the change is greater than +/- 3dB. Based on conventions used in traffic noise assessment a semantic scale has been applied to define the scale of the impact for construction traffic which is presented in Vol 5 Table 8.4.4. The noise level changes are associated with likely significant effects. The overall significance assessment is based on this and other parameters described later in this section. The estimated change in traffic noise levels will be fully assessed in the EIA. In the absence of baseline traffic data for the PEIR the effect of construction traffic will be assessed qualitatively.

Vol 5 Table 8.4.4 Noise - construction traffic assessment criteria

<table>
<thead>
<tr>
<th>Predicted noise change</th>
<th>Impact scale</th>
<th>Rating of likely significant effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increase of more than 10dB</td>
<td>Substantial increase</td>
<td>Potentially significant adverse effect</td>
</tr>
<tr>
<td>Increase 6-10dB</td>
<td>Moderate increase</td>
<td></td>
</tr>
<tr>
<td>Increase of 3-5dB</td>
<td>Slight increase</td>
<td></td>
</tr>
<tr>
<td>Less than 3dB</td>
<td>Negligible change</td>
<td>Not significant effect</td>
</tr>
<tr>
<td>Decrease of more than 3dB</td>
<td>Slight decrease</td>
<td>Potentially significant beneficial effect</td>
</tr>
</tbody>
</table>
Determining magnitude of groundborne noise and vibration impacts from a TBM

8.4.44 Prediction of groundborne noise and vibration from a TBM has been undertaken using the procedure identified in Transport Research Laboratory Report 429 on Groundborne vibration caused by mechanised construction works, which is specified in BS5228: Part 2: 2009 Code of practice for noise and vibration control on construction and open sites: Vibration.

8.4.45 There are no relevant national or international standards setting criteria for groundborne noise. The impact criteria set out in Vol 5 Table 8.4.5 have therefore been drawn from similar projects in the UK, eg, Crossrail, the Jubilee Line and High Speed 1. These criteria were agreed with the local authorities, stakeholders and at parliamentary review.

8.4.46 These projects assessed groundborne noise in terms of the absolute level of noise generated by a train passing by. Absolute criteria, rather than noise change criteria, apply for groundborne noise for three main reasons. Firstly there is rarely any appreciable ambient groundborne noise at a receptor. Secondly, the character and nature of groundborne noise differs from other ambient noise heard inside buildings. Thirdly, the body of experience and research available with regard to human response to groundborne noise has mostly been based on this noise indicator. The overall significance assessment in the table below is based on this and other parameters described later in this section.

**Vol 5 Table 8.4.5 Noise (groundborne) assessment criteria - residential**

<table>
<thead>
<tr>
<th>Impact classification</th>
<th>Groundborne noise Level dBLA_{max}, slow (measured indoors, near the centre of any dwelling room on the ground floor)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Negligible</td>
<td>&lt; 35</td>
</tr>
<tr>
<td>Low</td>
<td>35-39</td>
</tr>
<tr>
<td>Medium</td>
<td>40-44</td>
</tr>
<tr>
<td>High</td>
<td>45-49</td>
</tr>
<tr>
<td>Very High</td>
<td>&gt;49</td>
</tr>
</tbody>
</table>

**Vol 5 Table 8.4.6 Noise (groundborne) impact criteria - non-residential**

<table>
<thead>
<tr>
<th>Building</th>
<th>Likely significant effect threshold dBLA_{max}, slow</th>
</tr>
</thead>
<tbody>
<tr>
<td>Theatres / Large Auditoria &amp; Concert Halls</td>
<td>25</td>
</tr>
<tr>
<td>Sound Recording / Broadcast Studios</td>
<td>30</td>
</tr>
<tr>
<td>Places of meeting for Religious Worship / Courts / Lecture Theatres / Museums / Small Auditoria or Halls</td>
<td>35</td>
</tr>
<tr>
<td>Offices / Schools / Colleges / Hospitals / Hotels /</td>
<td>40</td>
</tr>
</tbody>
</table>
Where buildings are utilised for more than one use, then the building has been assessed on the basis of the most sensitive use.

**Determining magnitude of groundborne noise and vibration impacts from underground TBM supply trains**

The temporary supply train railway can generate groundborne noise and vibration in the same way as a permanent railway. The impact of the proposed supply train operations has been calculated using the empirical calculation method developed and validated initially for the design and construction of High Speed 1 which includes 15km of twin bore tunnel under London and which has operated without complaint since the line opened in 2007. This approach is also compliant with ISO 14837-1: 200590, which provides guidance on the calculation and assessment of railway groundborne noise and vibration.

The method is empirical, developed from thousands of measurements, and takes account of key parameters, including tunnel design, tunnel depth, ground conditions, receiving building foundations and receiving building type.

Typically groundborne noise and vibration levels from temporary construction railways are less than those associated with the operation of the TBMs.

The impact criteria specified above have been used when considering groundborne noise and vibration from supply trains.

**Determining magnitude of operational noise and vibration impacts**

The extent of operational noise effects will depend whether it is shown that operational noise from tunnel filling events or ventilation fans have the potential to cause noise effects at nearby receptors. For the purposes of the PEIR it is not possible to predict noise levels relative to the local background noise levels (as defined by BS414291) at nearby receptors as there are not currently sufficient details regarding the design of plant equipment. At a later stage, the methodology described in BS4142 would be used to determine the likelihood or not of complaint according to the relative level (and character) of the predicted operational noise relative to the background noise level. For the PEIR, it is assumed that it will be necessary to provide adequate noise attenuation to avoid significant effects where there is a possibility that they could occur. The incorporation of noise controls is currently being reviewed by the Thames Tunnel engineering team to ensure that noise emission will be properly controlled.
8.4.53 The potential for vibration from water cascading during tunnel filling events would be assessed using BS6472 to determine the likelihood of adverse comment by the occupants of nearby buildings. If this were to be an issue it is expected that this would only affect buildings very close to drop shafts. Again, any impacts would be assessed based on the guidance in the Standard and the factors described in the following sections. This assessment is on-going and is not included in the PEIR.

**Defining resource value / receptor sensitivity**

8.4.54 Having identified the magnitude of impacts for the various potential impacts, the value/sensitivity of nearby receptors will be identified using the generic approach presented in Section 2.

**Determining the significance of effects**

8.4.55 Noise, groundborne noise and vibration have been evaluated to determine if there would be adverse impacts or the potential to cause significant effects according to the criteria described above. The overall assessment of significance for residential property would be evaluated using the above criteria as well as professional judgement based on the following factors:

a. The type of effect: eg, exceeding the vibration impact criteria for building damage is sufficient alone to identify a significant effect, whereas for all other effects additional consideration is given to:

i. the number of impacts

ii. the severity of the impacts

iii. the proportion of residential properties subject to a significant impact

iv. duration of impact.

8.4.56 In the case of vibration effects on building occupants a significant effect is identified where the low probability of adverse comment values are exceeded as well as consideration of the above factors.

8.4.57 For non-residential receptors significant effects would be evaluated, on a receptor-by-receptor basis, using the established impact criteria (where appropriate) and professional judgement based on the following factors:

a. The type of effect: eg, exceeding the vibration impact criteria for building damage is sufficient alone to identify a significant effect whereas for all other effects additional consideration is given to:

i. the severity of the impact

ii. the design of the receptor affected

iii. the existing ambient noise and vibration levels in the receptor affected

iv. the use and hence sensitivity of the receptor

v. duration of impact.
Cumulative, in combination and compound effects

8.4.58 The general approach to assessing cumulative, in combination and compound effects is described in Section 2. The specific approach for noise and vibration is described below.

8.4.59 Cumulative construction noise and vibration effects could potentially arise as a result of other committed, but as yet un-built developments in the area of each site. Based on the available planning information for the locality of each surface site, the potential cumulative effects will be considered qualitatively. The likelihood of other committed developments resulting in increased effects relative to those caused by the Thames Tunnel surface site will depend on the proximity of the other developments, their likely noise emission and the prominence of the noise emission relative to the ambient noise climate. These factors will be considered to qualitatively evaluate any construction noise cumulative effects.

8.4.60 It is expected that any operational effects associated with noise emission from ventilation plant or tunnel filling noise will only affect the closest properties immediately around the sites. However, the likelihood of other committed developments resulting in increased operational plant noise effects relative to those caused by the Thames Tunnel surface site will depend on the proximity of the other developments. These factors will be considered to qualitatively evaluate any construction noise cumulative effects.

Project-wide effects

8.4.61 Noise and vibration effects are relatively localised around a fixed source. Given the separation of the surface sites it is not anticipated that there would be project-wide effects resulting from the summation of noise or vibration effects from individual sites.

8.4.62 Indirect noise effects from construction traffic accessing different surface sites in a particular area could potentially interact to produce greater effects than would have resulted from a single site. In the absence of baseline traffic data for the PEIR, the assessment of any such effect has been qualitative.

Assumptions and limitations

8.4.63 Baseline noise surveys were scoped to cover site construction hours for daytime working and in some cases 24-hour working. Since the Scoping Report was published, there have been a number of sites where the potential for extended working in the evening has been identified for certain limited periods (e.g., for concrete pours). Based on the likely noise levels and durations of these particular extended hours operations and the likely evening noise levels (estimated from daytime results), the requirement for additional baseline noise monitoring during the evening period at these sites will be considered following the PEIR.
8.5 **Approach to mitigation**

**Construction**

8.5.1 The Contractor would be required, in so far as is reasonably practicable, to control and limit noise and vibration levels so that residential properties and other sensitive receptors are protected from excessive noise and vibration levels arising from construction activities.

8.5.2 The CoCP (see Volume 2) establishes the framework within which noise and vibration as a result of the works will be controlled. The CoCP Part B will identify noise and vibration sensitive receptors, measured baseline noise levels, outline of likely construction method and programme, activities and locations requiring detailed consideration in Section 61 Applications and proposed noise and vibration monitoring locations.

8.5.3 Contractors would be required to apply for Section 61 consents (s.61) under the Control of Pollution Act 1974.

8.5.4 Before any works can be undertaken, the Contractor would submit the working hours it requires to the local authority, in an application for prior consent under s.61 of the Control of Pollution Act (s.61 consent). Work would not commence until the local authority has agreed in writing. As required by the Control of Pollution Act, “Best Practicable Means” would be employed and demonstrated through programme, method and noise predictions to the local authority in the s.61 consent application that would ensure that noise from all activities is minimised.

8.5.5 Further specific best practice measures for the control of noise and vibration are detailed in the CoCP.

8.5.6 Additionally, the operation of the temporary construction railway should consider where required, speed restrictions and upgrading the temporary construction railway.

8.5.7 Additional mitigation will be considered where significant construction noise or vibration effects are assessed. The specific mitigation will depend on the nature of the noise source but measures may include:

a. enclosure of equipment to control airborne noise

b. use of alternative processes - which may not be the first choice in terms of optimal construction efficiency, but address a particular noise issue

c. additional localised temporary screening

d. controlled hours of a particular activity.

**Operation**

8.5.8 It is not anticipated that additional mitigation will be required as appropriate mitigation controls would be incorporated as part of the design of the surface sites, drop shafts and associated plant equipment.
9 Socio-economics

9.1 Introduction

9.1.1 This section sets out the full EIA methodology for the assessment of socio-economic effects associated with the Thames Tunnel project. Work which has not been fully completed for the PEIR will be completed for the ES, and this is noted below and within each site specific assessment volume.

9.1.2 The need for an assessment of socio-economic effects results from the potential for the project to generate impacts upon the economy, social infrastructure, facilities and services, and amenity of various related receptors both at a site specific and project-wide level, and cumulatively and in combination.

9.1.3 The topic specific methodology presented in this section builds upon the generic assessment methodology summarised in Section 2 and develops this to take account of the range of potential socio-economic environmental effects considered likely to arise from the construction and operation of the project.

9.1.4 The EIA methodologies for the assessment of effects relating to other environmental topics such as air quality, noise and vibration, visual, and transport are addressed in the respective technical sections of this volume. An understanding of these methodologies and topics is required to give context for potential in combination socio-economic effects arising from impacts related to these topics.

9.2 Scoping Opinions and technical engagement

9.2.1 A summary of the scoping and technical engagement undertaken in relation to socio-economics is contained in Volume 4, Sections 3.9 and 4.9.

9.3 Baseline data collection methodology

9.3.1 In order to assess potential socio-economic effects, the relevant baseline conditions need to be identified and understood.

9.3.2 For socio-economics, baseline data is collected to establish existing site specific conditions in relation to three overriding themes:

a. economy
b. social infrastructure facilities and services
c. amenity (within the local environment).

9.3.3 The socio-economic baseline data presented in the PEIR (and which will also be presented within the ES) includes a description of the relevant physical characteristics at and surrounding each site, including relevant development nearby, and its physical relationship to the site.

9.3.4 The baseline also identifies potential impact receptors and considers their potential sensitivity to impacts. In the socio-economic context, receptors are individuals or groups (for example, open space users, businesses, workers, residents, etc) who use particular socio-economic resources (that
is, business or community assets, amenities and opportunities such as commercial properties, residential properties, social infrastructure or public rights of way).

9.3.5 Sensitive receptors are described in the baseline section of the site-specific volumes, including those located on and adjacent to the immediate site and within the neighbouring area. Sensitive receptors along the proposed construction phase access routes are also described where these are considered relevant to the consideration of potentially significant amenity effects.

9.3.6 The manner in which a receptor experiences a socio-economic impact can occur in several different ways:

a. an economic/financial gain or loss
b. a gain or loss of a resource or access to a resource
c. a gain or loss of amenity derived from, or experienced while using, a resource.

9.3.7 Data and information included within this PEIR in relation to socio-economic themes have been obtained from a wide range of sources including desk-based data collection, basic reconnaissance field surveys and information provided by consultees. For the ES, further more detailed, survey work will be undertaken during 2011 in order to augment the information that has so far been able to be collected to inform the assessments contained within this PEIR.

9.3.8 Data has been collected at different spatial levels according to the nature of the potential effect to be assessed and the particular requirements for the site specific condition in question.

9.3.9 Generally, economic data is collected and presented at the relevant area of statistical detail/aggregation, whilst information related to the provision of a social infrastructure facility or services is usually collected and analysed within the context of local provision. Amenity related baseline conditions are presented within the context of the site, its existing functions and its surroundings as determined by the physical layout of development and potential receptors.

9.3.10 For desk top baseline data, the date of the data (where relevant) is given in Vol 5 Table 9.3.1 below. Other data collected through field surveys has been (and continues to be) collected during 2011. Where relevant specific survey dates and times will be referenced alongside the reported baseline data.

**Desk based baseline data**

9.3.11 The analysis of baseline conditions is primarily desk-based and carried out using a number of recognised data sources. These are shown in Vol 5 Table 9.3.1 below.

9.3.12 The baseline analysis has included a review and consideration of policy and site-specific allocations, as appropriate and as made at various levels including: locally (Borough) and regionally (Greater London). Documents that have been reviewed include:
a. Borough Local Development Frameworks (LDF) including Core Strategy documents and proposals maps (or saved Local Plan policies, if applicable)

b. Borough Employment Land Reviews and London 2010 Industrial Land Baseline

c. Borough Open Space Assessments and Audits.

9.3.13 Some data sources are not consistent with each other. These variations, which are usually due to differences in the methodology and definitions on which the datasets are based, are noted where they occur and judgements made where necessary on how to interpret data.

9.3.14 Similarly, each data source provides a snapshot of a certain point in time, depending on the date at which the data were collected. This date, and the associated baseline year, varies depending on the data sources in question, as set out in Vol 5 Table 9.3.1 below.

9.3.15 In addition to the data sources listed in Vol 5 Table 9.3.1 below, web-based research has been undertaken to provide supplementary information, for example to check the location and capacity of local community facilities.

**Vol 5 Table 9.3.1 Socio-economic desk based baseline data sources**

<table>
<thead>
<tr>
<th>Source</th>
<th>Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Battersea Power Station redevelopment, marketing brochure</td>
<td>Information about the project (<a href="http://www.battersea-powerstation.com">http://www.battersea-powerstation.com</a>)</td>
</tr>
<tr>
<td>Census of Population (2001)</td>
<td>Travel to work area (TTWA)</td>
</tr>
<tr>
<td>Colliers International and St George marketing brochure</td>
<td>Construction schedule and qualitative information on St George’s Wharf (<a href="http://www.colliersid.com/propertyAttachments/841.pdf">http://www.colliersid.com/propertyAttachments/841.pdf</a>)</td>
</tr>
<tr>
<td>Free Trade Wharf information website</td>
<td>Information about the development (<a href="http://www.free-trade-wharf.co.uk">http://www.free-trade-wharf.co.uk</a>)</td>
</tr>
<tr>
<td>Source</td>
<td>Data</td>
</tr>
<tr>
<td>--------</td>
<td>------</td>
</tr>
<tr>
<td>Green Flag Awards website</td>
<td>Information about the project (<a href="http://www.keepbritaintidy.org/GreenFlag/AboutUs/AboutGreenFlagAward/Default.asp">http://www.keepbritaintidy.org/GreenFlag/AboutUs/AboutGreenFlagAward/Default.asp</a>)</td>
</tr>
<tr>
<td>London Parks and Gardens Trust (dates vary by site)</td>
<td>Qualitative information on parks and open spaces</td>
</tr>
<tr>
<td>London Development Database (updated annually)</td>
<td>Information on adjacent planned developments</td>
</tr>
<tr>
<td>London Plan – Consolidated with Alterations since 2004 (2011)</td>
<td>Open Space Hierarchy and Accessibility Criteria</td>
</tr>
<tr>
<td>LB Hammersmith and Fulham Submission Draft Core Strategy (2010)</td>
<td>Information on site-specific allocations and planned developments relevant to the Hammersmith Pumping Station and Carnwath Road Riverside sites.</td>
</tr>
<tr>
<td>LB Lambeth, Business Premises Study (2007)</td>
<td>Employment floor space supply and vacancy</td>
</tr>
<tr>
<td>LB Lambeth Core Strategy (2011)</td>
<td>Opportunities for additional open space creation.</td>
</tr>
<tr>
<td>LB Lambeth Open Spaces Strategy (2004)</td>
<td>Open space deficiency levels</td>
</tr>
<tr>
<td>LB Lewisham Submission Draft Core Strategy Development Plan Document</td>
<td>Information on site-specific allocations and planned developments adjacent to Earl Pumping Station site</td>
</tr>
<tr>
<td>LB Tower Hamlets, Annual Monitoring Report (2007)</td>
<td>Quantitative date on open space deficiency</td>
</tr>
<tr>
<td>LB Tower Hamlets Core Strategy Development Plan Document (2010)</td>
<td>Deficiency area of local parks and open space</td>
</tr>
<tr>
<td>LB Tower Hamlets, King Edward Memorial Park management plan 2007-17 (2008)</td>
<td>Operational information</td>
</tr>
<tr>
<td>LB Tower Hamlets, Parks Guide</td>
<td>Information on the use and hire of</td>
</tr>
<tr>
<td>Source</td>
<td>Data</td>
</tr>
<tr>
<td>-----------------------------------------------------------------------</td>
<td>------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>LB Wandsworth Children’s Centres information</td>
<td>Opening hours, access, age suitability</td>
</tr>
<tr>
<td>LB Wandsworth Employment Land and Premises Study (2010)</td>
<td>Employment floor space supply and vacancy</td>
</tr>
<tr>
<td>LB Wandsworth Libraries</td>
<td>Opening hours, access</td>
</tr>
<tr>
<td>LB Wandsworth Open Space Study (2007)</td>
<td>Qualitative data on local open space</td>
</tr>
<tr>
<td>LB Wandsworth Technical Services Unit (correspondence April 2011)</td>
<td>Use of Barn Elms Sports Centre, Barn Elms Boat House (Information and data sheets on the level of use of the facility)</td>
</tr>
<tr>
<td>Mayor of London’s Thames Festival information</td>
<td>Information on viewpoints and accessibility along the River Thames (<a href="http://www.thamesfestival.org/index.php">http://www.thamesfestival.org/index.php</a>)</td>
</tr>
<tr>
<td>RB Kensington and Chelsea Core Strategy Development Plan Document (2010)</td>
<td>Information on site-specific allocations and planned developments adjacent to RBKC sites</td>
</tr>
<tr>
<td>Secret Intelligence Service premises guide</td>
<td>Qualitative data on building at Albert Embankment (<a href="http://www.sis.gov.uk/our-history/buildings">http://www.sis.gov.uk/our-history/buildings</a>)</td>
</tr>
<tr>
<td>Shadwell Basin Activity Centre website</td>
<td>Opening hours, access, courses, use of premises (<a href="http://www.shadwell-basin.org.uk">http://www.shadwell-basin.org.uk</a>)</td>
</tr>
<tr>
<td>Sprole Court information</td>
<td>Qualitative data</td>
</tr>
<tr>
<td>St James Tideway Wharf marketing brochure</td>
<td>Information about the project (<a href="http://www.tideway-wharf.co.uk/assets/pdfs/tideway_wharf_booklet.pdf">http://www.tideway-wharf.co.uk/assets/pdfs/tideway_wharf_booklet.pdf</a>)</td>
</tr>
<tr>
<td>Thames Recreational Users Study (2007)</td>
<td>Information on Thames users</td>
</tr>
<tr>
<td>Trees for Cities tree planting programme</td>
<td>Sponsorship of tree planting programme and school sports days in King Edward Memorial Park</td>
</tr>
</tbody>
</table>
Field survey baseline data

9.3.16 Reconnaissance visits have been made to all sites, comprising a walkover of the area and, if likely to be affected, adjacent areas. Observations were made of key site characteristics, features, potentially vulnerable receptors and constraints.

9.3.17 As stated above, for the ES, further more detailed, field surveys will be undertaken during 2011 in order to augment the information that has so far been able to be collected to inform the assessments contained within this PEIR.

9.3.18 These field surveys will include primary research surveys to examine the usage levels of potentially affected public open spaces. The methodology for these primary research surveys is specific to the type and nature of the primary research being undertaken.

9.3.19 The open space usage surveys will focus on counting the number of users of public open spaces, according to the type of activity being engaged in by users, at specific points appropriate to each respective survey area. The methodology employed for public open space primary research surveys has been developed, and surveys have started. The methodology will be described in the ES as appropriate.

9.4 Assessment methodology

9.4.1 The assessment seeks to establish the net potential economic and social effects of the project. The effects of the project are considered at varying spatial levels according to the nature of the effect considered, through comparison of the development (in a specified assessment year) with a base case scenario, and with alternative development scenarios where this is deemed to be required. This approach is consistent with English Partnerships Guidance. Further details regarding the assessment cases for the socio-economics assessment are provided below.

9.4.2 Where relevant reference has been made to the adopted London Plan (GLA (2008) London Plan consolidated with alterations since 2004), borough Unitary Development Plans (UDPs) and Local Development Framework (LDF) Core Strategy Development Plan Documents (DPDs), both adopted and emerging. Relevant policies referred to include those concerning open space deficiency/accessibility criteria, site specific allocations, and employment land-use.

Construction and operational effects

9.4.3 Construction phase effects are considered for all sites, with the exception of Beckton Sewage Treatment Works. The rationale for not giving further consideration to socio-economic effects at Beckton Sewage Treatment Works is set out in Volume 28. For some of the sites, operational effects are not relevant and are therefore not considered further. Where this is the case the rationale for this is set out within the relevant site specific volumes.
Assessment cases and years

9.4.4 The generic assessment cases are described in Section 2. The following section describes the specific approach for socio-economic receptors.

Assessment cases

Base case

9.4.5 The base case for assessment will be a future case, without the project, in any particular assessment year.

9.4.6 Whilst the existing baseline data which is collected forms a ‘current baseline’, it will be important to consider how the baseline environment is likely to change, in any event, in the absence of the project. For example local resident populations are likely to change over time (through natural growth, migration or new development), new businesses may open or existing businesses may expand, the provision of social infrastructure may change, and the physical characteristics of potentially affected receptors or adjacent areas may change.

9.4.7 The base case has been predicted as accurately as is possible to ensure the robustness of the subsequent assessment. This is achieved by having regard to information such as published draft and approved planning policy, consented planning applications and proposed developments (by reference to current planning applications).

9.4.8 Data collected at the desk based level is typically retrospective in nature. However, where available and relevant, forecasts have been collected and presented based on the relevant assessment period in order to establish a base case.

Development case

9.4.9 A development case is a future case during either the construction or operation of the project in the same assessment year as the equivalent base case. The assessment typically considers the ‘development case’ compared with the ‘base case’ in any particular assessment year (see below).

Assessment years

9.4.10 The construction assessment year(s), for the purposes of site specific socio-economic assessments, is the total duration of construction at each respective site.

9.4.11 This is because socio-economic impacts and effects arising from a project of this nature, in particular impacts and effects on facilities and their users, typically last for the whole duration of construction works rather than peaking in a particular period.

9.4.12 An exception to this approach may be appropriate with regard to amenity effects, ie, effects occurring as a result of:

a. air quality
b. noise and vibration
c. visual
d. transport
e. other impacts.

9.4.13 These may occur individually or in-combination. It may be appropriate to consider impacts at the peak in construction activities when these effects are likely to be greatest. An assessment of the likelihood of such effects has been undertaken with information available at the time of writing the PEIR and the assessment is therefore preliminary and only indicative at this stage.

9.4.14 For assessment of socio-economic project-wide effects, the assessment years cover the total duration of the project construction overall.

9.4.15 The operational assessment year for the purposes of the socio-economic assessment is Year 1, the first full year of operation.

Assessment areas

9.4.16 The assessment of socio-economic effects is conducted at different spatial levels according to the nature of the effect that is likely to occur. The assessment area varies greatly according to the impact in question and the receptors likely to be affected. For example effects on users of social infrastructure are likely to depend on the catchment area of the resource or service they utilise. By contrast the construction workforce is likely to be affected at a wider geographical level owing to the fact that workers are anticipated to be drawn from a wider ‘travel to work area’, in this case, Greater London.

9.4.17 The various spatial levels of analysis and associated rationale are set out in detail below in Vol 5 Table 9.4.1.

**Vol 5 Table 9.4.1 Socio-economic impacts by spatial/ geographic scale**

<table>
<thead>
<tr>
<th>Impact</th>
<th>Geographical area of impact</th>
<th>Rationale for effect area</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Economic impacts</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Net employment generation</td>
<td>Greater London</td>
<td>Travel to Work Area, derived from Census 2001</td>
</tr>
<tr>
<td>Potential loss of employment land</td>
<td>Borough level</td>
<td>Aggregated Supply Level</td>
</tr>
<tr>
<td>Displacement of businesses</td>
<td>Business specific and Borough level</td>
<td>Professional experience</td>
</tr>
<tr>
<td>Changes in local spending</td>
<td>Borough level</td>
<td>Travel to Work Area, Census 2001</td>
</tr>
<tr>
<td>Impact on wider London economy</td>
<td>Greater London</td>
<td>Travel to Work Area, derived from Census 2001, Typical primary spatial extent of the majority of indirect and induced economic transactions</td>
</tr>
<tr>
<td><strong>Social infrastructure, facilities and services impacts</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Impact

<table>
<thead>
<tr>
<th>Impact</th>
<th>Geographical area of impact</th>
<th>Rationale for effect area</th>
</tr>
</thead>
<tbody>
<tr>
<td>Impact on open space provision</td>
<td>Radii of 400m to 1.2km</td>
<td>GLA, London Plan (2008)/ URS Scott Wilson experience</td>
</tr>
<tr>
<td>Impact on play space provision</td>
<td>Radii of up to 800m</td>
<td>GLA, Providing for Children and Young People’s Play and Informal Recreation SPG, 2008</td>
</tr>
<tr>
<td>Impact on river space</td>
<td>To be determined based on physical extent of recreational or commercial use</td>
<td>Spatial incidence of recreational or commercial activities</td>
</tr>
<tr>
<td>Impact on social infrastructure provision</td>
<td>To be determined based on modes of access and respective travel times</td>
<td>Professional experience from conducting LA strategic infrastructure studies</td>
</tr>
<tr>
<td>Impact on use of and/or access to public rights-of-way</td>
<td>On-site/Convenient walking distance</td>
<td>Professional experience</td>
</tr>
</tbody>
</table>

### Amenity-related Impacts

<table>
<thead>
<tr>
<th>Impact</th>
<th>Geographical area of impact</th>
<th>Rationale for effect area</th>
</tr>
</thead>
<tbody>
<tr>
<td>Impacts on recreation, leisure, tourism</td>
<td>To be determined based on modes of access and respective travel times</td>
<td>Professional experience</td>
</tr>
<tr>
<td>Impact on residential, recreational or commercial amenity from in combination impacts</td>
<td>On-site/ or within range of at least two in combination environmental effects (see relevant environmental effect topic)</td>
<td>See relevant environmental effect topic</td>
</tr>
<tr>
<td>Aesthetic, public health and amenity effect of improved water quality and regulatory compliance</td>
<td>Greater London</td>
<td>Spatial incidence of development scheme</td>
</tr>
</tbody>
</table>

### Significance criteria

#### Determining magnitude of impacts

9.4.18 The magnitude of an impact is its severity or scale. The magnitude of an impact on a receptor reflects consideration of information and analysis relating to:

- spatial extent (localised/isolated versus widespread with potential secondary effects)
b. extent (number of groups and/or people, households or businesses affected)

c. duration (short term (less than 12 months), medium term (1 – 5 years) and long-term (+ 5 years) impacts)

d. conformity with standards for provision or accessibility (as set out in regional or local planning guidance)

e. permanency of the impact

f. likelihood of impact occurring

g. the scope for embedded environmental design features or mitigation

h. value of the resource.

9.4.19 Based on the above considerations guideline criteria are used to determine the magnitude of the impacts. These criteria have been established based on professional judgement and are presented in Vol 5 Table 9.4.2.

<table>
<thead>
<tr>
<th>Impact magnitude</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>An impact that will be very severe/beneficial or very likely to affect large numbers of groups and/or people usually anticipated at a London-wide or sub-regional level or continue beyond the project life and effectively constitute a permanent, long-term impact on the base case conditions.</td>
</tr>
<tr>
<td>Medium</td>
<td>An impact that will somewhat likely to affect a moderate number of people in the wider local area (eg, borough-wide) or continue beyond the project life so that there is an effect on the base case experienced for a medium or long term duration.</td>
</tr>
<tr>
<td>Low</td>
<td>An impact that may affect a small number of people in the local authority area and does not extend beyond the life of the project so that base case is not affected beyond a short- or medium-term duration.</td>
</tr>
<tr>
<td>Negligible</td>
<td>An impact that is temporary in nature and is unlikely to measurably affect the well-being of people or a lower value resource so that the existing base case remains constant.</td>
</tr>
</tbody>
</table>

9.4.20 Guideline criteria have been established using professional judgement to determine the sensitivity of the receptors. These are presented in Vol 5 Table 9.4.3.
Vol 5 Table 9.4.3 Socio-economic receptor value/sensitivity criteria

<table>
<thead>
<tr>
<th>Receptor value and/or sensitivity</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>Individuals or groups who are already at risk and that have little or no capacity to experience the impact without incurring a significant economic loss (or gain), loss (or gain) of access to a social or economic resource, or loss (or gain) of amenity.</td>
</tr>
<tr>
<td>Medium</td>
<td>Individuals or groups that have a limited or average capacity to experience the impact without incurring a significant economic loss (or gain), loss (or gain) of access to a social or economic resource, or loss (or gain) of amenity.</td>
</tr>
<tr>
<td>Low</td>
<td>Individuals or groups that generally have adequate capacity to experience impacts without incurring a significant economic loss (or gain), loss (or gain) of access to a social or economic resource, or loss (or gain) of amenity.</td>
</tr>
</tbody>
</table>

Determining the significance of effects

9.4.21 The significance of a socio-economic effect is a product of the likely magnitude of the impact and the likely sensitivity of the receptor. The approach to identifying potential receptors and considering their significance is set out above.

9.4.22 The criteria for judging the significance of effects is based on professional judgement.

9.4.23 Effects are considered significant if both impact magnitude and receptor sensitivity is high or medium. Additionally, effects are considered significant if impact magnitude is high and receptor sensitivity is low, or alternatively if receptor sensitivity is high and impact magnitude is low. This equates to major and moderate adverse/beneficial effects.

9.4.24 Other effects, equating to minor adverse/beneficial and negligible effects, represent not significant effects. This reflects the judgment that effects which are minor adverse/beneficial are not significant.

9.4.25 The socio-economic approach to determining the significance of effects is in-line with that presented in Vol 5 Table 9.4.4.
Vol 5 Table 9.4.4 Socio-economics - significance of effect criteria

<table>
<thead>
<tr>
<th>Significance of receptor</th>
<th>Impact magnitude</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>High impact</td>
</tr>
<tr>
<td>High</td>
<td>Major adverse – significant</td>
</tr>
<tr>
<td>Medium</td>
<td>Major adverse – significant</td>
</tr>
<tr>
<td>Low</td>
<td>Moderate adverse - significant</td>
</tr>
</tbody>
</table>

Cumulative, in combination and compound effects

9.4.26 The general approach to assessing cumulative, in combination and compound effects is described in Section 2. The specific approach for socio-economics is described below.

9.4.27 There may be potential for cumulative effects to arise in the event that other developments proceed at the same time as the project, and if the impacts of these developments combine. Major developments, both existing and planned, in the vicinity of this site have been incorporated into the future base case that is being used as part of the assessment. This allows the effects of the project to be assessed cumulatively with other major local developments. This assessment will be documented within the topic assessment and presented in the ES. The assessment will be completed once significance has been ascribed to the residual effects of the project.

9.4.28 As stated in Section 2, the PEIR does not include a full consideration of in combination effects. However, the socio-economic assessment does include a preliminary assessment of the potential for amenity effects at the site specific level on neighbouring sensitive receptors during the construction phase. Such effects could occur as a result of air quality, noise and vibration, or visual impacts and may occur in isolation or in combination. In this respect, the socio-economic assessment is an exception with regard to considering amenity effects and does include a preliminary consideration of the potential for in combination effects of this sort. See Volume 5 para 9.4.36 to 9.4.39 for further information.

Site cumulative effects

9.4.29 Based on the available planning information for the locality of each site (including the other side of the River Thames where appropriate), potential
cumulative effects resulting from other developments will be assessed to ascertain whether or not a cumulative effect in relation to socio-economics is likely to occur.

9.4.30 Where the project may potentially result in the temporary or permanent loss of public open space (and that loss critically impairs the amenity offered by that resource) there will be a need to consider any other developments that would result in a similar loss of open space within a radius of the site that is up to twice the distance of the park’s catchment area, as defined within The Mayor’s Open Space Hierarchy.

9.4.31 For example, if the project is likely to impact on provision of open space within a ‘local park’ (as defined within the Open Space Hierarchy), a cumulative effects assessment would need to consider any other development that may have the same impact within 800m of the site. This distance is twice the catchment distance (i.e., 400m) that is given within the Mayor’s Public Open Space Hierarchy as acceptable maximum distance from homes for access for a local park (and also for small open spaces and pocket parks). By considering other proposed developments on open spaces within 800m of the site, the cumulative effect assessment would capture any effects from other developments which might accumulate together with effects from the project and result in a loss of access to open space resources for people living within 400m of the proposed construction site.

9.4.32 In addition, developments located further from the site, but where there is the potential for amenity effects to occur during the construction phase, access routes will also be considered. Where possible, regard will be had to other developments considered by the transport assessment that may result in significant amenity effects.

9.4.33 For assessments of cumulative socio-economic effects presented in the ES, the significance criteria applied will be the same as those set out in Vol 5 Table 2.4.1.

**Project-wide cumulative effects**

9.4.34 Effects resulting from other developments considered significant at a project-wide level will be assessed within the ES to ascertain whether or not a cumulative effect in relation to socio-economics could likely occur.

9.4.35 For assessments of project-wide socio-economic effects presented in the ES, the significance criteria applied will be the same as those set out in Vol 5 Table 2.4.1.

**Amenity effects**

9.4.36 Impacts arising as a result of the proposed works may potentially act individually or in combination to reduce the amenity experienced by residents, businesses or users of social infrastructure.

9.4.37 In order to assess whether or not an in combination effect is likely to result from the works consideration has been given to the Scoping Report and likely outcomes of the assessments undertaken by other EIA topics. These are:
a. Air quality
b. Noise and vibration
c. Visual impact
d. Transport.

9.4.38 The assessment of amenity and in combination effects has been undertaken using information from other EIA topic assessments available at the time of publication of the PEIR. As a result, and for the purposes of the PEIR, the assessments of amenity and in combination effects made at this stage are preliminary and indicative.

9.4.39 The assessments have primarily had regard to the Scoping Report for each respective topic area. Where the potential for two or more major, moderate, or minor adverse effects is anticipated as arising in relation to these topic areas a preliminary assessment has then been made of the potential significance of the resulting in combination effect, from a socio-economic amenity perspective. This preliminary assessment has been made through consideration of the preliminary effect significance assessments made in the air quality, noise and vibration, and visual site specific assessments.

**Compound effects**

9.4.40 Compound effects are those topic specific effects that may not be significant when assessed within a single site but when combined (or compounded) by the same effect occurring on more than one nearby Thames Tunnel site the effect is of greater significance.

9.4.41 As for cumulative effects, it has not been possible to carry out a full assessment of compound effects for the purposes of the PEIR. A more detailed assessment will be presented within the ES.

9.4.42 This assessment will be carried out in a systematic manner and will consider and explain the potential for similar effects at respective sites to combine and produce a compound effect. Where the potential for significant compound effects to occur is identified in the ES the significance criteria applied will be the same as those set out in Vol 5 Table 2.4.1.

**Project-wide effects**

9.4.43 The project-wide socio-economic effects of the project (eg, job creation, aesthetic perception, public health and amenity) have been assessed through analysis of related indicators, with consideration made of how the project relates to these indicators during both the construction and operational phases. The significance criteria set out in Vol 5 Table 2.4.1 are applied.

**Assumptions and limitations**

9.4.44 The main general assumptions and limitations for the socio-economics assessment are set out below. Site-specific assumptions and limitations are contained within site specific volumes.
Baseline surveys – social infrastructure

9.4.45 Surveys to ascertain additional baseline conditions for certain types of social infrastructure are planned during 2011. These may provide additional baseline data or information on the level of use and/or types of users of:

a. open space
b. slipways
c. river foreshore space
d. rights of way
e. community facilities.

9.4.46 Where such survey information is not available at the time of writing assumptions have been made regarding usage levels based on desk-based research, other publicly available sources, and professional judgement for the purposes of the PEIR. Any such assumptions are stated and explained within each site-specific baseline section. A full baseline dataset will be used for the EIA.

Amenity effects

9.4.47 Surveys and survey results to ascertain baseline conditions for other EIA topics are in certain cases are preliminary and indicative only and are thus subject to further confirmation at the ES stage. When available this will provide additional information or confirmation in respect of:

a. Air quality
b. Noise and vibration
c. Visual impact
d. Transport.

9.4.48 Where there is an absence of data, for the purposes of the PEIR, assumptions have where possible been made regarding the extent, duration, likelihood and scope for mitigation of amenity and in combination effects based on desk-based research, Scoping Opinions and responses, and other publicly available sources. This has allowed a preliminary assessment of the amenity and in combination effects resulting from adverse air quality, noise and vibration, visual, and transport impacts.

9.4.49 For EIA purposes a more detailed assessment will be undertaken once more detailed design information is available. Accordingly, a complete baseline data set and assessments results relating to other EIA topics will be incorporated into the assessment of a number of potential socio-economic amenity effects within the ES.

9.4.50 The methodology for taking account of the results of assessments relating to other EIA topics may evolve further as additional data becomes available. If this is the case, further information will be presented in the ES as appropriate.
Construction employment information

9.4.51 Information on the number of workers likely to be employed as a result of works during the construction period is not yet confirmed. Accordingly, for the PEIR, a preliminary assessment has been made and the likely magnitude of any impact has been assessed in a preliminary manner using estimates and/or caveats. The assessment is made at the project-wide level.

Spending at local businesses

9.4.52 Spending at local businesses will be estimated based on likely employment during the construction phase. As stated above, information on the number of workers likely to be employed as a result of works during the construction period is not yet confirmed. Accordingly, for the PEIR, the likely magnitude of any impact has been assessed in a preliminary manner using estimates or caveats. The assessment is made at the project-wide level.

9.5 Approach to mitigation

9.5.1 The site suitability selection process, and related consultation, has already taken into account the potential effects of the development on socio-economic indicators, and the assessment process will identify associated potential effects. This information will inform the development of a mitigation strategy that will address potential significant adverse effects. Where these effects are predicted as likely to occur, the mitigation strategy is being formulated to eliminate them, or reduce them to an acceptable level.

Construction

9.5.2 The assessment process identifies potential effects resulting from the construction works after implementation of the CoCP.

9.5.3 The potential for significant adverse effects (at site-specific and project-wide level) was identified at an early stage within the design process. Where the potential for significant adverse effects were deemed likely to occur, potential environmental design measures to eliminate them or reduce them to an acceptable level were identified for implementation within the design and also through the CoCP (see Volume 2). These measures have been and are continuing to be discussed with stakeholders and the relevant responsible authorities. Inputs into the CoCP by relevant assessment topic are detailed in the draft CoCP appended to Volume 2 of this report.

9.5.4 For the purposes of the PEIR any potential significant adverse effects after the implementation of the CoCP have been identified and potential mitigation measures have been recommended for discussion with stakeholders and the relevant responsible authorities. Where appropriate, these mitigation measures will be outlined with greater certainty in the ES.

Operation

9.5.5 If significant adverse socio-economic effects are identified in the operational phase, then as for construction effects, potential mitigation
measures will be recommended for discussion with stakeholders and the relevant responsible authorities.

**Cumulative, in combination and compound**

**Cumulative**

9.5.6 The approach to mitigation of cumulative effects will depend on the type and nature of the projects identified as being relevant for consideration and whether or not they will result in a cumulative socio-economic effect with the Thames Tunnel project. A mitigation strategy will then be developed, if required, and further detail presented in the ES as appropriate.

**Amenity**

9.5.7 Consideration of amenity effects is indicative and preliminary in the PEIR for the reasons detailed above.

9.5.8 Accordingly, any recommendations on the approach to mitigation are also preliminary at this stage. They nevertheless will be able to form the basis for discussion with stakeholders and the relevant responsible authorities as more detailed design information becomes available.

**Project-wide**

9.5.9 Significant adverse project-wide socio-economic effects may occur during both the construction and operational phases.

9.5.10 Where any such effects are identified, potential mitigation measures will be recommended for discussion with stakeholders and the relevant responsible authorities.
10 Townscape and visual

10.1 Introduction

10.1.1 This section sets out the full EIA methodology for the assessment of townscape and visual effects associated with the Thames Tunnel project. Work which has not been fully completed for the PEIR will be completed for the ES, and this is noted below and within each site specific assessment volume.

10.1.2 The methodology for the townscape and visual assessment generally follows the guidelines set out in the following documents:


c. The London Mayor’s London View Management Framework (LVMF, 2010) and other relevant mayoral strategies relating to townscape and visual amenity.

10.1.3 All of these documents are currently under review and the methodology that has been developed for this assessment seeks to accommodate recent developments as far as possible in the assessment of townscape and visual effects. The methodology described in this report has also been developed to ensure a level of assessment appropriate to the unique characteristics of the Thames Tunnel project.

10.2 Scoping Opinions and technical engagement

10.2.1 A summary of Scoping Opinions and technical engagement undertaken in relation to the townscape and visual assessment is included in Volume 4, Sections 3.10 and 4.10.

10.3 Baseline data collection methodology

10.3.1 The townscape and visual baseline has been established through desk based research and field survey to establish the character of each site, surrounding areas and the nature of existing views. The desktop and field survey data sources are outlined below, before describing the approach to establishing the townscape and visual baseline.

Desk based baseline data

10.3.2 Desk based data sources used in the establishment of the townscape and visual baseline are described in the table below.

Vol 5 Table 10.3.1 Townscape and visual desk based baseline data sources

<table>
<thead>
<tr>
<th>Source</th>
<th>Data</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Greater London</td>
<td>The London Plan</td>
<td>Information on London wide policies and designations</td>
</tr>
</tbody>
</table>
### Field survey baseline data

10.3.3 Field survey data used in the establishment of the townscape and visual baseline has been gathered through a range of surveys as described in the table below.

**Vol 5 Table 10.3.2 Townscape and visual field survey baseline data sources**

<table>
<thead>
<tr>
<th>Source</th>
<th>Data</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Winter field surveys</td>
<td>Information on the townscape and visual winter baseline.</td>
<td>This was undertaken to allow identification of townscape character areas, identification of visual assessment viewpoints, checking of the ZTV and an assessment of the effects in winter.</td>
</tr>
<tr>
<td>Summer field surveys</td>
<td>Information on the townscape and visual summer baseline.</td>
<td>This was undertaken to establish how the character of areas and the visual characteristics of viewpoints change in summer. This summer baseline will be</td>
</tr>
</tbody>
</table>
### Townscape baseline

**10.3.4** The townscape baseline presented in the site assessment volumes (Volumes 7 to 28), includes an overview of the elements which form the townscape baseline within the assessment area, using text and plans to describe:

- **a.** topography
- **b.** land use
- **c.** development patterns and scale, including reference to building heights
- **d.** vegetation patterns and extents, including known Tree Preservation Orders (TPOs)
- **e.** open space distribution and type, including statutory, non-statutory and local plan open space designations
- **f.** transport routes.

**10.3.5** These townscape baseline elements have been derived from GLVIA.

**10.3.6** The townscape baseline elements have been used to prepare a townscape character assessment covering the assessment area for each site, classifying the townscape into distinct character areas which display common features and characteristics. These character areas are influenced by statutory, non-statutory and local plan designations, particularly Conservation Areas. For the purposes of the assessment, the site is classified as a discrete area within the townscape.

**10.3.7** The site is defined by the maximum extent of the working area during construction. Any designations that the site or part of the site falls within, are noted. The character of the site is generally derived from the character of the surrounding townscape, but is described and assessed.

---

<table>
<thead>
<tr>
<th>Source</th>
<th>Data</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Verifiable photography</td>
<td>Verifiable photographs taken from each of the viewpoints agreed in advance with the local authority.</td>
<td>Verifiable photographs were taken in line with the requirements of the LVMF, including both day and night time photos during winter. Photos for some sites are complete, with the remainder to be taken and presented in the ES.</td>
</tr>
<tr>
<td>Verifiable surveying</td>
<td>Surveying was undertaken for each of the verifiable photography viewpoints.</td>
<td>Surveying was undertaken in line with the requirements of the LVMF.</td>
</tr>
</tbody>
</table>
separately as it defines the extent of direct effects on the townscape. All effects outside of the site would be indirect.

10.3.8 The character of the site and surrounding townscape character areas is described, influenced by existing documentation where available, including Conservation Area character appraisals. Any designated areas that the site or character area falls within are noted. Any particular components that make a significant contribution to the character of the site, or surrounding townscape character area, are noted and described, including listed buildings and structure, and planting areas.

10.3.9 For the site only, a detailed list of townscape components has been described and their condition noted, with reference to the following criteria:
   a. good – components are regularly maintained to a high standard
   b. fair – components are relatively well maintained
   c. poor – components are poorly maintained or damaged.

10.3.10 An assessment has been made of the site’s potential for townscape enhancement, in line with standard practice in GLVIA. Attributes which contribute to the potential for townscape enhancement may include:
   a. the absence or presence of strong characteristic features
   b. the condition of townscape components.

10.3.11 For surrounding townscape character areas, the condition of the townscape has been assessed as a whole, with reference to the criteria described in Section 10.3.9.

10.3.12 An assessment has been made of the baseline tranquillity of the site and surrounding townscape character areas. Attributes which contribute to the tranquillity of the site may include:
   a. land use
   b. level of seclusion or isolation
   c. extent and type of enclosure by surrounding land uses
   d. level of screening afforded by vegetation, ground level change or boundary treatments
   e. levels of vehicular traffic in, or close to the site
   f. levels of pedestrian traffic in, or close to the site
   g. the absence or presence of HGVs in, or close to the site
   h. the absence or presence of major infrastructure routes in the vicinity of the site.

**Determining resource value/receptor sensitivity**

10.3.13 An assessment has been made of the likely scale at which the townscape of the site and surrounding character areas is valued, based on which users may value the site and, where possible, statutory, non-statutory and local plan designations. Factors that influence the scale of townscape value are detailed in the table below.
Vol 5 Table 10.3.3 Townscape value scales

<table>
<thead>
<tr>
<th>Scale of townscape value</th>
<th>The site is:</th>
</tr>
</thead>
<tbody>
<tr>
<td>International</td>
<td>Located within a World Heritage Site.</td>
</tr>
<tr>
<td></td>
<td>Considered an internationally important component of the country’s character, experienced by significant numbers of international tourists.</td>
</tr>
<tr>
<td>National</td>
<td>Located within an Area of Outstanding Natural Beauty.</td>
</tr>
<tr>
<td></td>
<td>A nationally significant historic or cultural resource.</td>
</tr>
<tr>
<td></td>
<td>Considered a distinctive component of the country’s character, experienced by significant numbers of tourists from around the country.</td>
</tr>
<tr>
<td>Regional</td>
<td>Located within green belt, Metropolitan Open Land (MOL) or a regional scale park.</td>
</tr>
<tr>
<td></td>
<td>Considered a distinctive component of London’s character, experienced by a large proportion of the city’s population.</td>
</tr>
<tr>
<td>Borough</td>
<td>Designated open space within the local authority Unitary Development Plan (UDP) or Local Development Framework (LDF).</td>
</tr>
<tr>
<td></td>
<td>Designated as a Conservation Area.</td>
</tr>
<tr>
<td></td>
<td>Experienced by a significant proportion of the Borough’s population.</td>
</tr>
<tr>
<td>Local</td>
<td>A public, semi-public or private open space that serves the local community or residents.</td>
</tr>
<tr>
<td></td>
<td>A residential area, likely to be valued by the local community.</td>
</tr>
<tr>
<td>Limited</td>
<td>A commercial, industrial or disused area that has limited townscape value to the local community or residents.</td>
</tr>
</tbody>
</table>

With reference to condition, tranquillity and value, the sensitivity of the site and surrounding townscape character areas to change has been assessed. The assessment of sensitivity requires the application of professional judgement, in line with the guidance in GLVIA. The presence of any combination of attributes may be considered when assessing the sensitivity of the site or character area. This allows professional judgement to be used when determining the relative importance of different attributes, which varies on a site specific basis. Attributes which contribute to the sensitivity of the site may include the following in the table below (the occurrence of any one attribute may be sufficient to allocate the sensitivity rating).
### Vol 5 Table 10.3.4 Townscape sensitivity criteria

<table>
<thead>
<tr>
<th>Sensitivity</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>The site or townscape character area:</strong></td>
<td></td>
</tr>
</tbody>
</table>
| High | is valued at the international, national, regional or Borough scale  
  is predominantly characterised by townscape components that are rare and distinctive and/or listed  
  is designated as a conservation area, registered park and garden or public open space  
  has a character that is rare within the assessment area  
  has an elevated tranquillity  
  has limited tolerance to change  
  has components that are not easily replaced or substituted (eg, mature trees)  
  has limited scope for effective mitigation in character with the existing townscape. |
| Medium | is locally valued  
  has some components that are rare and/or distinctive  
  has a character which is common within the assessment area  
  has moderate levels of tranquillity  
  is fairly tolerant of change  
  has components that are easily replaced or substituted  
  has scope for effective mitigation in character with the existing townscape. |
| Low | has limited townscape value  
  has few or no distinctive components, or components that detract from the overall character of the site  
  has a character that is common within the assessment area  
  has limited tranquillity  
  is tolerant of change  
  has components that are easily replaced or substituted  
  has scope for effective mitigation in character with the existing townscape, and opportunities for an improvement in character. |

10.3.15 This list of attributes reflects best practice guidance from the GLVIA.
10.3.16 The character of the site and surrounding character areas at night time is also described, with reference to:
   a. the levels of lighting and light pollution within the site or surrounding character area
   b. the levels of lighting in the wider area, that may indirectly affect light levels within the site or character area
   c. the level and nature of night time usage by people, if any.

10.3.17 The sensitivity of the site and surrounding character areas to additional lighting are assessed accordingly on this basis.

**Visual baseline**

10.3.18 Within the assessment area of each site (defined in Section 10.4), visual receptor types are mapped by category in the following hierarchy:
   a. high sensitivity – residential, recreational including tourists
   b. medium sensitivity - transport
   c. low sensitivity -active sports, employment and other institutions.

10.3.19 These categories are based on best practice guidance from the Landscape Institute.

10.3.20 The visual baseline is described for each specific viewpoint selected through a detailed analysis of the visual resource of the assessment area, and confirmed in consultation with the relevant local authorities. These viewpoints have formed the basis for the visual assessment.

10.3.21 Viewpoints are selected to represent groups of receptors within the Zone of Theoretical Visibility (ZTV). Where a viewpoint is located in an area that may represent multiple receptor types, the most sensitive receptor is selected. Attributes which affect the selection of viewpoints may include:
   a. theoretical visibility of the project
   b. protected views, identified in the London View Management Framework SPG, Local authority UDPs, LDFs and SPGs, and Conservation Area character appraisals
   c. consultation and feedback from Local authorities and English Heritage
   d. the receptor type
   e. the indicative number of receptors
   f. the accessibility of the viewpoint
   g. the extent of screening or filtering of the view (eg, by buildings or vegetation).

10.3.22 For each viewpoint, text and photos have been used to describe the baseline characteristics in winter. For the EIA, text and photos will also be used to describe the baseline characteristics in summer. In each case, the following is described:
   a. the composition of the view, including foreground and background characteristics
b. the nature of the view of the site, including what, if anything, filters (or screens) the view and whether a view is a wide panorama, framed, glimpsed or sequential view.

### 10.4 Assessment methodology

#### General

10.4.1 This section describes the approach to assessing effects on townscape character and visual receptors arising from the construction and operation of the project. The two principal criteria which determine the significance of an effect are the sensitivity of the receptor and the magnitude of the impact. The sensitivity of the site, surrounding townscape character areas and visual receptors are described in the baseline sections of Volumes 7 to 28. The methodology for establishing the magnitude of impact is described further below.

#### Construction and operational effects

##### Assessment cases and years

10.4.2 The generic assessment cases are described in Section 2. The following section describes the specific approach for townscape and visual receptors.

**Assessment cases and years**

**Base case**

10.4.3 The base case for assessment will be a future case, without the project, in any particular assessment year. The base case for each site is a projection of the likely baseline in the particular assessment year, taking into account changes in the townscape.

10.4.4 Information is being assembled to identify current committed developments in the areas surrounding each of the sites, together with relevant major developments of such significance that they are likely to affect townscape conditions over a wider area.

**Development case**

10.4.5 A development case is a future case during either the construction or operation of the project in the same assessment year as the equivalent base case. The assessment typically considers the ‘development case’ compared with the ‘base case’ in any particular assessment year (see below).

10.4.6 In each instance, the development case has been compared with the base case (do-nothing). The future base cases have been established with reference to:

a. known future developments

b. planning policy including site specific allocations

c. consultation with statutory consultees

d. professional judgement on the growth and/or loss of vegetation.
Assessment years

10.4.7 The assessment of townscape and visual effects will be undertaken for the following assessment years:

a. construction: The peak construction year will be defined on a site specific basis. At each site, the peak in construction activity will be defined as the time when the site is fully site up with the largest amount of construction plant on site, including the cranes, and regular road and/or river traffic movements.

b. operation Year 1

c. operation Year 15. This allows an assessment to be made of townscape and visual effects once any vegetation planted as part of the project has matured or has achieved its design intention.

Assessment area

10.4.8 The assessment area has been defined as the area over which the physical components or changes caused by the introduction of the proposed development could affect peoples’ views of the townscape within the wider area. The ZTV has been used as a tool to establish the extent of the townscape and visual assessment areas, alongside professional judgement which has been used to interpret the model, in line with guidance provided by the Landscape Institute.

10.4.9 The ZTV for each site has been created by digitally modelling the landform within the assessment area using a digital terrain model (ground profile) combined with building height information from a digital surface model. Building height information was extracted using the OS MasterMap buildings layer to filter out trees and other vegetation from the digital surface model, which inaccurately skew the results if left in. This is due to the model interpreting all information as a solid barrier, whereas trees generally filter visibility rather than obstruct, particularly during winter. Bridges across the River Thames have also been manually removed from the model as views are typically present underneath the arches.

10.4.10 The proposed development has been incorporated into the model by modelling the heights and extents of the proposed development. An offset of 1.6m above ground level has been used to represent the eye level view of an average height person. The model highlights areas from which the proposed development is theoretically visible.

10.4.11 The results are presented on an OS MasterMap base, overlaying the ZTV layer with the buildings layer, highlighting the visibility from accessible locations only. This prevents the ZTV from illustrating widespread visibility of the proposed development from the roofs of buildings, which would be an inaccurate indication of the theoretical visibility of the project.

10.4.12 The validity of the ZTV has been checked on site, using professional judgement to ensure the output is a fair representation of the theoretical visibility of the proposed development.

10.4.13 In a number of locations, such as on the foreshore of the River Thames and in large open spaces, the ZTV generated by the model extends for
long distances. In these instances, the extent has been checked on site to assess where the model is providing a false indication of the visibility of the proposed scheme. This may result from thick bands of vegetation, structures such as walls or embankments, or bridges that are missing from the model. In addition, where no intervening structures are present, the extent of the ZTV (particularly along the corridor of the River Thames) is checked to identify at which point the components of the proposed development (including cranes during construction) become barely perceptible in the background of the view, due to the distance between the site and receptor.

10.4.14 Therefore, the extent of the assessment area for townscape and visual effects is defined by the maximum extent of the ZTV, excepting those locations where the visibility is a false representation, or where the components of the project would be barely perceptible. With regard to the visual assessment, representative viewpoints for assessment are identified within the ZTV.

**Townscape effects**

10.4.15 Physical changes to townscape may give rise to effects on townscape character.

10.4.16 Effects within the site boundary are typically direct, whereby townscape components are lost, damaged or altered by the construction or operation of the proposed development.

10.4.17 Effects within the wider townscape are indirect, whereby the proposed development alters the setting of surrounding townscape character areas and components.

**Determining magnitude of impacts**

10.4.18 The likely nature and magnitude of changes to individual townscape elements and characteristics are described together with the consequential effect on townscape character. Factors that are considered in assessing the magnitude of change to the site (either beneficial or adverse) are summarised in the table below, based on guidance from GLVIA.

**Vol 5 Table 10.4.1 Townscape within site impact magnitude criteria**

<table>
<thead>
<tr>
<th>Impact magnitude</th>
<th>Definition</th>
</tr>
</thead>
</table>
| High             | Total loss of or major alteration to key characteristics or components of the site  
|                   | Addition of new features or townscape components that would be incongruous with the existing character of the site  
|                   | Introduction of elements that markedly alter the tranquillity of the site |
| Medium           | Partial loss of or alteration to one or more key characteristics or components of the site  
|                   | Addition of new features or townscape components that |
## Impact magnitude | Definition
---|---
**High** | Total loss of or major alteration to key characteristics of the setting of the townscape character area  
Addition of new features or townscape components that substantially alter the setting of the townscape character area  
Introduction of elements that markedly alter the tranquillity of the townscape character area.

**Medium** | Partial loss or alteration to one or more key characteristics of the setting of the townscape character area  
Addition of new features or townscape components that form prominent elements of the setting of the townscape character area, but are largely characteristic of the existing setting  
Introduction of elements that noticeably alter the tranquillity of the townscape character area.

**Low** | Minor loss or alteration to one or more characteristics of the setting of the townscape character area
<table>
<thead>
<tr>
<th>Impact magnitude</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Addition of new features or townscape components that form largely inconspicuous elements of the existing setting of the townscape and are characteristics of the existing setting</td>
</tr>
<tr>
<td></td>
<td>Introduction of elements that discernibly alter the tranquillity of the townscape character area.</td>
</tr>
<tr>
<td>Negligible</td>
<td>No change to, or very minor loss or alteration of inconspicuous characteristics of the setting of the townscape character area</td>
</tr>
<tr>
<td></td>
<td>Addition of new features or townscape components that do not influence the overall setting of the townscape character area, or are entirely characteristic of the existing setting</td>
</tr>
<tr>
<td></td>
<td>Introduction of elements that make no perceptible change to the tranquillity of the townscape character area.</td>
</tr>
</tbody>
</table>

### Determining the significance of townscape effects

10.4.20 Determination of the significance of an effect requires the application of professional judgement to weigh the findings of the sensitivity of the receptor and the magnitude of an effect. The presence of any combination of factors may be considered when assessing the significance of effect. This allows professional judgement to be used when determining the relative importance of different factors, which varies on a site specific basis. Effects may be adverse or beneficial. The broad criteria that influence the level of significance of townscape effects are noted in Vol 5 Table 10.4.3. Both the major and moderate categories are considered to comprise a significant effect. Any one aspect described may result in a categorisation within that significance level.

10.4.21 The significance for townscape effects generally follows the criteria set out in GLVIA and DMRB, acknowledging that these documents are currently under review.

### Vol 5 Table 10.4.3 Townscape significance criteria

<table>
<thead>
<tr>
<th>Significance of effect</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Major adverse</td>
<td>The proposed development would result in effects that:</td>
</tr>
<tr>
<td></td>
<td>would be at considerable variance with the existing townscape character, degrading its integrity</td>
</tr>
<tr>
<td></td>
<td>would permanently degrade, diminish or destroy the integrity of valued characteristic features, elements and/or their setting</td>
</tr>
<tr>
<td></td>
<td>would be judged adverse at a national or regional level</td>
</tr>
<tr>
<td></td>
<td>would comprehensively conflict with regional or local environmental policies for the protection and</td>
</tr>
</tbody>
</table>
## Significance of effect

<table>
<thead>
<tr>
<th>Description</th>
<th>Significance of effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>The proposed development would result in effects that:</td>
<td></td>
</tr>
<tr>
<td>enhancement of the townscape.</td>
<td></td>
</tr>
</tbody>
</table>

| Moderate adverse | would be at variance with the existing townscape character |
|                 | would be judged adverse at a local level |
|                 | would not be wholly compatible with local environmental policies for the protection and enhancement of the townscape. |

| Minor adverse | would be slightly at variance with the existing townscape character |

| Negligible | would be compatible with the existing townscape character. |

| Minor beneficial | would improve and enhance the existing townscape character |
|                 | would restore valued characteristic features partially lost through other land uses. |

| Moderate beneficial | would markedly improve and enhance the existing townscape character |
|                    | would restore valued characteristics substantially lost through other land uses. |

| Major beneficial | would considerably and distinctly improve and enhance the existing townscape character |
|                 | would restore valued characteristic features substantially or entirely lost through other land uses. |

## Visual effects

10.4.22 Visual effects relate to:

a. the changes that arise in the composition of available views as a result of changes arising from the proposed development

b. people’s responses to changes.

## Verifiable photomontages

10.4.23 In some locations, as agreed with statutory consultees, the assessment of visual effects will be supported by the production of photomontages. These will be prepared for viewpoints where:

a. the receptor is highly sensitive to change and/or the viewpoint is identified in the London View Management Framework SPG, Local authority UDPs, LDFs and SPGs, and Conservation Area character appraisals
b. the magnitude of effect cannot be easily assessed with reference to plans, sections, elevations and 3D visualisations (eg, where views may be partially filtered or screened by vegetation or built form, or where the precise siting of elements has a particular importance in relation to the composition of a view).

10.4.24 Verifiable photomontages will be prepared for the ES to a recognised, verifiable methodology (defined below), which will be agreed with statutory consultees in advance.

10.4.25 The verifiable photomontages will be prepared in four stages:

a. collection of survey data and photography
b. creation of the digital terrain model
c. camera matching of the surveyed points into the digital 3D model
d. rendered photomontage production.

**Collection of survey data and photography**

10.4.26 At each verifiable photomontage viewpoint, photographs will be taken using a 21 megapixel digital SLR camera with a sensor size of 36 by 24mm (equivalent to a 35mm film still image frame). The camera will be mounted on a tripod at eye level (approximately 1.65m). The point on the camera system which coincides with that of the virtual render camera (on the 3D digital model) will be positioned in relation to a survey mark on the ground (survey road nail, existing feature with a diameter less than 5mm or a tipex mark) to a tolerance of 2mm in any direction. The orientation of the camera will be adjusted so that the optical axis and the horizontal axis of the sensor are aligned with the horizon, to an accuracy of 3mm per 100m.

10.4.27 A majority of verifiable photomontage viewpoints will be produced as panoramas. For the production of panoramic imagery, the mount rotates the camera in a horizontal plane around the survey coordinate, thus eliminating errors in overlapping imagery for panoramic cylindrical images or misaligned joints on 40 degree adjacent rectilinear section imagery.

10.4.28 Where verifiable photomontage viewpoint locations coincide with London View Management Framework River Panoramas, three rectilinear images will be taken with a 40 degree lens, which will then be assembled side by side to create a composite sectioned image of 120 degrees.

10.4.29 Images will be captured using the native camera RAW format to ensure maximum tonal and colour information is retained for use in the image processing stage. Choices for aperture and focus distance will be designed to render all parts of the scene in focus. Supplementary photographs will be taken to record the survey point and the camera position in the location.

10.4.30 Following collection of the images, the camera files will be imported into a proprietary image processing application which converts the RAW camera data into lossless RGB format files suitable for use in 2D image editing and 3D modelling applications. At this stage there will also be tonal and colour adjustments which aim to replicate the scene as honestly as possible
as it was perceived by the photographer at the time of capture. Lens correction software will remap the images to remove any optical defects, which would otherwise create distortion of the image in addition to the normal effects of projecting a 3D scene onto a 2D flat capture surface.

10.4.31 The proprietary software will create seamless and accurate cylindrical projections from an overlapping sequence of images which share a single camera coordinate, forming panoramic images where required.

10.4.32 The images will then be placed in a pre-prepared template where the centre of the optical axis is aligned with the image centre to account for any offset used in vertical framing adjustments or mechanical misalignment of the lenses optical axis and that of the sensor.

10.4.33 At each verifiable photomontage viewpoint, a survey will be conducted of the camera position and of camera control points at each location, to an accuracy of ± 1cm.

10.4.34 The camera position will be surveyed at the back of the camera, in alignment with the axis of the camera lens, or the point on the ground directly below the camera. The camera control points comprise a series of easily recognisable locations spread over the foreground and background of each photograph. These points will be used to verify the location and orientation of the virtual camera in the 3D digital model. All surveyed points will be supplied in OS coordinates.

Creation of the digital terrain model

10.4.35 The digital terrain model will be created using three main data sources:

a. LIDAR survey data for the existing topography
b. OS CAD plans to represent existing roads and buildings
c. Project CAD models that represent the proposed development.

Camera matching of the surveyed points into the digital 3D model

10.4.36 The virtual camera will be set up in a 3D modelling programme which allows different attributes to be adjusted to simulate a real camera. Camera matching is achieved by positioning the virtual camera to the reference points of each camera position, and moving the camera’s target (by rotating the camera position) until the camera control points are aligned over the surveyed positions in the photograph.

10.4.37 To verify that the virtual camera is correctly aligned, markers at the positions of the camera reference points are rendered at full resolution. This is then overlaid onto the photograph, to ensure their positions match the location of the camera control points.

Rendered photomontage production

10.4.38 Following the accurate positioning of the model and virtual camera, materials will be applied to the view in line with the architectural and landscape design for the proposed development. The view will then be rendered using the correct settings to simulate the light levels, time of the day and year, and weather conditions present at the time of the photograph.
Determining magnitude of impacts

10.4.39 The factors that are considered in assessing the magnitude of change on views and on visual amenity of the identified receptors (either beneficial or adverse) are summarised in the table below.

**Vol 5 Table 10.4.4 Visual impact magnitude criteria**

<table>
<thead>
<tr>
<th>Impact magnitude</th>
<th>Definition</th>
</tr>
</thead>
</table>
| **High**         | Total loss of or major alteration to key characteristics of the view from a receptor  
Addition of new features or components that are continuously highly visible and incongruous with the existing view from a receptor  
Substantial changes in close proximity to the visual receptor, within the direct frame of view. |
| **Medium**       | Partial loss of or alteration to one or more key characteristics of the view from a receptor  
Addition of new features or components that may be continuously highly visible, but are largely characteristic of the existing view from a receptor  
Changes a relatively short distance from the receptor, but viewed as one of a series of components in the middle ground of the view  
Substantial change partially filtered by intervening vegetation and/or built form, or viewed obliquely from the visual receptor. |
| **Low**          | Minor loss of or alteration to one or more characteristics of the view from a receptor  
Addition of new features or townscape components that may be continuously or intermittently visible, but are largely characteristic of the existing view from a receptor  
Changes within the background of the view, viewed as one of a series of components in the wider panoramic view from a receptor  
Change largely filtered by intervening vegetation and/or built form, or viewed obliquely from the visual receptor. |
| **Negligible**   | Very minor loss or alteration of inconspicuous characteristics of the view from a receptor  
Addition of new features or townscape components that are largely inconspicuous and characteristic of the existing site when viewed from a receptor  
Changes within the background of the view, viewed as an inconspicuous element within the wider panoramic view |
Determination of the significance of an effect requires the application of professional judgement to weigh the sensitivity of the receptor with the magnitude of an impact. Effects may be adverse or beneficial. The broad criteria that influence the level of significance of visual effects are set out in Vol 5 Table 10.4.5. Both the major and moderate categories are considered to comprise a significant effect.

Vol 5 Table 10.4.5 Visual effect significance criteria for townscape

<table>
<thead>
<tr>
<th>Significance of effect</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Major adverse</td>
<td>a marked deterioration in the existing view</td>
</tr>
<tr>
<td>Moderate adverse</td>
<td>a noticeable deterioration in the existing view</td>
</tr>
<tr>
<td>Minor adverse</td>
<td>a discernible deterioration in the existing view</td>
</tr>
<tr>
<td>Negligible</td>
<td>no perceptible deterioration or improvement in the existing view</td>
</tr>
<tr>
<td>Minor beneficial</td>
<td>a discernible improvement in the existing view</td>
</tr>
<tr>
<td>Moderate beneficial</td>
<td>a noticeable improvement in the existing view</td>
</tr>
<tr>
<td>Major beneficial</td>
<td>a marked improvement in the existing view</td>
</tr>
</tbody>
</table>

Cumulative, in combination and compound effects

The general approach to assessing cumulative, in combination and compound effects is described in Section 2. The specific approach for townscape and visual receptors is described below.

Cumulative and compound and townscape and visual effects derive from changes to the townscape and visual amenity caused by multiple Thames Tunnel sites or other non-related development within the ZTV, respectively.

The scope of the assessment of compound townscape and visual effects arising from multiple Thames Tunnel sites will be established with reference to the ZTVs for each site. Where the ZTV from two or more Thames Tunnel sites overlap an assessment of cumulative impacts from
Thames Tunnel sites will be undertaken. The intersecting ZTVs are illustrated on cumulative ZTV plans. For each townscape character area and visual receptor within the cumulative ZTV area, the combined townscape and visual effects arising from proposed Thames Tunnel works will be assessed using the townscape and visual methodology described above. This assessment will be undertaken for the construction, operation Year 1 and operation year 15 development cases.

10.4.45 Cumulative effects arising from other non Thames Tunnel related development will be assessed, where relevant, using the townscape and visual methodology described above. This assessment will be undertaken for the construction, operation Year 1 and operation Year 15 development cases.

10.4.46 No in combination effects are anticipated, and so no assessment will be undertaken.

**Project-wide effects**

10.4.47 Townscape and visual effects are related to site specific effects, and compound effects arising from the inter-visibility of sites close to each other only. Therefore, no assessment of project-wide effects will be undertaken.

**Assessment assumptions and limitations**

10.4.48 The assessment is based on the information available at the time of writing. It is considered that sufficient information has been available to define both the areas likely to be affected by the works and the likely nature and extent of effects.

10.4.49 The assessment is based on professional judgement and takes into account both the adverse and beneficial contribution that new development can make upon the existing townscape character of the site, its environs and on the visual resource of surrounding receptors.

10.4.50 During the baseline survey there were some areas which were inaccessible (eg, private land, commercial premises and residential buildings). In these instances professional judgement has been used to approximate the likely views from these locations. Where viewpoints have been selected to reflect the visibility of the site from tall residential properties, a photo is included from public land in close proximity to the property, taken at ground level, and a commentary included on how the view may appear from a higher elevation.

10.4.51 Projections of the future base case are based on information available at the time of writing, from planning applications, planning policy and consultation with statutory consultees.

**10.5 Approach to mitigation**

**Construction**

10.5.1 Measures to prevent and avoid effects during the construction phase, such as protection of trees have been incorporated as far as possible into the draft CoCP. In addition, a further process of iterative assessment and
design will be employed in the period following the publication of the PEIR to further reduce any adverse effects arising during construction, for example, through minimising loss of vegetation as far as possible. The resulting residual effects are then described.

**Operation**

10.5.2 Environmental design measures to prevent and reduce adverse operational effects have been embedded into the project proposals as far as possible. A further process of iterative assessment and design will be employed to reduce adverse effects on townscape and visual resources. The resulting residual effects will then be described.
11 Transport

11.1 Introduction

11.1.1 This section sets out the full EIA methodology for the assessment of transport effects associated with the Thames Tunnel project. Work which has not been fully completed for the PEIR will be completed for the ES and the related Transport Assessment (TA), and this is noted below and within each site specific assessment volume.

11.1.2 The effects of the construction and operational phases of the project on pedestrians, cyclists, bus and coach services, rail services, river services, taxi operations and private traffic are considered within the defined study areas that have been agreed with Transport for London (TfL) and the local highway authorities (LHAs).

11.1.3 During construction the project would generate additional traffic on the highway network, including heavy goods vehicles (HGVs), and additional journeys associated with construction workers travelling to and from sites. In certain locations, changes to traffic, pedestrian and cycling routes would also be required to facilitate construction activity. During the operational phase, the project would generate a small number of vehicles accessing the sites occasionally for inspection and maintenance works.

11.1.4 This section of the PEIR describes the approach to assessing the likely transport effects associated with both the construction and operational phases of the project. It is noted that the PEIR details the preliminary finding of the assessment based on professional judgement drawing on knowledge of the transport networks and their operational characteristics in the vicinity of each site, construction activity associated with the project and discussions with TfL and the LHAs.

11.1.5 A more detailed Transport Assessment report will be contained as an Appendix to the ES and the findings summarised in the main text of the ES. The methodology for this more detailed assessment is also described below.

11.1.6 The assessment of transport effects informs other environmental topic assessments, including in particular those for noise and air quality, for which transport information forms one of the assessment inputs.

11.2 Scoping Opinions and technical engagement

11.2.1 A summary of scoping and technical engagement undertaken in relation to transport is contained in Volume 4, Sections 3.11 and 4.11.

11.3 Baseline data collection methodology

General approach

11.3.1 Existing transport conditions at each of the sites have been established and been agreed with TfL and the LHAs to provide baseline data against which the potential effects arising from the construction and operational phases of the project can be assessed (for a given assessment year).
11.3.2 Baseline observations have been informed by site visits, collation of available information from TfL and the LHAs and other sources and on-site data collection. Further details on data sources are provided in paras. 11.3.21 to 11.3.34

11.3.3 The scope and nature of baseline data collection has been discussed with TfL and the LHAs. The following sections describe the baseline data presented for each site.

**Pedestrian and cycle networks**

11.3.4 Pedestrian and cycle networks and flows are described in relation to existing walking and cycling networks and facilities, including pedestrian / Toucan crossings, cycle routes and cycle parking (including London Cycle Hire stations) in the vicinity of each site. Pedestrian and cycle flows derived from data collection sources are presented.

11.3.5 The networks in the context of the linkages which they provide for pedestrians and cyclists moving through and around each construction site and the degree of connectivity to other transport modes and to facilities and services are also described.

**Public transport networks**

11.3.6 Existing public transport services operating in the area surrounding each site together with known proposals for new services are outlined. The wider public transport network operations where these are relevant to project-wide assessments are also described.

11.3.7 Information is provided on the routes/lines and frequency of nearby mainline rail, London Underground Limited (LUL) and Docklands Light Railway (DLR) services.

11.3.8 Details of existing bus routes and frequencies are also provided to form the baseline for assessment. This includes details of existing bus stop and stand locations and the condition of bus facilities including bus shelters and bus priority measures in close proximity to the sites.

11.3.9 Where appropriate, existing coach parking for set-down, layover and pick-up activities is identified as part of the baseline.

11.3.10 Similarly, details of any specific taxi infrastructure, such as rank locations, are included in the baseline conditions.

11.3.11 Existing public river transport services operating in the surrounding and wider area are outlined. Information is provided on the frequency of services and locations of piers, including the levels of use of the river for commercial and leisure purposes. River infrastructure that may be relevant to the transportation of construction materials by water is also detailed.

11.3.12 The Public Transport Accessibility Level\(^{\text{iii}}\) (PTAL) at each of the proposed sites is determined. This is particularly relevant to the range of transport

\(^{\text{iii}}\) The PTAL is a measure of the level of access to public transport a particular area has. It is calculated by reviewing the nearest public transport stops (bus, tube, train or tram) and the frequency of these services. PTAL scores rank from 1 – 6 with 1 representing poor access, and 6 representing excellent access to public transport.
choices available to construction personnel travelling to and from each site. PTAL values also provide background information on the relative importance of each location in the context of wider travel within London.

11.3.13 PTAL calculations are undertaken using the standard PTAL methodology described in the TfL Transport Assessment Best Practice Guidance\(^93\). Reference was also made to the PTAL calculator within the TfL Planning Information Database online\(^94\).

11.3.14 The geographic threshold for considering public transport services in the vicinity of each construction site reflects the thresholds indicated in the TfL Public Transport Accessibility Level methodology, typically covering distances of 400m and 960m from the site for bus and rail / river services respectively.

11.3.15 It is recognised that the PTAL methodology does not consider public transport services beyond these threshold distances in the PTAL calculation. This does not necessarily mean that public transport services are beyond walking distance and therefore the PTAL values are considered in the context of the wider transport networks that might serve construction workers travelling to and from each of the sites.

**Highway network**

11.3.16 The road hierarchy, authority responsibilities and key elements of the surrounding highway network are identified.

11.3.17 Existing traffic conditions on the local highway network are established from data collected in traffic surveys and from existing traffic model sources where available and appropriate. From this, the hourly network peak flows are identified.

11.3.18 Existing access provision for parking and servicing at properties adjacent to the construction sites is identified to ensure that any effects on access to these properties are identified as part of the assessment.

11.3.19 The baseline information identifies existing on-street parking, of all types, that is at or adjacent to the proposed sites. It also outlines existing parking conditions in the local area, including details of Controlled Parking Zones, on-street loading provision and controls and proximity to the Congestion Charging Zone. At locations where car parking is expected to be affected by Thames Tunnel construction works, parking activity levels have also been examined to inform the assessment of construction effects on local parking facilities.

11.3.20 An analysis of accident data for the local roads in the vicinity of each of the sites is also included. The analysis considers the severity, casualty type and location of recorded accidents.

**Desk based baseline data**

11.3.21 Desk based baseline data sources have been utilised in order to ensure a comprehensive baseline is available to support the assessment process.

11.3.22 Information has been sought from available sources within TfL and the LHAs, and other reliable published sources where appropriate. Vol 5 Table 11.3.1 details the information collected.
11.3.23 Discussions have also taken place with TfL on the following issues:

a. The availability and use of information that may be contained within TfL sub-regional or local transport models that may be relevant to both the existing and future base case scenarios.

b. Detailed information from traffic signal installations required for the assessment of potential effects and mitigation.

Vol 5 Table 11.3.1 Transport desk based baseline data sources

<table>
<thead>
<tr>
<th>Source</th>
<th>Data</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>TfL</td>
<td>Accident record data</td>
<td>Sourced via TfL from police database records.</td>
</tr>
<tr>
<td>TfL BODS database</td>
<td>Bus timetable and patronage information</td>
<td></td>
</tr>
<tr>
<td>TfL RODS database</td>
<td>Rail timetable and patronage information</td>
<td>Particularly for the TfL Underground, DLR and Overground networks.</td>
</tr>
<tr>
<td>TfL and/or service operators</td>
<td>River passenger service timetable and patronage information</td>
<td></td>
</tr>
<tr>
<td>TfL and LHA</td>
<td>Pedestrian and cycle flow information</td>
<td>Available information sought and reviewed for appropriateness before inclusion in the Transport Assessment.</td>
</tr>
<tr>
<td>TfL and LHA</td>
<td>Pedestrian and cycle route networks</td>
<td>To confirm the status of elements of the pedestrian and cycle route networks.</td>
</tr>
<tr>
<td>TfL and LHA</td>
<td>Parking controls</td>
<td>Including Controlled Parking Zones and hours of operation.</td>
</tr>
<tr>
<td>TfL and LHA</td>
<td>Traffic flow data</td>
<td>Available information including permanent traffic count data sought and reviewed for appropriateness before inclusion in the Transport Assessment.</td>
</tr>
<tr>
<td>TfL</td>
<td>Sub-regional and local traffic model information</td>
<td>Potential source of modelled traffic flow data providing baseline information and also as a basis for assessment of future cases.</td>
</tr>
</tbody>
</table>
Field survey baseline data

11.3.24 A programme of field survey baseline data collection has been developed to provide current information on traffic, pedestrian and cycle flows in the vicinity of each of the construction sites. The majority of this field work was undertaken during May 2011 with additional field data collected in July 2011. School and public holiday periods were excluded from the data collection; with the exception of automatic traffic count data which were collected both during school term and school holiday periods to provide a background comparison.

11.3.25 Where necessary, supplementary field survey work is being undertaken to enable the assessment to respond to issues raised by TfL or the LHAs, or to address identified effects in further detail.

11.3.26 In parallel, information has been sourced from TfL and LHA databases and from TfL sub-regional and local traffic models. Where this information covers any additional locations identified through the engagement, its use for the assessment has been or will be agreed with the relevant authorities. Where such information does not address additional locations identified, a further programme of data collection will be scheduled.

11.3.27 Field survey data collection covers those topics shown in Vol 5 Table 11.3.2. The scale of the data collection required varies from site to site and not all of the data sources illustrated in the table below are necessary in all locations. The field surveys undertaken in relation to each site are detailed in the site specific volumes (Volume 7-28).

Vol 5 Table 11.3.2 Transport field survey baseline data sources

<table>
<thead>
<tr>
<th>Source</th>
<th>Data</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Commissioned field surveys</td>
<td>Manual classified vehicle turning counts at junctions</td>
<td>Undertaken by video or manual data collection.</td>
</tr>
<tr>
<td>Commissioned field surveys</td>
<td>Automatic volumetric vehicle counts</td>
<td>Undertaken using the temporary installation of automatic traffic count equipment.</td>
</tr>
<tr>
<td>Commissioned field surveys</td>
<td>Pedestrian and cycle flow surveys</td>
<td>Undertaken by video or manual data collection at junctions and on other key walking and cycling routes.</td>
</tr>
<tr>
<td>Commissioned field surveys</td>
<td>Queue length and journey time surveys</td>
<td>Undertaken by video or manual data collection at junctions. Journey time surveys undertaken by manual data collection on key routes.</td>
</tr>
<tr>
<td>Commissioned field surveys</td>
<td>Saturation flow measurements</td>
<td>Undertaken where necessary.</td>
</tr>
</tbody>
</table>
11.3.28 Data collection covers the key peak and off-peak time periods required for the assessment. The key time periods are:

a. weekday morning peak period  
b. weekday evening peak period  
c. weekend peak period  
d. weekday day-time off-peak period  
e. night-time period.

11.3.29 The requirement for night-time period data collection and assessment is only relevant at sites where continuous working hours are anticipated (24-hour operations). At these sites, continuous working hours do not necessarily imply that vehicle movements would take place over a 24-hour period; these may be limited to daytime hours to reduce impacts on the transport networks.

11.3.30 The need for continuous working hours at any site will depend upon the nature of site activities. In general, CSO interception sites are unlikely to require 24-hour working; while connection and main tunnel drive sites may require 24-hour working for short or long periods of time.

11.3.31 Appropriate peak, off-peak and night-time periods to be surveyed and assessed have been discussed and agreed with TfL and the LHAs.

11.3.32 The field survey work was undertaken by specialist traffic survey subcontractors working to an agreed methodology and programme.

11.3.33 Field data were processed by the survey subcontractors and provided to the consultant in tabulated formats as appropriate. The information will be collated to produce coordinated baseline traffic, pedestrian and cycle flow diagrams for the vicinity of each construction site.

11.3.34 This will then be combined with such information available from the TfL database and model sources to produce a comprehensive baseline dataset for each construction site, which has been discussed and agreed with TfL and the LHAs.

11.4 **Assessment methodology**

11.4.1 The overall assessment methodology for the project is provided in Section 2. The Transport Assessment methodology is detailed within this section. Relevant transport planning policy is detailed in Volume 2, Section 4.

**General approach**

11.4.2 The Transport Assessment has been carried out with reference to the following guidelines:

a. Transport Assessment Best Practice Guidance\(^{93}\)
b. TfL guidance and standards including those related to traffic modelling, bus infrastructure, pedestrian and cycle infrastructure

c. IEMA Guidelines for the Environmental Assessment of Road Traffic

d. Design Manual for Roads and Bridges (DMRB) guidance.

11.4.3 The assessment examines the implications of the project at three levels for the construction phase:

a. Site specific assessments, to identify the impacts local to each of the individual construction sites – these assessments are contained within the site-specific Volumes 7-28. Preliminary site-specific assessments are included in the PEIR.

b. Borough level assessments, to identify the impacts associated with combinations of sites acting together within one authority area, or combinations of sites across adjacent authority areas acting together – this assessment will be contained in the ES.

b. A project-wide assessment, to identify the impacts associated with all construction sites within the project acting together – a preliminary project-wide assessment is contained in Volume 6.

11.4.4 For the operational phase, the assessments are site-specific only. As transport activity associated with this phase is expected to be very low at each site, there is no requirement to address Borough level or project-wide issues within the assessment.

11.4.5 Vol 5 Table 11.4.1 provides a simplified flow diagram illustrating the principles of the forecasting and assessment approach. It applies to both the construction and operational phases, subject to para. 11.4.4. The diagram shows the site-specific, Borough and project-wide levels of assessment and the iterative relationship between the construction methodology, logistics strategy, assessment and the identification of mitigation measures. It also identifies the preparation of an Implementation Plan for transport mitigation which will guide the scope and delivery of these measures through the construction and operational phases of the project.
Vol 5 Figure 11.4.1 Transport - forecasting and assessment process

Data gathering and collation
- Field surveys
- Desk-based sources

Baseline data synthesis and base case forecasting

2018 reference base case (construction)

Other future year base case(s) (construction)

2020 base case (operation)

Trip generation (vehicles, personnel) for construction and operational phases

Future year development case(s)

Site-Specific Assessments
- Walking and Cycling
- Public Transport
- Highway capacity
- Access and Traffic Management

Borough Level Assessments
- Public Transport
- Highway Capacity
- Strategic Highway Diversions

Mitigation measures

Implementation Plan

Committed / planned developments and schemes

Manpower and activity forecasts

Project-wide Assessment
- Public Transport
- Highway Capacity
- Strategic Highway Diversions
Construction and operational effects

11.4.6 A comprehensive description of the construction and operational proposals for each site, including site layout, site access, parking and servicing proposals is provided in Volume 2, Section 5, and Section 3 of the site assessment volumes (Volumes 7-28).

11.4.7 The construction proposals would influence vehicle and personnel movement demands through a combination of:

a. the construction and site methodology, including the works to be undertaken at each site, which would influence the number of personnel required at each location and the likely volumes of material (and thus construction traffic) that are expected

b. the construction programme, which would influence the profile of movement demands in time both for individual sites and for sites in combination

c. the logistics strategy, including the degree to which the river may be used to transport materials to and from certain sites, which would directly influence the numbers of construction vehicles associated with construction in each location.

11.4.8 The transport effects of the project are assessed against a construction logistics strategy which envisages:

a. excavated material being exported by river at Carnwath Road Riverside, Chambers Wharf and Kirtling Street

b. 90% of cofferdam fill being imported and subsequently removed by river at Putney Bridge Foreshore, Chelsea Embankment Foreshore, Heathwall Pumping Station, Albert Embankment Foreshore, Victoria Embankment Foreshore, Blackfriars Bridge Foreshore, Chambers Wharf and King Edward Memorial Park sites

c. all other materials being imported and exported by road.

11.4.9 It has been assumed in the transport assessment that a maximum of 10% of the daily construction vehicle movements associated with materials would take place in each of the peak hours. Sensitivity tests have been undertaken if different proportions are considered likely to occur at specific points in the construction programme for each site (Appendix C). Movements associated with construction personnel have been derived from the anticipated shift patterns and working hours at each site.

Construction phase assessment

11.4.10 The assessment for the construction phase considers transport issues associated with all transport modes. The approach is described in the paras. 11.4.14 to 11.4.25, the outcomes of which have been related to the impact criteria identified in paras. 11.4.57 to 11.4.65 and in Vol 5 Table 11.4.1 combining modal findings where necessary.

11.4.11 The PEIR provides a qualitative assessment based on discussions with TfL and the LHAs, knowledge of the transport networks and their
operational characteristics in the vicinity of each site and knowledge of the construction programme, duration and levels of construction activity.

11.4.12 These elements have been considered in the context of the range of receptors present in each location and the significance criteria identified in paras. 11.4.57 to 11.4.73. Professional judgement has been applied to determine qualitatively the likely effects and their significance in each location being assessed.

11.4.13 The completed Transport Assessment will include full quantitative and qualitative analysis and the transport effects reported in the Transport Assessment will be based on that detailed analysis.

**Pedestrians and cyclists**

11.4.14 Physical changes to pedestrian and cycle routes arising from the proposals at each construction site are identified. The implications of those changes are examined in relation to pedestrian and cycle journey times, safety and levels of pedestrian and cycle demand.

11.4.15 Consideration is also given to any linkages to key pedestrian or cycle destinations that would be affected by the project, including for example, links to public transport stops and interchanges, major tourism destinations and access to the Thames Path.

**Public transport**

11.4.16 The assessment examines the additional passenger demands that would be placed on public transport services (primarily bus, rail and river) directly by construction personnel, at each site and project-wide. Analysis is undertaken to determine whether these demands could be accommodated on existing services, whether modifications to services would be required, or whether other measures need to be provided as part of the CoCP to address personnel travelling other than by private car.

11.4.17 Public transport services, particularly bus services, may also be affected by impacts on the operation of the highway network. The assessment of the highway network is discussed in paras. 11.4.20 to 11.4.25 below. From the outcomes of that analysis, the assessment identifies whether road-based public transport services would suffer additional delay or whether infrastructure such as bus stops would require amendment.

11.4.18 At certain sites consideration is given to the impact of the project on river passenger services and other river activity, including recreational activity. The analysis examines whether use of the river to transport construction materials would lead to any effects on other river users. It also examines whether passenger piers would require relocation or amendment and the implications of such changes for both passengers and river service operators.

11.4.19 The assessment also considers the need for relocation or reprovision of set-down, pick-up or standing facilities for both taxis and coaches in the vicinity of construction sites.
**Highway network**

11.4.20 The assessment examines whether the construction site proposals would result in a loss of on-street car parking on a temporary or permanent basis. Where appropriate, it identifies whether and how alternative provision could be made for such displacement and the impact on parking provision and activity that would result.

11.4.21 The operation of the highway network is examined at both a strategic and a local level. At the strategic level, sub-regional models developed by TfL are used to analyse the changes to network operation that would result from activity associated with all construction sites in operation at a given time. This enables key combinations of sites which would be most likely to have the greatest network effects to be identified and further tests to be made of potential strategies for mitigation.

11.4.22 The strategic modelling work also informs the scope of local network modelling around individual construction sites. Where local road junctions would be affected by construction traffic, the assessment uses appropriate junction modelling software to determine the effects and test potential solutions.

11.4.23 Where traffic signal modelling is required, TfL have been consulted to ensure that relevant signal timing and operational information was taken into account. Traffic signal modelling follows TfL’s standard modelling guidelines.

11.4.24 Potential mitigation and management measures developed using the local models are incorporated into iterations of the strategic modelling to ensure that any wider implications are addressed in the overall assessment.

11.4.25 The analysis of highway network operation enables information to be produced in relation to network and junction capacity and operation and thus to potential changes to journey times that could arise from the project, either locally or in the wider area.

**Operational phase assessment**

11.4.26 Transport effects during the operational phase are expected to be relatively minor and would arise from occasional maintenance activity at sites or permanent changes to the transport networks following completion of the construction work.

11.4.27 As the number of trips associated with operation would be very low, much of the assessment for the operational phase is undertaken on a simplified basis and concentrated on the safety of access for maintenance vehicles and the implications of any additional transport infrastructure that would be created at each site.

11.4.28 The PEIR provides a qualitative assessment based on discussions with TfL and the LHAs, knowledge of the transport networks and their operational characteristics in the vicinity of each site and knowledge of the proposals for the operational phase.

11.4.29 Baseline data have been considered in the context of the range of receptors present in each location and the significance criteria identified in
paras. 11.4.57 to 11.4.73. Professional judgement has been applied to determine qualitatively the likely effects and their significance in each location being assessed. The transport effects reported in the Transport Assessment (and ES) will be based on more detailed information and qualitative analysis where this is appropriate.

11.4.30 During the operational phase it is anticipated either that existing pedestrian and cycle routes would be reinstated, or that additional infrastructure and routes would be created that would improve pedestrian and cyclists connectivity, journey times or safety. The assessment therefore examines whether the operational phase would lead to changes in these indicators compared to the operational base case.

11.4.31 During the operational phase, the public transport networks are not expected to differ from the base case conditions unless new permanent infrastructure is proposed as part of the operational phase designs. This could include bus, coach, taxi and river service infrastructure. Where permanent changes could be anticipated, these have been discussed with TfL, the LHAs, operators and other stakeholders and the implications for public transport journey times and service patterns are identified in the assessment.

11.4.32 The operation of the highway network is not considered likely to be affected by the operational phase of the project and the assessment addresses highway issues primarily in relation to the physical aspects of access to the sites for maintenance vehicles and the provision or reprovision of car, coach and taxi parking.

**Assessment cases and years**

11.4.33 The generic assessment cases are described in Section 2. The following section describes the specific approach for transport.

**Base case**

11.4.34 The base case for assessment will be a future case, without the project, in any particular assessment year.

11.4.35 The Transport Assessment is developing a base case for a typical assessment year within the overall construction period (2019) which has been discussed and agreed with TfL and the LHAs. This acts as a 'reference point', from which base cases for other assessment years can be developed.

11.4.36 To develop this 'reference' base case:

a. Information is being assembled to identify current committed developments in the areas surrounding each of the sites, together with relevant major developments of such significance that they are likely to affect transport conditions over a wider area.

b. Consideration is being given to planned development identified in policy documents, where this is likely to occur within the Thames Tunnel construction timeframe. These have been discussed with TfL and the LHAs to determine appropriate time and scale thresholds for consideration.
c. Committed or planned public transport enhancement proposals likely to be implemented during the construction period are being identified and included.

d. Other committed transport infrastructure schemes are also being taken into account at a strategic level, together with known planned schemes that are considered reasonably likely to be implemented within the Thames Tunnel construction period.

e. Allowance is being made, where appropriate, for general background growth in transport demand during the assessment time periods, although it is anticipated that the inclusion of infrastructure and development schemes planned within the period addresses the majority of the likely growth in transport demands.

11.4.37 The majority of future development which is envisaged in the London Plan 2011 and local policy documents, together with future infrastructure schemes, is already included within TfL sub-regional models for future years. This is relevant to the consideration of project-wide and possibly Borough level effects.

11.4.38 A list of schemes for inclusion in the assessment has been discussed with TfL and the LHAs to identify those which are considered likely to influence the outcomes of the assessment, and any which are not already incorporated within TfL models for the wider area. Those which are not already included in TfL models have been included in the “reference year” base case either at local or sub-regional levels as appropriate.

11.4.39 Details of the development and infrastructure schemes included in the future year base case will be set out in the Transport Assessment accompanying the ES.

11.4.40 In Agreeing the future year base case(s), consideration is also being given to how these relate to any specific forecasting years adopted in TfL sub-regional models, or other sources from which data were derived.

11.4.41 A base case is also being developed for the operational phase assessment, adopting Year 1 (unless otherwise agreed with TfL and the LHAs that an alternative year would provide greater consistency with existing strategic transport forecasting models).

Development case

11.4.42 A development case is a future case during either the construction or operation of the project in the same assessment year as the equivalent base case. The assessment typically considers the ‘development case’ compared with the ‘base case’ in any particular assessment year (see below).

11.4.43 Development cases are being prepared for each of the individual construction sites, and for combinations of sites, based on the identified assessment years relevant to each.

11.4.44 The development case incorporates the expected construction activity for each site, and combinations of sites, in addition to the future year base case. It will also take account of any proposed transport management
measures which are identified as part of the construction proposals, so that the impacts of these can be considered as part of the development case.

11.4.45 The methodology for the assessment varies depending upon the mode of transport being examined. The general approach is to assess the proposals, identify impacts and effects, determine any additional mitigation necessary (over and above that already included as part of the proposed development and construction methodology), and establish delivery mechanisms and residual impacts.

11.4.46 The assessment covers the time periods set out in para. 11.3.28, including a night-time period assessment where 24-hour working is anticipated. Additionally, at certain sites, a sample “event” period will be assessed. This is relevant only where sites are close to locations where special events generating large movements of people or vehicles are held from time to time. The need for these “event” assessments is being discussed and agreed with TfL and the relevant LHAs through the engagement process.

11.4.47 A development case is being prepared for the operational phase, taking account of any permanent structures or changes to the transport networks and including allowance for occasional maintenance activities at the individual sites. Transport demands in the operational phase are expected to be minimal and not to give rise to effects of any major significance. Detailed quantitative modelling is not expected to be necessary for the operational phase assessment and the position will be discussed and agreed with TfL and the LHAs.

Assessment years - construction phase

11.4.48 The duration and nature of construction activity would vary from site to site and not all sites would experience peak activity at the same time within the overall construction programme.

11.4.49 A future year base case for the assumed peak construction year (representing the year in which project-wide activity is at a maximum) has been created to form a reference point for the assessment of the transport effects of the project during the construction phase. Where peak activity at individual sites, or combinations of adjacent sites, is expected to occur in a different year, this ‘reference’ base case (2019) for the assumed peak construction year will be used as a basis from which to interpret the likely effects in the year of peak activity at the specific location being assessed. This is being done in consultation with TfL and the LHAs.

11.4.50 For site-specific assessments, the period of peak construction activity will be identified based on the anticipated programme and activity levels. Where this represents a relatively short-term peak activity period, this will be adopted for the assessment of effects in the vicinity of that site. Where peak activity is expected to last for a number of months (for instance at main tunnel drive sites) an appropriate assessment year will be identified using knowledge of the existing transport networks, planned future development and/or infrastructure enhancements by others, and discussions with the relevant highway authority and TfL.
11.4.51 The assessment of effects associated with concurrent construction activity at multiple sites (contained in Volume 6), whether at a Borough level or project-wide, adopts an assessment year identified from a review of the cumulative construction activity at the relevant sites, based on the proposed construction programme. For the transport topic, this sometimes requires more than one assessment year to be considered, particularly where project-wide effects are considered.

11.4.52 Transport information will also be provided as an input to assessments under other topic headings, including for example noise and air quality effects, consistent with the assessment years selected for those topic assessments.

**Assessment years - operational phase**

11.4.53 The assessment year for the operational phase is Year 1 of operation by which time all construction work is expected to be complete and any permanent structures and changes to transport routes and networks are expected to be in place.

**Assessment areas**

11.4.54 For each site, the study area has been defined in consultation with the LHA and with TfL. The study areas include access to the sites, immediately adjacent junctions and the highway network on the likely construction traffic routes between each site and the TfL Road Network (TLRN) or Strategic Road Network (SRN). The study areas informed the geographic scope of data collection.

11.4.55 The study areas for each site and for any Borough level assessment are included in the transport sections within Volumes 7-28.

11.4.56 For certain sites or combinations of sites, consideration has also been given to the effects of route diversions that may be required as part of traffic management proposals during construction. This includes diversions for traffic, buses, cyclists and pedestrians. Routes over which these diversions could occur have been included within the assessment.

**Significance criteria**

11.4.57 The significance of potential transport effects will be determined with reference to the guidelines published by IEMA\(^{95}\) and in the DMRB\(^{96}\). The degree of significance is derived from measures of the magnitude / scale of the change and the sensitivity of the receptors affected.

11.4.58 The magnitude, sensitivity and significance definitions are provided in the sections below. These definitions and category levels will be used when assessing both the construction and operational transport-related effects of the project.

**Determining magnitude of impacts**

11.4.59 The IEMA Guidance\(^{95}\) lists a number of transport impacts for consideration in the environmental assessment:

a. severance

b. driver delay
11.4.60 This assessment will consider these IEMA criteria and combine certain aspects of them to produce five impact criteria for the purposes of this assessment. The adopted criteria are:

a. road network delay
b. pedestrian / cycle delay – which also reflects a measure of severance
c. pedestrian amenity – which principally reflects the nature of impacts on pedestrian routes, and thus incorporates indicators of fear and intimidation
d. accidents and safety – which reflects a measure of HGV traffic and pedestrian route issues
e. hazardous loads.

11.4.61 These impacts will be considered in the context of the receptors which they are likely to affect, from those set out in Vol 5 Table 11.4.2. Some impact criteria will affect only certain receptors. For instance:

a. driver delay will primarily affect vehicle users, including emergency vehicles, cyclists and bus users and operators
b. pedestrian delay will affect those on foot and potentially those cycling, where cyclists are using routes such as the Thames Path.

11.4.62 Other impacts, such as those related to safety and hazardous loads, may affect all receptors to a greater or lesser degree.

11.4.63 The IEMA guidance makes it clear that a “... critical feature of environmental assessment is determining whether a given impact is significant.” Furthermore, “for many effects there are no simple rules or formulae which define thresholds of significance and there is, therefore, a need for quantified information whenever possible. Such judgements will include the assessment of the numbers of the people experiencing a change in environmental impact ...”.

11.4.64 The IEMA impact classifications, amended as discussed above, are presented in Vol 5 Table 11.4.1. Whilst a number of these criteria can be dealt with in a quantifiable way, the consideration of the magnitude of the impact is also related to the context of the location in which the impact is identified as occurring. Thus, for instance, smaller changes in traffic flow may have greater impacts in locations where existing traffic flows are lower than in location where flows are already high; similarly additional delays to pedestrians or traffic may be perceived as being of lower magnitude on busier roads where delays can already be expected to be longer than in other locations. An element of professional judgement is therefore also applied.
11.4.65 The table below indicates the selected criteria for determining the magnitude of an impact. These criteria are not specified in the IEMA Guidance\textsuperscript{95} and have been developed for this project based on knowledge of the transport networks and travel activity in the vicinity of construction sites, together with professional judgement on the degree to which certain changes may be considered significant in the context of those conditions.
### Vol 5 Table 11.4.1 Transport – impact magnitude criteria

<table>
<thead>
<tr>
<th>Impact magnitude</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ROAD NETWORK DELAY</strong></td>
<td></td>
</tr>
</tbody>
</table>
| High | Adverse: Increase in average delay to vehicles > 4 minutes at a junction or per km of route being assessed  
Beneficial: Decrease in average delay to vehicles of > 4 minutes at a junction or per km of route being assessed |
| Medium | Adverse: Increase in average delay to vehicles of 2 to 4 minutes at a junction or per km of route being assessed  
Beneficial: Decrease in average delay to vehicles of 2 to 4 minutes at a junction or per km of route being assessed |
| Low | Adverse: Increase in average delay to vehicles of 1 to 2 minutes at a junction or per km of route being assessed  
Beneficial: Decrease in average delay to vehicles of 1 to 2 minutes at a junction or per km of route being assessed |
| Negligible | Change in average delay to vehicles of < 1 minute at a junction or per km of route being assessed |
| **PEDESTRIAN / CYCLE DELAY** | |
| High | Adverse: Increase in average waiting time of > 2 minutes at a crossing; or increase in journey time of > 4 minutes per km on a pedestrian route  
Beneficial: Decrease in average waiting time of > 2 minutes at a crossing; or increase in journey time of > 4 minutes per km on a pedestrian route |
| Medium | Adverse: Increase in average waiting time of 1 to 2 minutes at a crossing; or increase in journey time of 2 to 4 minutes per km on a pedestrian route  
Beneficial: Decrease in average waiting time of 1 to 2 minutes at a crossing; or increase in journey time of 2 to 4 minutes per km on a pedestrian route |
| Low | Adverse: Increase in average waiting time of 0.5 to 1 minute at a crossing; or increase in journey time of 1 to 2 minutes per km on a pedestrian route  
Beneficial: Decrease in average waiting time of 0.5 to 1 minute at a crossing; or increase in journey time of 1 to 2 minutes per km on a pedestrian route |
<table>
<thead>
<tr>
<th>Impact magnitude</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Negligible</td>
<td>Change in average waiting time of (&lt; 0.5) minute at a crossing; or increase in journey time of (&lt; 1) minute per km on a pedestrian route</td>
</tr>
</tbody>
</table>

**PEDESTRIAN AMENITY**

| High             | **Adverse**: Pedestrian routes or footways closed requiring pedestrians to cross road, or narrowed to \(< 2.0\)m in width  
|                 | **Beneficial**: New pedestrian routes, crossings or footways created leading to increased pedestrian space |
| Medium           | **Adverse**: Pedestrian routes or footways closed or diverted without need to cross road, or narrowed to \(< 2.5\)m in width  
|                 | **Beneficial**: Pedestrian routes or footways increased in width to \(> 2.5\)m |
| Low              | **Adverse**: Pedestrian routes or footways require protection but are not diverted and at least \(2.5\)m in width (or unchanged where existing width \(< 2.5\)m)  
|                 | **Beneficial**: Pedestrian routes or footways increased in width by \(> 0.5\)m |
| Negligible       | Pedestrian routes or footways not affected |

**ACCIDENTS AND SAFETY**

| High              | **Adverse**: Pedestrians / cyclists required to make additional road crossings to follow diversion routes; average hourly construction HGV flows \(> 40\) vph two way; carriageway narrowed to \(< 6.5\)m; site access directly onto strategic road  
|                  | **Beneficial**: New controlled pedestrian crossings or cycle facilities provided; carriageway increased in width over existing dimensions; HGV movements associated with existing / previous site uses removed |
| Medium           | **Adverse**: Pedestrians required to cross site access and typical pedestrian flows \(> 240\) pph; average hourly construction HGV flows \(> 20\) vph two way and site access directly onto strategic road  
<p>|                  | <strong>Beneficial</strong>: Pedestrian and/or cycle routes increased in width; site access from strategic road removed after construction; HGV movements associated with existing / previous site uses reduced by (&gt; 50)% |
| Low              | <strong>Adverse</strong>: Pedestrians required to cross site access and typical pedestrian flows (&lt; 240) pph; average hourly construction HGV flows (&gt; 4) vph two way, site access not directly onto strategic road |</p>
<table>
<thead>
<tr>
<th>Impact magnitude</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Beneficial</strong>: Site access removed after construction; HGV movements associated with existing / previous site uses reduced by 0% to 50%</td>
<td></td>
</tr>
<tr>
<td>Negligible</td>
<td>Average hourly construction HGV flows &lt; 4 vph two way; site access not directly onto strategic road; pedestrians required to cross site access and typical pedestrian flows &lt; 120 pph</td>
</tr>
</tbody>
</table>

**HAZARDOUS LOADS**

<table>
<thead>
<tr>
<th>Level</th>
<th>Adverse</th>
<th>Beneficial</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>Average of &gt; 1 hazardous load per week expected</td>
<td>Hazardous loads associated with previous site uses removed completely</td>
</tr>
<tr>
<td>Medium</td>
<td>Average of 1 hazardous load per week expected</td>
<td>Hazardous loads associated with previous site uses removed, post-construction site uses likely to generate less than one hazardous load per month</td>
</tr>
<tr>
<td>Low</td>
<td>Average of 1 hazardous load per month expected</td>
<td>Post-construction situation likely to generate no more than one hazardous load per year on average</td>
</tr>
<tr>
<td>Negligible</td>
<td>No hazardous loads expected</td>
<td></td>
</tr>
</tbody>
</table>
Defining resource value / receptor sensitivity

11.4.66 Having identified the magnitude of impacts, the value/sensitivity of nearby receptors will be identified using the criteria identified in Vol 5 Table 11.4.2.

11.4.67 The Institute of Environmental Management and Assessment (ie, MA) Guidelines for Environmental Assessment identify groups and special interests which should be considered within the Transport Assessment. These are:
   a. people at home and in work places
   b. sensitive groups including children, the elderly and disabled
   c. sensitive locations, eg, hospitals, churches, schools, historical buildings
   d. people walking and cycling
   e. open spaces, recreational sites, shopping areas
   f. sites of ecological / nature conservation value.

11.4.68 Taking these groups into consideration, and in the context of the fact that the greatest impacts from this project are likely to arise from construction activity, typical receptors to be considered in relation to the assessment can be summarised as:
   a. resident occupiers in the surrounding properties
   b. business and workplace occupiers in the surrounding area
   c. pedestrians and cyclists travelling within and through the surrounding area – with particular reference to sensitive pedestrian groups such as children, the elderly and those with mobility impairments
   d. private vehicle users travelling on the highway network in the surrounding area
   e. public transport users (passengers), including bus, taxi, river and rail passengers travelling to, from and through the surrounding area
   f. public transport operators whose operational processes may be affected by changes to services as a consequence of route diversions or changes to journey times
   g. emergency services requiring access within the surrounding area.

11.4.69 Based on the above, the relevant receptors are detailed as part of the baseline assessment for each site and their likely levels of sensitivity identified. The receptor value/sensitivity criteria are shown in Vol 5 Table 11.4.2 and are based on professional judgement of the sensitivity of the different receptors within the context of the transport networks and environment along the route of the Thames Tunnel. The sensitivity of a given type of receptor may vary from location to location depending upon the context of the area under assessment.
Vol 5 Table 11.4.2 Transport – receptor value/sensitivity criteria

<table>
<thead>
<tr>
<th>Receptor value and/or sensitivity</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>Residents living close to construction sites; all emergency services; pedestrians and cyclists using routes immediately adjacent to construction sites; all sensitive pedestrian users (children, elderly, mobility impaired).</td>
</tr>
<tr>
<td>Medium</td>
<td>Business occupiers close to construction sites; residents living close to construction vehicle routes but at a distance from construction sites; private vehicle users on the network adjacent to construction sites; public transport users on services passing construction sites.</td>
</tr>
<tr>
<td>Low</td>
<td>Business occupiers adjacent to construction routes but at a distance from construction sites; private vehicle users on the wider highway network; public transport users on the wider network; public transport operators.</td>
</tr>
</tbody>
</table>

Determining the significance of effects

11.4.70 The significance of transport effects is determined from the combination of the identified impacts and their magnitude with the receptors affected by those impacts and their sensitivity to them.

11.4.71 Professional judgement has been used to identify the criteria for impact magnitude and the sensitivity of receptors. The significance of effects is identified from consideration of the number of impact indicators exhibiting high, medium and low impacts and the number of receptors responding to those impacts.

11.4.72 This approach requires further judgement to be applied, given that there is no specific quantitative guidance available against which the assessment can be set.

11.4.73 Vol 5 Table 11.4.3 sets out a summary of the likely designation of the significance of transport effects when all impact indicators and receptors are combined. Within the Transport Assessment and final ES more detailed matrices will be presented to indicate the results of the assessment in terms of the balance of impacts on receptors and draw out the conclusions on the significance of transport effects in each location and project-wide. The principle of identifying the overall significance of transport effects at a location combining impact magnitude and receptor sensitivity draws on the generic significance matrix provided in Vol 5 Table 2.4.1.

Vol 5 Table 11.4.3 Transport significance of effect criteria

<table>
<thead>
<tr>
<th>Significance of effect</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Major adverse</td>
<td>Assessment showing majority of impacts to be of high adverse magnitude and particularly affecting</td>
</tr>
</tbody>
</table>
### Significance of effect | Description
--- | ---
| **Moderate adverse** | Assessment showing majority of impacts to be of medium adverse magnitude and affecting receptors of all sensitivities |
| **Minor adverse** | Assessment showing majority of impacts to be of low adverse magnitude, with isolated impacts of medium adverse magnitude, and affecting receptors of all sensitivities |
| **Negligible** | Assessment showing majority of impacts to be negligible, with isolated impacts of low adverse or beneficial magnitude, and affecting receptors of all sensitivities |
| **Minor beneficial** | Assessment showing majority of impacts to be of low beneficial magnitude and affecting receptors of all sensitivities |
| **Moderate beneficial** | Assessment showing majority of impacts to be of medium beneficial magnitude and affecting receptors of all sensitivities |
| **Major beneficial** | Assessment showing majority of impacts to be of high beneficial magnitude and particularly affecting receptors of medium and high sensitivity |

### Cumulative and in combination effects

11.4.74 The general approach to assessing cumulative, in combination and compound effects is described in Section 2.

11.4.75 The transport assessment includes committed developments and transport infrastructure proposals within the base cases. These are carried forward into the development cases for the assessment, which is thus inherently cumulative and takes account of the impacts arising from those committed schemes when identifying the significance of effects associated with the project.

11.4.76 It is not expected that effects associated with other environmental topics being considered in the EIA will influence the significance of transport-related effects associated with the project. It is, however, recognised that transport issues may influence other environmental topics including for example noise, vibration and air quality assessments, and the outcomes from the Transport Assessment will be used as inputs to those topics where appropriate.

### Compound and project-wide effects

11.4.77 The scope for the Borough level and project-wide assessment has been agreed with TfL and the LHAs. This includes elements of the TLRN and SRN, together with consideration of other routes forming a key part of the bus, cycling or walking networks. It is primarily concerned with the
impacts arising from a number of construction sites in concurrent operation, and the degree to which these give rise to impacts on the transport networks as a result of diversion of traffic or public transport services over a wider area. The assessment also takes into account all relevant committed developments.

11.4.78 The assessment of Borough level and project-wide effects required more integrated modelling so that the operation of the wider road network can be considered in parallel with the site-specific assessments discussed above.

11.4.79 For Borough level and project-wide assessments, reference will be made where necessary to existing TfL sub-regional models to examine the strategic effects of wider traffic or public transport service diversions. The areas to be examined have been agreed with TfL and the LHAs and include Borough roads and parts of the TLRN likely to be affected by the project. The intention is to provide consistency with other work already undertaken by TfL and consistency across the assessment of Borough level and project-wide effects.

11.4.80 Where possible the assessment will be undertaken using existing TfL or other models as an agreed basis for assessment, allowing potential effects to be identified. If further investigation of effects at particular locations is required, this will be undertaken using the local junction modelling software as part of the process of iteration between the two levels of modelling.

11.4.81 The determination of the significance of effects relating to Borough level and project-wide activity will be undertaken with reference to the impact magnitude and receptor sensitivity criteria identified earlier in Vol 5 Table 11.4.2 and Vol 5 Table 11.4.3.

Assumptions and limitations

Assumptions

11.4.82 The assumptions for the Transport Assessment are:

a. information from TfL sub-regional and local models is acceptable for use in compiling the baseline information, subject to review and agreement of appropriateness with TfL and where necessary the LHAs.

b. baseline information collected during fieldwork in May and June 2011 is considered “current” and acceptable as a basis for developing the future year base and development cases by TfL and other authorities.

c. it is appropriate for the assessment to be based on known committed development and infrastructure proposals, and on planned development and infrastructure proposals included within formal policy and implementation documents at the time the assessment is produced, and that potential developments which do not have this level of certainty are not included in the assessment. The committed developments and infrastructure proposals included in the assessment are set out in Appendix D.
Limitations

11.4.83 Limitations relevant to the assessment include:

a. The availability of data in the wider area. It is impractical to undertake a wholesale area-wide data collection exercise through fieldwork and therefore for the wider area, the assessment will rely upon information available from TfL models, or other modelled sources, for existing and future years.

b. Pedestrian and cycle network impacts will be assessed in the vicinity of individual construction sites, where impacts would be greatest and the assessment does not cover these networks across a wider area except where it is immediately evident that combinations of sites could affect longer-distance walking or cycling activity.

c. The assessment is based on the operation of the transport networks under normal undisrupted day-to-day conditions in the time periods being assessed and does not address 'special event' conditions except where the proximity of a construction site to a venue commonly used for such special events means that assessment is appropriate.

11.5 Approach to mitigation

Construction

11.5.1 The Thames Tunnel project, including the proposals for individual construction sites, has been designed with input from the transport specialists. The design of the proposals already takes account of transport considerations including traffic management proposals around the sites; pedestrian and cycle route diversions; and measures within the draft CoCP.

11.5.2 Where such measures form part of the project, they are identified in Section 3 of Volumes 7-28 and have been considered as embedded environmental design within the assessment and hence incorporated from the outset.

11.5.3 Where the assessment indicates effects of a significance that requires additional mitigation, which are not addressed by the measures already contained within the proposed development, the assessment will identify further mitigation measures that may be necessary to deal with the assessed effects. These may include:

a. additional traffic management measures in the vicinity of sites or on vehicle routes to and from the sites

b. additional pedestrian and cycle diversion routes, wayfinding, safety or other management measures for these users

c. requirements for on-site car parking and for modification to existing on-street parking provision (whether for cars, coaches, service vehicles or taxis) that may be necessary

d. further travel demand management measures for construction personnel to increase the use of sustainable transport modes or to reduce the impact of personnel movements at sensitive times
11.5.4 Proposed mitigation solutions will be developed and discussed with TfL and the LHAs, informed by revised analysis taking account of the mitigation proposals. The agreed mitigation will then be re-assessed to identify residual effects which will be reported in the ES.

**Operation**

11.5.5 Information on the transport proposals for the operational phase, once construction has been completed, is provided to support the operational phase assessments.

11.5.6 Where necessary, any mitigation required on a permanent basis to address movement and access to, from and around the sites in their reinstated post-construction form will be identified.
12 Water resources – groundwater

12.1 Introduction

12.1.1 This section describes the methodology used to assess the impacts and effects on groundwater resources (quantity and quality) from the project. The methodology includes individual site and regional assessment methods. These methods are universally applicable to assessing the effects resulting from the construction and operational phases of the project although the level of detail varies according to the receptor value and sensitivity.

12.1.2 Volume 2 of the PEIR provides the project context. In terms of geology, the tunnel and shafts to be constructed will encounter a range of different geologies from London Clay, a mix of gravel, sand and silty clay to chalk in the east of the city. The two aquifers\textsuperscript{iv} encountered by scheme are the upper aquifer comprising the Alluvium and River Terrace Deposits/gravels, and the lower aquifer comprising the lower part of the Lambeth Group (Upnor Formation), Thanet Sands and the Chalk.

12.1.3 There is potentially some overlap between groundwater and land quality where the presence of contaminated land may have an effect on groundwater if the project creates a pathway. The land quality assessment identifies soil contamination and the measures to be put in place to prevent further pollution of groundwater. The groundwater assessment includes consideration of existing groundwater pollution and the mitigation measures to ensure that the project does not exacerbate the pollution of groundwater bodies.

12.1.4 There is also overlap with flood risk and aquatic ecology. Where there is potential for groundwater flooding as a result of the project, this is of greater significance in surface water flood risk areas. Similarly, potential changes in groundwater levels from dewatering activities may result in more significant effects if there are groundwater dependent ecosystems.

12.2 Scoping Opinions and technical engagement

12.2.1 A summary of scoping and technical engagement undertaken in relation to groundwater is contained in Volume 4, Sections 3.12 and 4.12.

12.3 Baseline data collection methodology

12.3.1 The baseline data collection methodology for the PEIR is outlined in Section 2.

12.3.2 Data sets used for scoping were updated with the latest information available. A full list of data used for scoping is given in Vol 5 Table 12.3.1

\textsuperscript{iv} An aquifer is a permeable strata, either through intergranular and/or fracture permeability and which is capable of supporting water supply and/or river base flow. There are two types of aquifers, principal and secondary aquifer depending on whether these are regionally or locally important.
along with notes to indicate where data sets have been updated for this report.

**Vol 5 Table 12.3.1 Groundwater - desk based baseline data sources**

<table>
<thead>
<tr>
<th>Source</th>
<th>Data</th>
<th>Date received</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>BGS</td>
<td>British Geological Survey (BGS) 1:50,000 scale digital geological data</td>
<td>February 2009</td>
<td></td>
</tr>
<tr>
<td>EA</td>
<td>Licensed groundwater abstraction boreholes and their ownership, purpose</td>
<td>December 2010</td>
<td>Abstraction licence rates, aquifer, and status (active or dormant)</td>
</tr>
<tr>
<td>LBs</td>
<td>Unlicensed groundwater abstraction boreholes and their details from local authorities</td>
<td>June 2009</td>
<td>Contacted 14 LBs along tunnel alignment</td>
</tr>
<tr>
<td>EA</td>
<td>Designated source protection zones</td>
<td>December 2010</td>
<td>Some SPZs* changed during the scoping process</td>
</tr>
<tr>
<td>EA</td>
<td>Groundwater level records for EA observation boreholes</td>
<td>September 2009</td>
<td>Updates received</td>
</tr>
<tr>
<td>EA</td>
<td>Groundwater quality results for EA observation boreholes</td>
<td>June 2009</td>
<td>Updates received</td>
</tr>
<tr>
<td>EA</td>
<td>Ground Source Heat Pump (GSHP) schemes and their details</td>
<td>December 2010</td>
<td>Updates received</td>
</tr>
<tr>
<td>EA</td>
<td>Regional Groundwater Levels in Chalk from 2000 to 2008</td>
<td>December 2010</td>
<td>2009 and 2010</td>
</tr>
<tr>
<td>EA</td>
<td>London Basin Aquifer Conceptual Model (60121R1, June 2010)</td>
<td>December 2010</td>
<td></td>
</tr>
<tr>
<td>Thames Tunnel</td>
<td>Ground Investigation (2009) borehole logs, construction details, monitoring regime and available water level records and water quality results</td>
<td>March 2010</td>
<td></td>
</tr>
</tbody>
</table>

*Source Protection Zones (SPZ)
Field survey baseline data

12.3.3 The aim of monitoring is to provide a comprehensive summary of conditions across all sites, strata and land quality conditions at sites and along the tunnel alignment.

12.3.4 The approach to groundwater quality monitoring was a phased one, with the steps to be taken outlined below:

a. samples to be collected from selected locations and analysed for the full EA suite on one occasion

b. data from this sampling round to be compared with other baseline water quality data from EA water quality monitoring boreholes, Lee Tunnel monitoring boreholes and water supply/abstraction boreholes (if the data is publicly available)

c. define the list of potential pollutants associated with construction, based on chemicals to be used during construction and soils and groundwater analysis at sites

d. recommend and agree (by means of an update to the Groundwater Environmental Monitoring Methodology report) key parameters for baseline monitoring which define the Thanet Sands and Chalk water quality

e. prior to construction, analyse Thanet Sands and Chalk groundwater samples for the agreed parameters which define Chalk water quality, and for potential construction and contaminated land pollutants

f. over the same period, analyse groundwater samples from the superficial deposits for an agreed suite of parameters which includes potential construction and contaminated land pollutants

g. water quality sampling and analysis to be carried out quarterly

h. after one year of sampling, agree baseline conditions and ‘trigger’ and ‘action’ concentrations for key substances

i. agree actions to be taken and mitigation in the event of trigger and action concentrations being exceeded

j. during construction, analyse water samples using the same agreed baseline suites

k. two years prior to operation, start to include substances in the analysis that may be associated with CSO discharges.

12.3.5 Groundwater level monitoring commenced in various scheme GI boreholes in 2009.

12.3.6 Groundwater quality monitoring commenced with sampling pump installation in April 2011. Additional boreholes are proposed in 2011 and level and quality monitoring will be undertaken and used within the EIA.
12.4 **Assessment methodology**

**General**

12.4.1 The identification of potential effects was undertaken by quantifying the impact, assessing the value of the receptor and then using the generic matrix presented in Section 2 (Vol 5 Table 2.4.1) to determine the effect. This approach identifies potential sources, or ‘causes’ of any impacts, in this case from both the construction and operation of the project. It also identifies receptors, in this case groundwater resources that could potentially be affected. However, the presence of a ‘cause’ and a potential receptor does not always infer an effect. For a receptor to be affected by a source, there needs to be a clear mechanism or ‘pathway’. For example, construction activities in the London Clay to the west may be physically close to a groundwater abstraction from the underlying Chalk but with no hydraulic connection, no impact will occur. In contrast, in the east where the Chalk is unconfined, a direct hydraulic connection may exist and potential impacts will be greater.

12.4.2 The first stage of the process was to review all of the potential receptors, ie, the controlled waters, groundwater abstractors and groundwater dependent ecosystems that have the potential to be affected.

12.4.3 The next stage was to identify impacts from both the construction and operation of the project. The construction activities around the individual sites and the tunnel have the potential to affect groundwater. The operation of both the sites and the tunnel are considered in terms of their potential effects on groundwater.

12.4.4 The regional nature of groundwater means that project-wide and cumulative effects are important. For example, dewatering at one site may have consequences for regional groundwater. These aspects are taken into account within conceptual models and by using the principles of superposition.

12.4.5 The Ground Investigations (GI) undertaken in 2009 has recorded depths and thicknesses of geological strata to an accuracy of two decimal places. In comparing these depths top that of the shaft and interception chamber construction depths, it has been necessary to apply a similar of accuracy to all measurements contained within the groundwater sections of the PEIR.

12.4.6 In the case of tunnels, these are included to the nearest 10m.

**Construction and operational effects**

12.4.7 Both construction and operational effects may arise from activities at any of the sites and from the tunnels. The potential effects on groundwater resources (quantity and quality) at the sites may include:

**Potential construction effects**

a. creation of vertical pathways for pollution from contaminated land or groundwater to aquifers or between aquifers/sub-aquifers with different quality groundwater via the shafts
b. physical obstruction to groundwater flow resulting in an increase or lowering of groundwater levels, changing groundwater storage and potentially increasing groundwater flood risk

c. physical disturbance which may cause turbidity in the Chalk aquifer and affect nearby groundwater abstractions

d. temporary lowering of groundwater levels during dewatering or depressurisation or for creating tunnel linkages which may
e. affect groundwater users (for example licensed abstractors or ground source heat pump schemes)
f. cause mobilisation of poor quality water (for example from contaminated sites, saline zones or the Thanet Sands)
g. have an effect on groundwater dependent ecosystems. changes in groundwater quality as a result of the use of concrete, bentonite, grout, oils and greases or accidental spillages
h. removal of tunnel excavated material and temporary storage at drive sites, if contaminated, may have an effect on groundwater quality at the storage location.

12.4.8 The potential effects on groundwater along the route of the main tunnel and connection tunnels during construction are similar to those at the sites and include:

a. creation of a lateral pathway for pollution along the line of the Thames Tunnels (for example by connecting poor quality groundwater with high quality groundwater)

b. physical obstruction to groundwater flow resulting in an increase or lowering of groundwater levels

c. physical disturbance which may cause turbidity in the Chalk aquifer and which may affect nearby groundwater abstractions

d. changes in groundwater quality as a result of the use of construction materials and injection of grout during tunnel boring.

**Operational effects**

12.4.9 The potential effects on groundwater from operations at the sites include:

a. disruption of groundwater flow locally due to the presence of shafts and other underground structures giving rise to groundwater flooding or effects on local groundwater users and dependent ecosystems

b. changes in groundwater quality as a result of leakage or contamination from shafts

c. effect on groundwater resources (quantity) as a result of leakage into the shafts

d. spread of pollution if the shaft creates a pathway from a source of groundwater contamination.

12.4.10 The potential effects on groundwater along the route of the main tunnel and connection tunnels during operation include:
a. changes in groundwater quality as a result of leakage from the tunnels
b. physical obstruction to groundwater flow resulting in an increase or lowering of groundwater levels
c. effect on groundwater resources (quantity) as a result of leakage into the tunnels
d. spread of pollution if the tunnel route creates a pathway from a source of groundwater contamination.

**Assessment cases and years**

**Base case**

12.4.11 The base case for assessment will be a future case, without the project, in any particular assessment year.

12.4.12 The base case conditions are taken to be the same as current baseline conditions. Since groundwater varies in time and space in response to climate and anthropogenic influences, a range of scenarios are included in the site specific base case where appropriate. For example if dewatering was predicted to lower groundwater levels by 3m, the lowest reasonable recent groundwater level is used to define the base case and to assess the effect of dewatering. Conversely, if groundwater flooding is a potential issue, maximum reasonable groundwater levels are considered in the base case.

12.4.13 No changes in the ground water base case are considered likely as a result of proposed major new developments considered to date. The Water Framework Directive and resultant measures may indirectly lead to some improvements in ground water quality and levels across London but this is not guaranteed and is not factored into the future base case for groundwater.

**Development case**

12.4.14 A development case is a future case during either the construction or operation of the project in the same assessment year as the equivalent base case. The assessment typically considers the ‘development case’ compared with the ‘base case’ in any particular assessment year (see below).

**Assessment years**

12.4.15 The development case for groundwater varies depending on the activities which may affect groundwater. The most extreme case is considered; for example, if dewatering is programmed for three years duration, the effects after pumping for three years are considered. This means that there is not necessarily a common assessment year for the groundwater topic across all of the sites.

12.4.16 In defining the reasonable groundwater level base case, professional judgement is used to determine the maxima and minima. This is because groundwater levels in London have changed significantly over the years. For example, the low groundwater levels experienced during the twentieth century are not used as minima as they are not representative of current
conditions; groundwater abstraction licensing is now carefully managed by the Environment Agency and as a result groundwater levels are relatively stable.

12.4.17 There are local influences where groundwater abstractions increase and decrease and cause a change in groundwater levels. Where these are known they are included in the assessments. However, details of actual abstraction rates are not usually in the public domain, so the assessments rely on licensed rates.

12.4.18 There are also significant influences on groundwater levels as a result of construction dewatering schemes. Permits to discharge large quantities of water give some indication of possible abstraction rates.

Assessment areas

12.4.19 The assessment areas for groundwater are not fixed at precise radii from sites or distances away from the tunnel alignment.

12.4.20 The effects on groundwater may extend less or further away depending on the hydrogeological setting and the method of construction taking place. The design includes a large number of environmental design measures to help minimise the extent of any effects.

12.4.21 Groundwater modelling work to be undertaken for the ES will confirm the extent of any effects. In the meantime, the main focus for assessments carried out for the PEIR are as follows:

a. receptors within a 2km radius of a site

b. receptors within 1km radius of the tunnel alignment (this distance is less than for sites as the only dewatering/depressurisation envisaged for the construction of the tunnel will be for the linkages between the connection and main tunnels).

Significance criteria

12.4.22 An assessment of significance is undertaken using the methodology provided in the Web-based Transport Analysis Guidance; specifically the Water Environment Sub-Objective WebTAG Unit 3.3.11v. Although this method was designed for transport projects, it is applicable to, and widely used for, other development types.

12.4.23 Significance of effects are defined as major, moderate or minor (adverse or beneficial), or negligible, and are a function of:

a. magnitude of impact

b. receptor value or sensitivity, as set out in the generic significance matrix in Section 2.

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v The methodology set out in this TAG Unit provides an appraisal framework for taking the outputs of the EIA process and analysing the key information of relevance to the water environment. The guidance provides a method, by which the significance of the identified potential impacts can be appraised consistently by decision makers. It is based on guidance prepared by the EA and builds on the water assessment methodology in Design Manual for Roads and Bridges (DMRB) 11:3:10.
Determining magnitude of impacts

12.4.24 The magnitude of a potential impact is defined, based on the likely loss of the attribute (see Vol 5 Table 12.4.1). The definition of an attribute is ‘a groundwater source (e.g., licensed and unlicensed abstraction, ground source heat pump scheme), a groundwater body or a groundwater-fed habitat’. It is important to consider, at this stage, that potential impacts can be positive as well as negative and it is the purpose of an EIA to highlight the full spectrum of potential effects from a proposed development.

Vol 5 Table 12.4.1 Groundwater impact magnitude criteria

<table>
<thead>
<tr>
<th>Impact magnitude</th>
<th>Definition</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Major</td>
<td>Results in loss of attribute</td>
<td>Pollution of groundwater body. Permanent lowering of groundwater levels</td>
</tr>
<tr>
<td>Moderate</td>
<td>Results in effect on integrity of attribute or loss of part of attribute</td>
<td>Temporary deterioration of groundwater quality Temporary lowering of groundwater levels</td>
</tr>
<tr>
<td>Minor</td>
<td>Results in temporary effect on attribute</td>
<td>Measurable changes in attribute, but of limited size and/or proportion</td>
</tr>
<tr>
<td>Negligible</td>
<td>Results in an effect on attribute but of insufficient magnitude to affect the use/integrity</td>
<td>No significant impact on the economic value of the feature</td>
</tr>
</tbody>
</table>

12.4.25 There is an element of judgment in quantifying impacts. The value of the receptor also has some bearing on this. For example, if there is a deep Chalk borehole with a pump at a depth of 150m and 50m below the water table, drawdown of 2m would have less impact than the same drawdown in a 6m deep gravel borehole. The value of the Chalk borehole may be greater but the impact is less than on the gravel borehole in this example.

12.4.26 Various policies and guidelines are taken into account when quantifying impacts. The EA’s London Groundwater Licensing Policy was produced to restrict further abstraction in areas approaching their sustainable limits. The policy states that new consumptive licences from the Chalk is completely restricted in parts of London, whilst in other parts it is restricted to < 200 m$^3$/d annual average (EA, 2010). A dewatering design which involves dewatering in excess of this amount (without any mitigation) could be assessed as having a major to moderate impact depending on its setting.

12.4.27 Another consideration is whether groundwater levels are drawn down from the Thanet Sands into the Chalk by the dewatering, beyond the managed levels of the Chalk. The concern with this process is that it may lead to
deterioration in water quality within the Chalk. To overcome this potential problem, the EA will try to maintain piezometric heads in the Chalk above the top of Thanet Sands at all times. At Vauxhall Bridge for example recent piezometry shows Chalk heads to be at around -35mOD. The range of future heads which may be acceptable to the EA would be from around -50mOD to -20mOD; plus or minus 15m compared to the current situation.

12.4.28 As part of the management of the London Basin Chalk aquifer, the EA (2010) has stated that future licensing decisions will be subject to local assessments. These assessments may take into account the following:

a. the long-term trend in groundwater levels over the several years in the vicinity of assessment site

b. how the levels at the assessment site compare with base of the London Clay, the aim being to manage abstraction to keep groundwater levels above the Thanet Sands

c. any recent abstraction developments in the vicinity of the assessment area, including any refusals on resources grounds within recent years

d. the proximity of the assessment site to an existing or proposed Artificial Recharge Scheme.

12.4.29 Other considerations include where existing groundwater pollution or land contamination is present. The magnitude of impacts during construction may vary, for example, an existing pollution plume within an aquitard layer above an aquifer could have a greater impact than a small amount of contamination present at the near surface (and which is likely to be remediated in advance of any scheme construction activities taking place on site). The Environment Agency have advised that no ‘historically irreversible polluted groundwater bodies exist in the area relevant to the project.

12.4.30 The Water Framework Directive requirement to achieve ‘good qualitative status’ is a key consideration. Where activities have the potential to cause permanent deterioration or a failure of ‘good’ status of the groundwater body the potential impacts are major. Moderate impacts may arise when a temporary deterioration or failure occurs. Minor impacts are those which cause temporary deterioration that have no long term consequences.

12.4.31 In terms of operational activities, there are potential sub-surface barriers to groundwater. The sub-surface barriers to groundwater flow are different depending on the hydrogeological setting. In the case of the deeper aquifer, flows to a nearby abstraction source may be affected. In the case of the shallow aquifer, a build up of groundwater pressure behind a sub-surface structure may lead to a rise in groundwater levels and the increased potential for groundwater flooding in certain circumstances.

12.4.32 The other operational activity relates to the use of the tunnel to transfer combined sewer discharges to Beckton STW. There is potential for seepage from the sub-surface structures into the surrounding groundwater bodies. However the tunnel will seldom be full and over much of its length...
the operating pressure is less than the Chalk head, so the period of time and the length of tunnel over which seepage is possible are limited.

12.4.33 For the majority of the time the tunnel will be empty so there is potential for inflows. The magnitude of this impact is based on the licensing policy discussed above.

**Defining resource value / receptor sensitivity**

12.4.34 The sensitivity or importance of groundwater (the receptor) is based on its considered value. For example, its value may be as a source of drinking water supplies or as a support to a groundwater dependent ecosystem. The table below provides a generic definition of receptor value and sensitivity criteria.

**Vol 5 Table 12.4.2 Groundwater receptor value/sensitivity criteria**

<table>
<thead>
<tr>
<th>Receptor value and/or sensitivity</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very High</td>
<td>attribute with a very high quality and rarity, regional or national scale and limited potential for substitution</td>
</tr>
<tr>
<td>High</td>
<td>attribute with a high quality and rarity, local scale and limited potential for substitution</td>
</tr>
<tr>
<td>Medium</td>
<td>attribute with a medium quality and rarity, local scale and limited potential for substitution</td>
</tr>
<tr>
<td>Low</td>
<td>attribute with a low quality and rarity, regional or national scale and limited potential for substitution</td>
</tr>
</tbody>
</table>

12.4.35 The approach used for the assessments considers both the groundwater quantity and quality aspects of the receptor.

12.4.36 The factors taken into account in defining the importance of receptors in respect of quantity include its definition according to the EA’s principal aquifer/secondary aquifer/unproductive strata definition. For example, the Chalk aquifer is defined as a principal aquifer and will be given very high/high importance value in the assessments. The upper aquifer is of medium value in this area.

12.4.37 The presence of any abstractions is a combined quality/quantity consideration. Public water supply abstractions will be the largest and most sensitive sources within the Central London area where there is no possibility for substitution. These sources (as defined by the EA’s Source Protection Zone Maps) are given a higher importance than other types of abstractions. Sources licensed for agricultural or industrial uses, are defined as medium importance, although consideration will need to be
given to the size of the abstraction (and its ability to be replaced / substituted if there is an effect on this source). The low importance category is given to smaller abstractions (unlicensed sources and Ground Source Heat Pump (GSHP) schemes). In all cases, a degree of professional judgement is needed to assess the importance of any abstraction sources, but where derogation of a licence could occur the effects are likely to be major or moderate depending on the duration (permanent or temporary) of the effect. An effect on groundwater quality may be more significant than lowering of groundwater levels as it will take longer to reverse any changes.

12.4.38 Across the central London area, there are natural variations in groundwater quality which affects the assessment of importance of the groundwater receptor. Where the aquifer is known to be brackish/saline this reduces the potential use of the groundwater, nonetheless it is still important that the receptor is protected.

12.4.39 Vol 5 Table 12.4.3 (quantity) and Vol 5 Table 12.4.4 (quality) present a summary of some of the criteria used for assessing the importance of groundwater receptor value.
### Vol 5 Table 12.4.3  Groundwater receptor value/sensitivity – quantity criteria

<table>
<thead>
<tr>
<th>Receptor value and/or sensitivity</th>
<th>Quantity</th>
<th>Geological setting</th>
<th>Source Protection Zone</th>
<th>Licensed Abstraction Sources</th>
<th>Unlicensed Abstraction Sources</th>
<th>GSHP Schemes</th>
<th>Groundwater-fed wetlands</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very High</td>
<td>Principal aquifer</td>
<td>Hydraulic connection between upper and lower aquifers, high water table present</td>
<td>Within SPZ 1</td>
<td>Within calculated capture zone and used for drinking water supplies. No alternative source</td>
<td>Within calculated capture zone and used for drinking water supplies. No alternative source</td>
<td>Within calculated capture zone of a currently licensed GSHP scheme. No alternative source</td>
<td>Presence of EU designated site within 1km radius eg, SAC or Ramsar site</td>
</tr>
<tr>
<td>High</td>
<td>Principal aquifer</td>
<td>Separation of upper and lower aquifer aquifers through thin layer of Lambeth Group (LG)</td>
<td>Within SPZ 2</td>
<td>Within calculated capture zone and used for industrial/agric supplies. Alternative source available</td>
<td>Within calculated capture zone and used for industrial/agric supplies. Alternative source available</td>
<td>Within calculated capture zone of a currently licensed GSHP scheme. Alternative source available</td>
<td>Presence of nationally designated site within 1km radius eg, SSSI</td>
</tr>
<tr>
<td>Medium</td>
<td>Secondary aquifer</td>
<td>Separation of upper and lower aquifers through thick layer of LG</td>
<td>Within SPZ 3</td>
<td>Within calculated capture zone but source known to be unused</td>
<td>Within calculated capture zone but source known to be unused</td>
<td>Within calculated capture zone of a proposed GSHP scheme</td>
<td>Presence of locally designated site within 1 km radius</td>
</tr>
<tr>
<td>Receptor value and/or sensitivity</td>
<td>Quantity</td>
<td>Receptor value and/or sensitivity</td>
<td>Quantity</td>
<td>Receptor value and/or sensitivity</td>
<td>Quantity</td>
<td>Receptor value and/or sensitivity</td>
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<td>----------------------------------</td>
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<td>----------------------------------</td>
<td>-------------------</td>
<td>----------------------------------</td>
<td>-------------------</td>
</tr>
<tr>
<td>Low</td>
<td>Unproductive strata</td>
<td>Separation of upper and lower aquifers* by London Clay and LG</td>
<td>Outside any SPZs</td>
<td>Outside any calculated capture zone</td>
<td>Outside any calculated capture zone</td>
<td>Outside any calculated capture of a GSHP scheme</td>
<td>No designated sites within a 1km radius</td>
</tr>
</tbody>
</table>

* Lower aquifer – Upnor Formation, Thanet Sands and the Chalk

Upper aquifer – Alluvium and River Terrace Deposits
Vol 5 Table 12.4.4 Groundwater receptor value/sensitivity – quality criteria

<table>
<thead>
<tr>
<th>Receptor value and/or sensitivity</th>
<th>Quality</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Groundwater quality</td>
</tr>
<tr>
<td>Very high</td>
<td>Freshwater (&lt; 500 ppm)</td>
</tr>
<tr>
<td>High</td>
<td>Freshwater (&lt;1000 ppm)</td>
</tr>
<tr>
<td>Medium</td>
<td>Brackish water (1000-10,000 ppm)</td>
</tr>
<tr>
<td>Low</td>
<td>Historically irreversible polluted groundwater body (none known within study area)</td>
</tr>
</tbody>
</table>

\(^1\) Ref: http://www.engineeringtoolbox.com/water-salinity-d_1251.html

**Determining the significance of effects**

12.4.40 Once the magnitude of an impact is derived (Vol 5 Table 12.4.2), the significance of the potential effect can then be determined, by combining this with the receptor value/sensitivity (Vol 5 Table 12.4.3 and Vol 5 Table 12.4.4), and using the generic significance matrix as set out in Section 2.

12.4.41 In assessing fully the significance of an effect, it is necessary to consider the hydrogeological setting. In the context of lowering groundwater levels, for example, this effect may be of greater or lesser significance depending on whether the lowering of groundwater levels affects the ‘Basal Sands’ (Thanet Sand Formation and Upnor Formation). Where this layer has been dewatered, mobilisation of sulphate and precipitation of iron oxides from solution can occur, leading to a deterioration of groundwater quality. The impacts of dewatering at individual sites will be assessed and added together to give the project-wide impact of dewatering in space and time.

**Project-wide effects**

12.4.42 Groundwater by its nature is susceptible to project-wide effects from activities taking place at a number of sites. Dewatering during construction is an example of an activity that will potentially combine to the increase the lowering of groundwater levels. These effects will be taken
into account using the principles of superposition and numerical modelling where necessary.

12.4.43 The methodology to be used for assessing the dewatering impacts is under development (see Appendix D). The quantified impacts will be combined with detailed information on the receptors, such as the depth of the boreholes and the height of water table above the pump, in order to assess the significance of the predicted effects.

12.4.44 More detailed models of individual sites will also be developed using the SEEPW software. This software has been chosen because it can represent radial groundwater flow around the shafts and has potential to model shaft design features that could provide mitigation, such as the use of a diaphragm wall on the sites where construction is required within the Chalk.

12.4.45 Depending on the initial results from this modelling work, consideration will then be given to using the London Basin Groundwater Model (owned by the EA) to confirm the findings of these simplified models.

12.4.46 Similarly, the assessment of project-wide effects from tunnelling will initially be based on a qualitative approach. Ongoing monitoring of groundwater levels has commenced for the project. A total of 199 boreholes have been constructed within three phases of ground investigation for the Thames Tunnel. Two thirds of these have been land based whilst the other third has been undertaken from jack-up rigs within the River Thames. The boreholes have enabled a detailed analysis of the geology across the project in addition to providing further geotechnical data derived from downhole geophysics, in situ tests and gas and groundwater monitoring installations. A marine geophysical and hydrographic survey has further augmented data from the borehole investigation, in particular when interpolating the geology between boreholes.

12.4.47 Piezometers and standpipes were installed in the project boreholes to monitor groundwater levels in response zones in different formations by means of data loggers and/or manual dips. Groundwater monitoring records from the completion of each borehole to early 2011 were available for the PEIR. Monitoring of groundwater quality continues as part of the Thames Tunnel project monitoring programme and additional boreholes will be installed in 2011. Further information will be presented in the ES.

12.4.48 In addition, the EA has a network of observation monitoring boreholes across London for which records are available dating back to 1963. Long term records were provided up to September 2009 at the time of PEIR preparation.

12.4.49 If necessary, further modelling work may be required to assess the project-wide effects. The seepage from the surrounding geologies along

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vi The superposition principle states that the net response at a given place and time caused by two or more stimuli is the sum of the responses which would have been caused by each stimulus individually.
the tunnel route will be calculated using an analytical solution for water inflow, based on Goodman (1965):

\[ q = \frac{2 \pi K H_0}{2.3 \log(2H_0/R)} \]

Where  
- \( q \) = inflow per unit length  
- \( K \) = hydraulic conductivity  
- \( H_0 \) = Head into tunnel  
- \( R \) = tunnel radius

**Assumptions and limitations**

12.4.50 Assessments completed for the PEIR have been based on largely qualitative principles, i.e., modelling results have not been incorporated into these assessments.

12.4.51 In some instances, ground investigation data is yet to be gathered and the information used has come from the nearest available site. Additional data from boreholes will be available for the final assessment for the later ES.

**12.5 Approach to mitigation**

12.5.1 The measures to be adopted by the project-wide draft Construction CoCP (discussed in Volume 2), and the environmental design measures to prevent pollution and to control discharges, are expected to minimise the effects of the project during construction and operation.

12.5.2 Monitoring of construction and operational effects is part of the environmental design. The type of monitoring will include groundwater levels (for assessing quantity aspects) and groundwater quality (for assessing quality aspects). The monitoring regime would be used to define trigger values following which risk assessment on impacted receptors would be carried out, and actions and mitigation agreed as necessary.

**Construction**

12.5.3 There are environmental measures already in the project design to avoid or minimise effects on groundwater. The tunnel route (and the associated sites) from west to east, traverses the London Clay, the Lambeth Group and the Chalk. Ground conditions change and different construction techniques will therefore be needed.

12.5.4 The general approach for the construction of shafts will be to seal out the upper aquifer, in the west using sheet piles and in the east secant piled walls. In the case of the lower aquifer, the approach will be to reduce flows as much as possible by constructing either a diaphragm wall or sinking caisson structures with buried footings which are jacked into the ground. Where necessary ground treatment will be undertaken to reduce fissure flows.
12.5.5 In the case of the tunnel, different tunnelling techniques will be used to suit geological and hydrogeological conditions. In the east, the Chalk is likely to provide higher flows and to minimise inflows to tunnel in this area it may be necessary to pre-treat the ground.

12.5.6 During the construction phase, where risk assessments are triggered and there is found to be an unacceptable effect, mitigation measures would be adopted.

12.5.7 Typical mitigation solutions for dealing with construction effects may include:
   a. provision of alternative water supply
   b. remediation to prevent spread of pollution
   c. water level management plans for wetlands
   d. drainage to alleviate groundwater flooding
   e. injection or abstraction to control groundwater levels
   f. appropriate design of storage area for settlement of dewatering fluids and excavated material.

**Operational**

12.5.8 The measures to be adopted for mitigating the operational effects will focus on regular maintenance of the tunnel/shaft and long term monitoring of any effects.

12.5.9 Where risk assessments are triggered and there is found to be an unacceptable effect, mitigation measures would be adopted.

12.5.10 The types of mitigation will be along the lines suggested for construction effects (see Section 12.5.7).

12.5.11 The Thames Tunnel and shafts will be subject to a regular programme of maintenance. The schedules are only outline at this stage and will be subject to review, but an indication of the programme is given below:
   a. large scale inspections once every 10 years
   b. small scale inspections on a more regular basis (approximately every 2 years), eg, maintenance of penstocks and electrics.
13 Water resources – surface water

13.1 Introduction

13.1.1 This section sets out the full EIA methodology for the assessment of surface water effects associated with the Thames Tunnel project. Work which has not been fully completed for the PEIR will be completed for the ES and this is noted below and within each site specific assessment volume.

13.1.2 The surface water resources assessment covers the effects of the proposed development on surface water receptors. The scope of the assessment is to:

a. identify the existing water resources baseline conditions
b. identify the future baseline conditions against which the project should be assessed
c. identify the need for potential mitigation measures, which can be used to counteract any identified negative effects
d. identify any residual potential effects with respect to surface water resources potentially affected by the proposed development, during construction and operation.

13.1.3 Effects on surface water resources have been considered in two ways:

a. the effects of the proposed Thames Tunnel scheme on the overall water quality of the Thames Tideway have been considered (Volume 6)
b. the effects of the proposed construction and operation of each of the 22 construction sites have been considered in relation to the water resources in the immediate vicinity of each site.

13.1.4 The impact of the development on flood risk and the effect of flood risk on the development have been included within a separate chapter within the site specific assessments. The assessment methodology for flood risk is contained in Section 14, below.

13.2 Scoping Opinions and technical engagement

13.2.1 A summary of Scoping Opinions and technical engagement undertaken in relation to surface water is contained in Volume 4, Sections 3.13 and 4.13.

13.3 Baseline data collection methodology

13.3.1 Data to support the formulation of a baseline has been collected from three main sources:

a. observed data and data used to determine current condition of the Tideway and other waterbodies relevant to each site in the Thames River Basin Management Plan (RBMP)
b. computational model simulations of the sewer network (including CSO operation) and the water quality conditions of the Thames Tideway.
13.3.2 It was agreed with the EA that baseline water quality in the Thames Tideway and relevant tributaries would be reported based on observed data and computation modelled data, as described below.

**Observed data**

13.3.3 Observed data has been collected from the following sources:

a. an overview of the current water quality in the Tideway (and other relevant tributaries or waterbodies) has been provided based on information given for each waterbody’s current classification in the Thames River Basin Management Plan (RBMP)

b. records of contamination at or adjacent to the proposed working sites as reported in the land quality sections

c. site walkover visits, during which:
   
   i. observations were made as to the surrounding conditions at each of the sites
   
   ii. a brief visual inspection was made of the defences, tributaries and foreshore
   
   iii. photographs were taken.

13.3.4 These data elements have been used to inform the current baseline. Dissolved oxygen levels (taken from Automatic Quality Monitoring Stations [AQMS]) for key rainfall events plotted with half-tide correction to give a representation of dissolved oxygen profile over time along the length of the Thames Tideway will be provided for the full ES, although these have not been included within the PEIR.

**Computation modelling simulations**

13.3.5 Simulations from computational models have been used to categorise the operation of the existing sewer network system and its effect on Thames Tideway water quality conditions. These predict likely base case conditions once other major schemes affecting water quality in the Thames Tideway come into operation. The three models used for the baseline and base case determination are described below.

**Thames Water sewer network models**

13.3.6 Thames Water represents the operation of the sewer network in London through the use of a series of InfoWorks CS hydrodynamic models. Each of the models is able to represent flow and water quality conditions in each of the main network catchments and predict spill frequency, volume and duration from CSOs in response to rainfall events.

13.3.7 These models have been used to describe and define the baseline as follows:

a. To describe the current operation of the CSOs in response to different rainfall events, both in terms of the quantity and quality of the discharged flow. Using a model simulation allows the current operation of the CSOs to be predicted for a range of different rainfall and operational scenarios. The models have therefore been used to
describe the operation of the CSOs for the current baseline for a range of rainfall events.

b. The models have also been used to model the future base case condition used to assess the impact of the project. This base case also includes the impact that predicted changes in population will have on wastewater flows in London’s sewer network and includes the effect of major schemes affecting water quality in the Tideway.

**Water quality model**

13.3.8 WRc developed a Water Quality Model (WQM) called QUESTS, on behalf of the EA and Port of London Authority (PLA), which predicts effects on the Dissolved Oxygen (DO) levels of the Tideway from CSO discharges and STW discharges as well as changes in natural processes. The QUESTS model was used over the course of the previous Thames Tideway Strategic Study (TTSS) whose remit was to identify and develop potential solutions to the CSO discharges and ultimately to improve the water quality of the Thames Tideway and its ecology (see Volume 2 for further discussion of the TTSS).

**Hydrodynamic estuary model**

13.3.9 In conjunction with consultants, the EA have developed a 2-dimensional hydrodynamic model of the Thames Tideway which can be used to predict changes in flow, flow velocities and vectors, and water levels as a result of changes to the hydromorphology of the Tideway and Tideway foreshore.

13.3.10 This model has been used to predict the current and future base case hydrodynamic flow conditions during construction and operation of works required in the foreshore. The results of the modelling have been used in a qualitative assessment of the changes in hydrodynamics in scour and sedimentation of foreshore sediments.

**Additional baseline data collection**

13.3.11 A Scour Screening study produced in February 2011\(^98\), modelled the possible scour effects at the 11 sites where foreshore work was initially proposed within the phase one scheme. Possible scour effects have therefore not yet been assessed for the following new foreshore sites, which may require assessment for the full EIA:

a. Dormay Street
b. Greenwich Pumping Station
c. Kirtling Street
d. Heathwall Pumping Station
e. Carnwath Road Riverside
f. Chambers Wharf.

13.3.12 Further water quality modelling is underway to determine the relative beneficial improvements that would accrue for other water quality improvements such as Biochemical Oxygen Demand (BOD) and Ammoniacal Nitrogen.
13.3.13 These results for baseline and assessment will be available for the ES, but were not available to inform the PEIR.

13.4 **Assessment methodology**

**General**

13.4.1 The methodology used for the assessment of effects on surface water resources and their significance differs slightly from the standard EIA methodology for Water Resources, in that the requirements of the Water Framework Directive (WFD) have also been taken into account.

13.4.2 In the absence of an EIA specific assessment methodology for WFD compliance, an assessment methodology has been derived specifically for the project to assess significance of effect. This is a six-stage process combining the Environment Agency WFD assessment guidance\(^99\) and the Water Environment Sub-Objective WebTAG Unit 3.3.1\(^1\)\(^0\) methodology.

13.4.3 InfoWorks sewer model runs and WQM runs are required from the climate change assessment for the 2080s.

13.4.4 Physical modelling outputs for the impact of some foreshore sites on scour and sedimentation are required to inform the ES. Physical models have been built for the following sites:

a. Victoria Embankment
b. Blackfriars Bridge
c. King Edward Memorial Park

13.4.5 The WQM will be run for a typical rainfall year (1980 water year, defined as the 12 month period ending on the 30\(^{th}\) September 1980) to determine 95 percentile performance for DO, BOD and Ammoniacal Nitrogen. This exercise will allow a comparison of the Tideway under existing conditions and modelled future conditions against the proposed WFD standards over a typical year.

13.4.6 Cumulative effects on a site by site basis will be assessed once key schemes have been identified for the production of the full ES.

**Construction and operational effects**

13.4.7 While some of the impacts of the proposed scheme would be common to both the construction and operational phases, the majority of the impacts and effects would be different for the two phases of the project. Construction and operation are therefore assessed separately, although a common methodology has been followed for these two aspects of the PEIR assessment.

**Assessment cases and years**

13.4.8 The generic assessment cases are described in Section 2. The following section describes the specific approach for surface water receptors.

**Current baseline**

13.4.9 The current baseline is the current condition of the Thames Tideway and related waterbodies in 2011.
Base cases

13.4.10 The base case for assessment will be a future case, without the project, in any particular assessment year.

13.4.11 The Lee Tunnel and the TTQI projects (improvement works at Mogden, Beckton, Crossness, Long Reach and Riverside STWs) will be operational by the time construction commences. Significant improvements in the water quality in the Tideway are anticipated as a result of these projects. The construction base case will therefore be the water quality in the Tideway with the TTQI and Lee Tunnel schemes in place.

13.4.12 Results from modelled simulations of conditions in 2021 (as simulated model runs are only available for 2006 and 2021) with the TTQI and Lee Tunnel in place have therefore been used for the construction base case.

13.4.13 The assessment year for the operational base case is the ‘do nothing’ scenario, in Year 1 of operation (note, the water resources assessment base case is reliant on modelled simulation data which uses population projections predicted to 2021).

13.4.14 Several other major improvements schemes affecting the Thames Tideway are scheduled for completion before Year 1 of operation, namely the Lee Tunnel and the TTQI projects (improvement works at Mogden, Beckton, Crossness, Long Reach and Riverside STWs) which will be operational by the time operation commences. The base case scenario therefore allows for the improvements to be afforded by these schemes as for the base case: construction defined above.

Development case

13.4.15 A development case is a future case during either the construction or operation of the project in the same assessment year as the equivalent base case. The assessment typically considers the ‘development case’ compared with the ‘base case’ in any particular assessment year (see below).

13.4.16 No changes in the surface water base case are considered likely as a result of proposed major new developments, other than the Lee Tunnel and the TTQI upgrades at the five STWs mentioned above. These developments will lead to improvements in water quality and these improvements are included within the future base case in each site specific volume (Volumes 7 to 28) and Volume 6.

Assessment years – construction

13.4.17 The assessment year for the construction base case is the ‘do-nothing’ scenario, in construction Year 1.

Assessment years – operation

13.4.18 The assessment year for the operation development case is the first year of Thames Tunnel operation. This allows for the various major Tideway improvements schemes planned for completion before this date (note, the water resources assessment base case is reliant on modelled simulation data which uses population projections predicted to 2021).
Further assessment years: climate change

13.4.19 In order to account for future impacts of climate change, the surface water assessments for the ES will also include assessment of the base case and development case in the 2080s.

13.4.20 At the time of production of the PEIR, work was underway to define the changes in rainfall, river temperature and river flow that may accrue by the 2080s as a result of the latest United Kingdom Climate Projections (UKCP09) for how the climate is predicted to change as issued by the United Kingdom Climate Impact Programme (UKCIP).

13.4.21 Changes in rainfall patterns, river temperatures and river flow by the 2080s are predicted to have an effect on the water quality conditions of the Thames Tideway against which the performance of the Thames Tunnel project should be assessed.

13.4.22 The work will define how input parameters to the InfoWorks models and WQM need to be changed to account for the effects of climate change, and subsequent modelling work will be undertaken with the changed parameters to assess the future performance of the project against the future case without it in place. These results were not available to inform the PEIR, but will be available to inform the ES.

Assessment areas

Site specific

13.4.23 Surface waterbodies within the study area are classified under the WFD, which assigns a status to each waterbody depending on the following factors:

a. ecological status is recorded on a scale of high, good, moderate, poor or bad, where ‘high’ represents ‘largely undisturbed conditions’

b. chemical status is assessed from compliance with environmental standards for chemicals that are priority substances and or priority hazardous substances, recorded as ‘good’ or ‘fail’.

13.4.24 There are seven waterbodies classified under the WFD relevant to the project, as shown in the table below. The current and future predicted status of these waterbodies is shown in the table below.

Vol 5 Table 13.4.1 Surface waterbodies classified by WFD

<table>
<thead>
<tr>
<th>Water body name/ID</th>
<th>Hydromorphological status</th>
<th>Current ecological quality</th>
<th>Current chemical quality</th>
<th>2015 predicted ecological quality</th>
<th>2015 predicted chemical quality</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thames Upper</td>
<td>Heavily modified</td>
<td>Moderate potential</td>
<td>Good</td>
<td>Moderate potential</td>
<td>Good</td>
</tr>
<tr>
<td>GB530603911403</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thames Middle</td>
<td>Heavily modified</td>
<td>Moderate potential</td>
<td>Fail</td>
<td>Moderate potential</td>
<td>Fail</td>
</tr>
<tr>
<td>GB530603911402</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thames Lower</td>
<td>Heavily modified</td>
<td>Moderate potential</td>
<td>Fail</td>
<td>Moderate potential</td>
<td>Fail</td>
</tr>
<tr>
<td>GB530603911401</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
In addition to the WFD classified waterbodies listed above, there are other smaller waterbodies that are not designated within the classification, as follows:

a. Bell Lane Creek
b. the lake in King George’s Park
c. the wetland centre at Barnes, adjacent to Barn Elms.

There are a number of connected conservation sites within the project area, designated under national legislation (Sites of Special Scientific Interest) and local policy (Local Nature Reserves, Sites of Importance for Nature Conservation, etc). There are however no sites designated under European or international legislation (SACs, SPAs or Ramsar sites) within the project area. As with the waterbody assessment above, not all of the designated sites within the study area have been assessed. An initial screening exercise has limited the number of sites to be considered to those which are water dependent and have the potential to be hydraulically linked to the proposed scheme. The dilution factor of the Tideway has also been considered to be relevant to the effects on designated conservation sites from the individual site works and therefore only hydraulically linked water dependent sites within 2km of each of the sites will be considered (ie, a site 2km downstream on the same waterbody would be considered but a site 2.5km away which does not lie on a linked waterbody would not be assessed).

**Project-wide area assessment**

The primary objective of the Thames Tunnel is to capture discharges from CSOs into the River Thames in order to meet the requirements of the EU Urban Waste Water Treatment Directive (UWWTD) and the related UK
Urban Waste Water Treatment Regulations. Should nothing be done to address the current situation, continuing population growth and incremental increases to impermeable areas are expected to increase the volume and frequency of discharges to the river. Such increased discharges will have associated increased adverse environmental impacts.

13.4.28 The River Basin Management Plan for the River Thames, published in December 2009, states that the London Tideway Tunnels “represent the primary measures to address point source pollution from the sewer system and are fundamental to the achievement of good status in this catchment” (Estuaries and Coastal Waters Catchment). The Thames Tunnel is therefore required to help to achieve compliance with the WFD as well as with the UWWTD.

13.4.29 The surface water assessment therefore covers the assessment of the significance of beneficial effects that would accrue to the Thames Tideway as a whole as a result of the project.

**Definition of WFD environmental objectives**

13.4.30 The environmental objectives are defined in Article 4, the core article, of WFD. The aim is long-term sustainable water management based on a high level of protection of the aquatic environment. These objectives are used for the assessment of all waterbodies, including those listed above as not being classified under the WFD.

13.4.31 The environmental objectives for surface waters, as taken from Article 4 of the WFD are presented in the table below:

<table>
<thead>
<tr>
<th>Objective</th>
<th>WFD reference article</th>
<th>Objective description</th>
</tr>
</thead>
<tbody>
<tr>
<td>WFD1</td>
<td>4.1 (a) (i)</td>
<td>Prevent deterioration of the status of all bodies of surface water</td>
</tr>
<tr>
<td>WFD2</td>
<td>4.1 (a) (ii)</td>
<td>Protect, enhance and restore all bodies of surface water, with the aim of achieving good surface water status by 2015</td>
</tr>
<tr>
<td>WFD3</td>
<td>4.1 (a) (iii)</td>
<td>Protect and enhance all artificial and heavily modified bodies of water, with the aim of achieving good ecological potential and good surface water chemical status by 2015</td>
</tr>
<tr>
<td>WFD4</td>
<td>4.1 (a) (iv)</td>
<td>Reduce pollution from priority substances and cease or phase out emissions, discharges and losses of priority hazardous substances</td>
</tr>
</tbody>
</table>

**Identification of surface water receptors**

13.4.32 The surface waterbodies within or adjacent to the study area that have the potential to be affected by the proposed scheme are then identified. Whilst the project-wide assessment considers the Tideway as single receptor, the assessment of effects at the 22 individual sites only assesses the impacts local to the proposed site.
Identification of impacts

13.4.33 The identification of potential impacts and the effects that these could have on surface water receptors has been carried out separately for the construction and operational phases of the proposed development. The same methodology has been used for both of these phases of the project, but using different base case years, as identified above.

13.4.34 All potential impacts have been identified using the Source Pathway Receptor model (S-P-R), whereby the source of impact is identified, followed by potential impact or pollution pathways and the surface water receptors that are likely to be affected.

13.4.35 As described, computational modelling scenarios have been used to predict future conditions and effects. These models have also been used to:

- predict project-wide (Tideway wide) beneficial effects on water quality, litter reduction, and amenity value
- predict changes in pollutant loading to the Tideway from the capture and interception of CSO discharges at the location of discharge (site specific)
- predict changes in discharged volumes, durations and frequency from the capture and interception of CSO discharges and the inferred effect on reduced discharge of sewage derived litter and pathogens
- predict changes in velocity, and hence scour and sedimentation of the foreshore sediments as a result of foreshore construction.

Impact assessment

13.4.36 The impact assessment then assesses whether the impacts would prevent or assist with the WFD environmental objectives being achieved. This includes an assessment of the duration and (if relevant) the reversibility of the effect.

13.4.37 Effects that do not impact on the WFD objectives specifically are also assessed for significance at a more local scale or against other legislative drivers.

Significance of effect

13.4.38 The predicted effects have then been assessed for their significance based on the following seven point scale:

- major adverse: the effects (even after mitigation) would prevent objective WFD1 being met, resulting in a deterioration of waterbody status; or would prevent objectives WFD2 and WFD3 being met resulting in a waterbody being prevented from achieving the minimum required status of ‘good’ (or ‘good potential’); or would prevent other legislative drivers being met
- moderate adverse: effects would not affect long term status of a waterbody under the WFD; but the effects of the project may be judged to be important at a local scale (i.e., in the local planning context), or prevent WFD4 from being achieved
c. minor adverse: effects that are of low importance in the decision making process and are reversible

d. negligible: effects that are below normal levels of perception

e. minor beneficial: improvements which are of low importance in the decision making process

f. moderate beneficial: positive effects of the project are unlikely to move a waterbody to a higher status but may be judged to be locally important

g. major beneficial: positive effects of the project are likely to result in ‘good status/potential’ being achieved; or, would allow future attainment of good status in combination with improvements required elsewhere; or would allow other legislative targets to be met.

Cumulative, in combination and compound effects

13.4.39 The assessment of cumulative, in combination and compound effects is underway but not suitably advanced for consideration in this report. The ES will include full details of the assessment outcomes.

13.4.40 The general approach to assessing cumulative, in combination and compound effects is described in Section 2.

13.4.41 The project-wide-cumulative effects of water quality improvements will be assessed as part of the overall water quality improvements; the methodology for this assessment is given below.

Project-wide effects

13.4.42 As discussed, the project will lead to improvements in the water quality, ecology, amenity and visual appearance of the Tideway and the beneficial effects that these improvements will generate have been assessed on a project-wide basis for the entire Tideway.

Improvements to DO

13.4.43 DO standards for the Thames Tideway were defined through the TTSS and are shown in the table below and explained in the subsequent text.

Vol 5 Table 13.4.3 Surface water objectives defined by the TTSS

<table>
<thead>
<tr>
<th>Threshold</th>
<th>Dissolved oxygen (mg/l)</th>
<th>Return period (years)</th>
<th>Duration (tides)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>4</td>
<td>1</td>
<td>29</td>
</tr>
<tr>
<td>2</td>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>3</td>
<td>2</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>4</td>
<td>1.5</td>
<td>n/a</td>
<td>1</td>
</tr>
</tbody>
</table>

* The objectives apply to any continuous length of river >3km. Duration means that the DO must not fall below the limit for more than the stated number of tides. A tide is a single ebb or flood. Compliance will be assessed using the network of AQMS stations.
a. Threshold 1 - the DO level in the Tideway must not fall below 4 mg/l for longer than 29 consecutive tides (approximately equal to 1 week) on more than one occasion per year.

b. Threshold 2 - the DO level in the Tideway must not fall below 3 mg/l for longer than 3 consecutive tides on more than one occasion every 3 years.

c. Threshold 3 - the DO level in the Tideway must not fall below 2 mg/l for longer than 1 tide on more than one occasion every 5 years.

d. Threshold 4 - the DO level in the Tideway must not fall below 1.5 mg/l for longer than 1 tide on more than one occasion every 10 years.

13.4.44 For all scenarios tested, the biggest summer rainfall events over a period of 40 years were modelled and each scenario subsequently tested for compliance against the DO standards. After each modelled rainfall event (over 100 in total) the modelled results were analysed for each scenario to determine whether the above DO thresholds had been breached and for how long. When all 40 years of data are considered, the return periods for each DO standard give rise to an ‘allowable failures’ figure, as follows:

a. Threshold 1 has a return period of once a year, which means that Tideway can fall below 4 mg/l for longer than 29 consecutive tides only once in each year; over 34 years of modelled data this results in an allowable number of 34 failures of this DO threshold.

b. Threshold 2 has a return period of once every 3 years, which means that Tideway can fall below 3 mg/l for longer than 3 consecutive tides only once every 3 years; over 34 years of modelled data this results in an allowable number of 11 failures of this DO threshold.

c. Threshold 3 has a return period of once every 5 years, which means that Tideway can fall below 2 mg/l for longer than 1 consecutive tide only once every 5 years; over 34 years of modelled data this results in an allowable number of 6 failures of this DO threshold.

d. Threshold 4 does not have a return period and hence does not have a number of allowable failures. This threshold level was taken from the extensive laboratory and field fishery studies undertaken for the TTSS which determined that 1.5 mg/l was the absolute level at which DO levels must be maintained in order to prevent adverse impact on the sustainability of fish populations in the Tideway.

13.4.45 As well as the full suite of 40 years of modelled rainfall events, the WQM was also used to simulate a full year of time series analysis with daily rainfall inputs used in the model. A typical year was selected by taking a single year (1980 water year) from the 40 years of data.

13.4.46 The development scenario has been assessed using the WQM against the base case scenario for these DO standards.
Assumptions and limitations

Assumptions

13.4.47 It has been assumed that the Lee Tunnel and STW upgrade schemes will be in place and fully operational by Year 1 of construction to form part of the future base case and development cases used for assessment of both the construction and operation effects.

Limitations

13.4.48 Full results from project ground investigations were not available at the time of compiling the assessments within this report so assessment of contamination risk from works on the foreshore and from intrusive ground works at the site have relied on existing records of contamination (see also Section 7).

13.4.49 The assessment of impact of foreshore works on scour and sedimentation of foreshore sediment has made use of preliminary 2-dimensional hydrodynamic modelling undertaken in support of the project design and EIA. At the time of compiling the PEIR, this computational modelling work was being supported by the construction of physical models of foreshore works at key sites; however, outputs from the physical model were not available to inform the surface water assessment.

13.4.50 The hydrodynamic 2-D model has been used to model the effect of velocity changes and resultant scour at sites where the effect is likely to be greatest. The possible effects of scour and sedimentation from foreshore sites have therefore been inferred for other sites for assessment purposes.

13.4.51 Definition of Tideway conditions and CSO operation during the future base cases and development cases are reliant on model simulations. All model simulations are only a representation of the future conditions and have degrees of error that must be considered. In particular, the WQM was designed specifically to allow a comparative assessment of solutions and future conditions and does not provide an exact prediction of the future conditions. It does however allow an accurate assessment of relative differences between scenarios and is considered by the EA to be ‘fit for this purpose’ as determined during the TTSS and as reported in the Needs Case report.

13.4.52 Future climate change simulations have not been completed as yet, therefore the impact of climate change on the beneficial impacts of the project will not be available until the full ES is completed.

13.4.53 The assessment of the beneficial effect of a reduction in sewage derived litter and pathogens discharged to the Tideway has been inferred from InfoWorks modelling results of the reduction in discharge volume, frequency and duration and have not been directly modelled.

13.5 Approach to mitigation

Construction

13.5.1 The majority of the potential effects on surface water receptors are likely to be mitigated through measures identified in the CoCP. The CoCP
measures are summarized in Volume 2. The assessment of project effects assumes these measures are in place.

13.5.2 However, there are likely to be some site specific mitigation measures for sites or activities that are particularly high risk. These have been identified as part of each site specific assessment volumes and the resultant change to any identified effects on surface water receptors has been discussed.

**Operation**

13.5.3 The operational effects would be generally beneficial although if there are any requirements for site specific mitigation (eg, permanent scour).
14 Water resources – flood risk

14.1 Introduction

14.1.1 A Flood Risk Assessment (FRA) has been prepared in accordance with the requirements of Planning Policy Statement 25: Development and Flood Risk (PPS25)\textsuperscript{101} covering effects of construction and operation, at all sites within the project and cumulatively across the project on the Thames Tideway. This assessment makes use of the PPS25 Practice Guide\textsuperscript{102} document and is consistent with the outputs and findings of the Thames Estuary 2100 (TE2100)\textsuperscript{103} study and the policy requirements of the London Plan\textsuperscript{104}. Borough specific documents have been reviewed in addition to other relevant flood risk planning, policy and legislative documents.

14.1.2 There are three levels of FRA; Development and Flood Risk – Guidance for the Construction Industry\textsuperscript{105} defines these three levels. PPS25 cites this process as a useful tool in ensuring a FRA is fit for purpose. The three levels of FRA are defined in the table below.
### Vol 5 Table 14.1.1 Flood risk - levels of FRA

<table>
<thead>
<tr>
<th>Level of FRA</th>
<th>Description of Report Content</th>
</tr>
</thead>
</table>
| Level 1      | Identification of any flooding or surface water management issues related to the development of the site that may need further investigation. Should be based on readily available existing information, including:  
  - SFRA,  
  - Environment Agency Flood Maps,  
  - Standing Advice  
  This Level will identify whether a FRA is required. |
| Level 2      | Produced if the Level 1 FRA identifies the site may lie within an area at risk of flooding or development of the site may increase flood risk due to increased runoff. Report will confirm sources of flooding which may affect the site. Study will include:  
  - Appraisal of available and adequacy of existing information  
  - Qualitative appraisal of the flood risk posed to the site, the potential impact of the development on flood risk on and off the site  
  - An appraisal of the scope of possible measures to reduce the flood risk to acceptable levels  
  This Level may identify that sufficient quantitative information is already available to complete a FRA appropriate to the scale and nature of the development. |
| Level 3      | Undertaken if the Level 2 FRA concludes that further quantitative analysis is required in order to assess flood risk issues related to the development site. This Level should include:  
  - Quantitative appraisal of the potential flood risk to the development  
  - Quantitative appraisal of the potential impact of development on the site under investigation on flood risk on and off the site  
  Quantitative demonstration of the effectiveness of any proposed mitigation measures |
14.1.3 The PEIR includes Level 1 FRAs of each site. This Level of FRA ensures all available information is collected and the flood risk to the project as a whole and to individual sites is assessed. This will inform the development of the project and the design of individual sites.

14.1.4 Flooding from all sources both to the sites and as a result of the sites’ development, and the project as a whole taking into account cumulative impacts, has been investigated within the relevant Part of all levels of the FRA and suitable flood management and mitigation suggested where applicable. Where flood risk is related to other environmental considerations such as water resources, these relationships are explored. Consequently, flood risk should be read in conjunction with other specialisms such as surface water discussed within the PEIR.

14.1.5 In due course a Level 2 FRA will be prepared for each location and a level 3 FRA as appropriate. A project-wide assessment of flood risk will also be completed. These documents will form part of the ES.

14.1.6 The FRA follows the standard format of an FRA and therefore this FRA methodology section does not follow the format of all of the other topic methodology sections.

14.1.7 The table below identifies where within this report the different parts of the FRA have been reported.

<table>
<thead>
<tr>
<th>FRA Part</th>
<th>Title</th>
<th>PEIR section</th>
<th>Ref</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Common sections relevant to all sites</td>
<td>Volume 5 Assessment Methodology</td>
<td>Vol 5 Section 13</td>
</tr>
<tr>
<td>B</td>
<td>Project-wide section</td>
<td>Volume 6 Project-wide effects</td>
<td>Vol 6 Section 15</td>
</tr>
<tr>
<td>C</td>
<td>Individual technical sections for every site where flood risk is considered as an issue, organised according to LB</td>
<td>Volumes 7-28 Site Assessments</td>
<td>Vol 7-28 Section 15</td>
</tr>
<tr>
<td>D</td>
<td>Conclusions section</td>
<td>Volumes 7-28 Site assessments and Volume 6 project-wide effects as appropriate</td>
<td>Vol 7-28 Section 15 and Vol 6 Section 15</td>
</tr>
</tbody>
</table>

14.1.8 Typically within an EIA, the significance of a potential effect is determined by assessing the magnitude of an impact against the vulnerability or sensitivity of a receptor. This process results in a series of effects being identified for each topic as, for example, an “adverse effect of minor significance”.

14.1.9 However, due to the nature of flood risk assessment, the term “magnitude of impact” is not appropriate as the assessment is concerned with the probability of an event occurring, as a result of the proposed development.
rather than a direct change in baseline conditions. Therefore, the potential severity of the flood risk effect is determined by:

a. considering a combination of the type of flood source
b. the flood mechanisms identified
c. the layout and design of the proposed receptor
d. the vulnerability of the proposed receptor.

14.1.10 For this reason the format of the “Water resources – flood risk” sections of the PEIR differ slightly from the other topic assessments as they do not use the terms magnitude of impact or significance of effect, but instead consider the “potential severity of the flood risk effect”.

14.2 Scoping Opinions and technical engagement

14.2.1 A Technical Working Group has been established with the Environment Agency (EA). It has also been important to engage with the EA in relation to the 2D hydrodynamic modelling and physical modelling undertaken to support this project in respect to flood risk (as well as aquatic ecology). The EA has been invited to comment on this work and attend a visit to view the physical model and discuss the 2D model and findings.

14.2.2 Engagement has also been undertaken between the project and Local authorities (LA’s) since under the Flood and Water Management Act, Lead Local Flood Authorities (i.e., each LB) have a responsibility to develop strategies for local flood risk management. The LA will also have a requirement to undertake the recommendations of TE2100.

14.2.3 Engagement with the LA’s has been in the form of a Flood Risk Forum where the project (site specific and as a whole) has been discussed in specific relation to Flood Risk (first Forum was 7th June 2011). The EA were also in attendance at this Forum. It is intended that the Forum, which will meet on an occasional basis, will allow engagement with Local authorities throughout the project.

14.2.4 A Flood Risk Scoping Report was prepared as part of the scoping stage of the project. This purpose of the report was to outline the proposed scope for future flood risk work to accompany the Thames Tunnel Development Consent Order. This document was intended to enable stakeholders to comment on the proposed approach to Flood Risk for the project.

14.2.5 The Flood Risk Scoping Report was issued to the EA and the LAs for informal comment in March 2011. Comments were received from April onwards and where appropriate have been addressed in the FRAs contained within the PEIR.


14.3 Baseline data collection methodology

Desk based baseline data

14.3.1 Baseline data was obtained for a number of different locations to identify the flood risks from all flood sources. As this initial stage is a Level 1 FRA
the assessment of flood risk is desk based on existing and available information (ie, secondary research where data has been collected from existing research/projects). Further work following this report may require the production of primary data through modelling which will be included within relevant Level 2/3 FRAs undertaken as later stage in the EIA process.

14.3.2 The EA have been the principal source of data (see the table below).

Vol 5 Table 14.3.1 Flood risk desk based baseline data sources

<table>
<thead>
<tr>
<th>Source</th>
<th>Data</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>EA</td>
<td>Data relating to all relevant rivers to the project (River Thames, Beverley Brook, River Wandle, River Lee, River Roding and River Ravensbourne/Deptford Creek)</td>
<td>Flood depth (node levels and depth grids) for all return periods including functional floodplain information</td>
</tr>
<tr>
<td></td>
<td>Flood defence information throughout the project study area</td>
<td>Drawings, flood defence standards, required defence standards, condition reports, NFCDD, flood defence improvements</td>
</tr>
<tr>
<td>EA Flood Zone information</td>
<td>Outlines for all modelled return periods</td>
<td></td>
</tr>
<tr>
<td>Historical flooding records</td>
<td></td>
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<tr>
<td>HR Wallingford</td>
<td>2D Hydrodynamic modelling of the River Thames</td>
<td></td>
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<tr>
<td></td>
<td>Physical modelling of specific sites within the Tideway</td>
<td></td>
</tr>
<tr>
<td>Thames Tideway</td>
<td>Survey data and other topographic data (DTM or LiDAR)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Preferred site details</td>
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</tbody>
</table>

14.3.3 Policy documents have been obtained from available data sources including the internet and the EA. The following provides a brief commentary on the data received within time to be utilised within the Level 1 FRAs reported within the PEIR.

Fluvial/tidal data

14.3.4 Hydraulic models enable the estimation of accurate floodplain extents and flood depths based on detailed topographic data of river channels including structures (bridges, culverts etc), flood defences and surrounding...
floodplain land. The floodplain extents are then compiled using rigorously developed statistically derived flow estimates. Hydraulic models have been developed for a number of watercourses within the study area by the EA. The following sections describe the available data and models for each river that have been used within the FRAs:

**River Thames**

14.3.5 River Thames information from the modelling study Tidal Thames Joint Probability Extreme Water Levels 2008 has been provided for the project in the form of model node locations and water levels.

14.3.6 The aforementioned modelling study makes use of a 2-D joint-probability computer hydraulic model. The joint-probability aspect of the model considers the confluence of different factors such as astronomical tides, tide surge and river flows have been taken into account. In summary, the calculation of extreme water levels involves two main stages:

   a. Estimating a matrix of water levels at various locations (or model nodes) along the estuary

   b. Calculating the statistical frequency (probabilities) with which a particular water level might be expected to occur at each of the model nodes.

14.3.7 This study modelled water levels to various Annual Exceedance Probabilities (AEP)s - 10%, 5%, 2%, 1%, 0.5%, 0.2% and 0.1%. Each of these probabilities have been modelled for present day (2005) and future years (2055 and 2107) with and without the Thames Barrier in place, taking into account Defra’s climate change allowances as set out in PPS25.

14.3.8 Some levels are lower for the more extreme probabilities when including climate change for the Thames Barrier operational scenario. This is because the hydraulic model takes into account the Thames Barrier closure rule (circumstances/conditions of closure) and assumes that it remains unchanged up to 2107. Increases in sea levels and fresh water flow means that the Thames Barrier closure rule will be met more often and a smaller number of tides will be allowed to flow up into central London each year. The highest tides experienced upstream of the Thames Barrier occur when the circumstances are within a fine margin of meeting the closure rule, and the decision is taken not to close (a near closure event). As there will be fewer tides per year upstream of the Barrier, and the ratio of near closure levels to regular tidal levels within this smaller number of tides remains constant, the number of near closure events will decrease, and therefore so do the modelled levels.

14.3.9 The model has also been run for the scenario where the Thames Barrier is absent to investigate the levels in the Thames in the absence of this flow control structure. The EA has requested that additional modelling of high fluvial flows at Teddington with the barrier open is undertaken.

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vii The Thames Barrier operation is based on the exceedence of combinations of high water levels at Southend-on-Sea and fluvial flows measured at Kingston. The decision to close the barrier is however human so closures are often carried out at lower levels than specified.
14.3.10 The EA have also commissioned a study to investigate the impact of multiple breaches in the Thames Tidal Defences along the River Thames from Teddington in the west to Purfleet in the East. The breach locations have been determined based on the interrogation of LiDAR to highlight low areas behind defences, classified as ‘critical locations’. Following this investigation, 110 critical breach locations were identified.

14.3.11 The modelling was undertaken in Tuflow on a 5m grid. The Tidal Thames Joint Probability Extreme Water Levels 2008 study was used to determine water levels within the Thames. As such, a ‘current day’ scenario was set to 2005 and was run for the 0.5% AEP event. Some models were run for the 0.5% AEP event for the year 2107. This work is currently under review with the target release in three months (mid summer 2011). All models and model results will be available post review.

**Beverley Brook**

14.3.12 The Beverley Brook and tributaries was modelled in 2008 using ISIS-TUFLOW (10m grid) (1D-2D linked modelling) software. The most up to date information available, from all sources, was also used in this exercise.

14.3.13 The model was run for the 20%, 5%, 2%, 1%, 1% + 20% for climate change and 0.1% AEP events with defences and the 1% and 0.2% AEP events without defences present. Outputs were in the form of flood outlines (20%, 5%, 1%, 1% + 20% for climate change defended and 1% undefended AEP events (0.1% AEP event was unstable)), water level, flow, velocity and depth data, and areas benefiting from defences.

14.3.14 Mean High Water Spring tide curve has been used for the downstream boundary condition. The rainfall-runoff approach of the Flood Estimation Handbook (FEH) was used to determine the sub-catchment inflow hydrographs.

14.3.15 The main outfall of the Beverley Brook into the River Thames is via Ashlone Wharf tidal flap gates. There are also two flood relief culverts: White Hart Lane and Elm Bank, which drain the river into the Thames. These discharges are influenced by tidal conditions on the River Thames.

14.3.16 The outputs of the modelling were produced to improve flood warning and planning, improve defence planning and maintenance, upgrade the EA flood maps, and for development planning purposes.

14.3.17 The model simulates fluvial flooding only, other contributions such as groundwater or surface water have not been included.

**River Wandle**

14.3.18 A modelling study of the River Wandle was carried out to improve flood mapping within the catchment. This in turn was needed for: emergency planning, development control and flood warning purposes.

14.3.19 An ISIS-TUFLOW model was developed, linking the 1D channel to the 2D floodplain. The existing ISIS portion of the model was reviewed thoroughly for erroneous data and updated/ re-schematised with new
survey data of both channels and structures. Norbury Brook and the River Graveny have been improved considerably using improved survey data.

14.3.20 The model hydrology (FRQSIM (Flood REeQuency SIMulation) method) was updated where necessary to make the method more robust. The downstream boundary has a tidal peak of 4mAOD that coincides with the fluvial peak.

14.3.21 The model was run for the 20%, 5%, 2%, 1%, 1% + 20% for climate change, and 0.1% AEP events for the defended scenario, and the 1% and 0.1% AEP events for the undefended scenario. Flood maps, outlines, peak water levels and flows, grid data for flood depths, flows, velocities and hazards, and areas benefiting from defences were produced, and hazard mapping from the above outputs.

14.3.22 There were instabilities within the 0.1% AEP event. As such, this is not as accurate as the other return period events.

River Lee

14.3.23 The River Lee was modelled as part of the Lower Lee Valley SFRA (Capita Symonds, 2005) using the ESTRY TUFLOW Model (1D – 2D linked hydrodynamic model) from Lea Bridge Road down to the confluence with the River Thames.

14.3.24 The TUFLOW model represents the whole floodplain within 2D domains, providing a more accurate representation of the flood behaviour. The topography of the 2D domain was based on data from a LiDAR ground survey, and the channel is represented through a series of 1D cross sections and structures.

14.3.25 Flood depth and flood extents were produced from the 1D – 2D flood modelling of the Lower River Lee. The following AEP scenarios were modelled: 1% fluvial + 5% tidal, 1% + 20% for climate change fluvial + 5% tidal and 0.1% fluvial + 5% tidal AEP defended events.

14.3.26 The model simulated fluvial flooding only and does not consider other contributions such as surface water or groundwater,

River Roding

14.3.27 Flood extents for the River Roding have been generated through 1D-2D linked modelling.

14.3.28 The model was run for 20% 10%, 5%, 1%, 1% +20% for climate change, 0.5% and 0.1% AEP events with defences present. The model was also run for 0.1% AEP without defences present. Flood depth and extent outputs were created.

River Ravensbourne/Deptford Creek

14.3.29 In 2008/2009 there was a review of the previous flood risk mapping work (carried out in 2006) on the River Ravensbourne. This included culvert asset surveys, manhole surveys and topographic surveys of additional/reclassified tributaries to supplement the previous modelling work. The result of this was the remodelling of the River Ravensbourne and all major tributaries using two linked ISIS-TUFLOW models (one of
the Ravensbourne and tributaries and one of the Quaggy and tributaries). The TUFLOW model grid was set to 6m.

14.3.30 Improvements have been made to the 2006 model including revised hydrology and improved representation of flooding through surcharging manholes and subsequent overland flow routes.

14.3.31 Outputs included flood levels, flows and extents for the defended catchment scenario. Following this, hazard maps were created by the EA using depth and velocity outputs (both with and without a debris factor) from the model.

14.3.32 The models were run for the 10%, 5%, 2%, 1% and 1% + 20% for climate change AEP events. The model results showed differences between 2006 and 2008/9 due to the inclusion of the 2d element of the model. This difference is a general increase in modelled flood extents. Events in the order of 1% AEP result in widespread flooding within the catchment.

**Flood defence data**

14.3.33 Flood defences are typically engineered structures designed to limit the impact of flooding. Flood defences take several forms including: river walls, raised walls, bunds/embankments, canalised channels, culverts and flood storage areas.

14.3.34 Given the urban nature of the study area, the majority of defences are hard engineered defences.

14.3.35 Flood defence data have been supplied by the EA in the form of National Flood and Coastal Defence Database (NFCDD). This contains spatial information on the location of the asset, asset type and description, maintainer, design standard and length. The EA also hold survey data containing information on defence crest heights. At the time of writing, this data has not been provided to the project.

14.3.36 Further information has also been provided in the form of some “as built” defence drawings.

**Flood Zone maps**

14.3.37 Flood Zone maps from the EA have been obtained. These have been compiled by the EA from the most up to date modelling within each area. They show the estimated extent of Flood Zone 2 (area with a 0.1% or greater AEP of flooding) and Flood Zone 3 (area with an AEP of less than or equal to 1% fluvial flood risk or 0.5% tidal flood risk). The maps ignore the presence of flood defences but do show where flood defences are present and areas which benefit from local defences.

14.3.38 The Flood Map gives a good indication of the areas at risk of flooding in the study area, but it does not provide detail on individual properties, or information on flood depth, speed or volume of flow. It also does not show flooding from other sources, such as groundwater, direct runoff from fields, or overflowing sewers.

**Historical flooding data**

14.3.39 Historical flood data is available within Borough specific SFRA’s.
Hydrodynamic modelling

14.3.40 Considering the complexity of the project and the importance of the River Thames, a 2D hydrodynamic model of the River Thames has been developed (HR Wallingford, (March 2011) London Tideway Tunnels, Combined Sewer Outflow Foreshore Works Tidal Flow Modelling – Overall impact upon the Tidal Thames) and used to determine the impact of the project (specifically foreshore works) on flow, sediment transport and morphological regime.

14.3.41 Modelling has been undertaken at the site scale to provide detail on changes to local flow and likely implications for sediment transport and morphology. Potential additive impacts of the project as a whole have also been investigated.

Topographic data

14.3.42 Topographic data for the project is in the form of survey data covering the majority of every site. This data should accurately represent the ground levels at each site.

Environment Agency design guidance

14.3.43 The EA have provided a document outlining essential standards and best practice design guidance for the project (EA, 14/12/10 Version 1, Tideway Tunnels Design Guidance). This draws on Byelaws such as the provision under Section 109 of the Water Resources Act 1991 and/or EA Thames Region’s Byelaws (Thames Region Land Drainage Byelaws, Environment Agency, 1991) that:

Under “No person shall, without the previous consent of the Authority:

a. erect or construct, or cause or permit to be erected or constructed, any fence, post, pylon, wall, wharf, jetty, pier, quay, piling, groyne, revetment, or any other building or structure whatsoever in or over the river

b. erect or construct, or cause or permit to be erected or constructed, any fence, post, pylon, wall, or any other building or structure within 8m measured horizontally from the foot of any bank of the river on the landward side or, where there is no such bank, within 8m measured horizontally from the top edge of the batter enclosing the river, or between a line drawn at a distance of 16m from the foot of any sea wall measured horizontally on the landward side and low water mark of mean spring tides; Provided that this sub-para. shall not apply to any fence or post if no part of such fence or post exceeds 1.5m in height above the level of the adjoining land and, in the case of a fence, it is required for the purpose of agriculture and is constructed only of posts and wire strands or wire netting of not less than 100mm square mesh

c. place or affix, or cause or permit to be placed or affixed, any gas or water main or any sewer or any pipe whatsoever, or any telephone wire or electric main or cable, in, under or over the river, or in, under, over or through any bank, drainage works or flood protection works, or within 8m measured horizontally from the foot of any bank of the river
on the landward side or, where there is no such bank, within 8m measured horizontally from the top edge of the batter enclosing the river; Provided that any person may execute any temporary works as aforesaid in case of emergency but in such event he shall forthwith inform the Authority and comply with any reasonable directions which the Authority may give with regard thereto."

14.3.44 The EA also encourages developers to explore opportunities for river restoration, where appropriate, as part of any development.

14.3.45 The EA requires a 5m undeveloped buffer strip alongside ordinary watercourses (standard EA requirement). This is to allow access for maintenance and encourage conservation and wildlife habitat.

14.3.46 The EA also have the following information relating to set back distances to existing Tideway Frontages (EA, 14/12/10 Version 1, Tideway Tunnels Design Guidance):

a. The maximum working area possible is sought to allow flexibility in future flood defence renewal, and for ease in inspection, repair and renewal.

b. For inspection, a 2m wide zone should be free of obstructions.

c. For repair, a 5m wide by 5m high zone should be provided where any obstructions very easily and cheaply removable/modifiable.

d. For renewal, a 12m wide by 20m high zone should be provided where any obstructions require only minor costs in removal or modification.

e. For terraced sloped approach to flood defences set back will need to be estimated on a case by case basis.

14.3.47 It should be noted that the EA prefers minimal encroachment into the foreshore at the expense of the above setback distances (established through discussions with the EA throughout project). The EA have suggested where the new Tideway Frontages encroach into the River, flood defences may be integral to the design of the shaft in order to limit encroachment. These will incorporate appropriate design to accommodate accidental loading and to allow for climate change.

14.4 Assessment methodology

Overview

14.4.1 The Level 1 FRA is in accordance with the requirements of Planning Policy Statement 25: Development and Flood Risk (PPS25) covering effects of construction and operation of the lifetime of the project (taking into consideration climate change) on the Thames Tideway, for both additive effects (ie, site specific effects that accumulate/act together to impact the project as a whole) and at the site specific scale.

14.4.2 The Level 1 FRA identifies any flooding or surface water management issues related to development that may need further investigation. The Level 1 assessment is based on readily available existing information, including: SFRA, EA flood maps and standing advice. The Level 1 FRA
can then be supported by Level 2 or 3 studies following confirmation of sites and development designs.

14.4.3 The aim of the Level 1 FRA is to assess the risks of all forms of flooding both to the project and as a result of the project. PPS25 emphasises the need for a risk-based approach to be adopted by planning authorities through the application of the Source-Pathway-Receptor (S-P-R) model. The approach to the Level 1 FRA will therefore be based on the S-P-R model in accordance with the recommendations of Annex E of PPS25.

14.4.4 The S-P-R model firstly identifies the causes or sources of flooding to sites. The nature and likely extent of flooding arising from any one source has been considered, eg, whether such flooding is likely to be localised or widespread. As well as flooding from the more apparent sources (Thames Tideway, and tributaries) the Level 1 FRA also includes an assessment of other sources of flooding as required in PPS25 (Annex C) including groundwater flooding, surface water flooding and flooding from artificial sources.

14.4.5 The presence of a flood source does not always imply a risk (eg, the presence of a sewer does not necessarily increase the risk of flooding unless the sewer is local to the site and ground levels encourage surcharged water to accumulate). The exposure pathway or flooding mechanism determines whether there is a risk of exposure to a flood source. The identification of flooding pathways has been undertaken by considering the site and surrounding topography, the proximity of the flood source to the receptor and the potential flood conveyance routes local to the site. This will require further investigation of the potential flow pathway created by the Thames Tunnel itself, which will be informed by modelling undertaken for SFRAs and supplemented by further modelling and assessment where required.

14.4.6 If a flooding mechanism is not considered to be present, then the risk from the flood source is considered to be negligible.

14.4.7 If a flood source and flooding pathway have been identified, the assessment of significance of the flood risk effect to the receptor has been determined by combining the likelihood of the flood event occurring with the severity of the effect if the flood event were to occur (or consequences).

14.4.8 Where modelled assessment data was available to inform the Level 1 FRA, it has been used to define the probability of a flood risk event occurring thereby providing a quantification of likelihood. However, for some sources of flooding (eg, groundwater) the probability or likelihood of flooding occurring is not fully quantified with existing information and a qualitative assessment has been undertaken based on expert judgement and other available information and records.

14.4.9 The potential severity of the flood risk effect has been determined by:
   a. considering a combination of the type of flood source
   b. the flood mechanisms identified
   c. the layout and design of the proposed receptor
d. the vulnerability of the proposed receptor.

14.4.10 Receptors include any people or buildings within the range of the flood source, which are connected to the source by a pathway. Within this Level 1 FRA, the receptor will be the site which is classified as ‘water and sewage transmission infrastructure’ including ‘docks, marinas and wharfs’. These land use types are classified as ‘water-compatible development’ and compatible within all flood zones according to Table D.2 in Annex D, PPS25.

14.4.11 The objectives of the Level 1 FRA are to:
   a. identify the flood risks from all flood sources from a desk based review of available information
   b. review all relevant flood risk literature, including the relevant boroughs’ SFRAs and SWMP (where available)
   c. review all design documents relevant to assessment of flood risk specific to the project
   d. propose options for flood mitigation in line with the recommendations of current best practice documents, suitable for the intended use and position of the development
   e. agree residual risk, which should be commensurate with the level of risk at individual sites and the project as a whole
   f. determine the general requirements for run-off attenuation from the proposed development and the implications for storm water attenuation / storage
   g. list possible options for the management and disposal of surface water run-off from the development, including provision for SUDS in line with relevant policy and the principles of the Management Train (presented in CIRIA C697107)
   h. support ongoing liaison with relevant bodies including the EA and the LA
   i. produce a Level 1 FRA report covering the project as a whole and individual sites outlining flood risk, surface water management considerations and the requirements for pursuing development options at the sites. Level 1 FRA is not suitable for submission with a planning application but will be developed in the future into a Level 2 and/or 3 for that purpose. As a supplement to the PEIR, this Level 1 FRA will be produced with the aim of confirming flood data and communicating potential implications.

14.4.12 The assessment of flood risk within this Level 1 FRA is under the following headings, in line with PPS25.

**Temporal scope**

14.4.13 The Level 1 FRA considers flood risk effects during construction periods over varying timeframes according to the length of construction required for the Thames Tideway as a whole and at each individual site.
14.4.14 In addition, the Level 1 FRA considers any potential operational effects from 2020 (tunnel operation) with the additional timeframe of 100 years into the future (from 2011) to assess potential impacts of climate change for the lifetime of the project as per the requirements of PPS25.

14.4.15 The validity period of available baseline data has been carefully considered (i.e., checking when the data was collected, and comparing this to the timing and nature of intended use) prior to use in the assessment process.

**Spatial scope**

14.4.16 Level 1 FRA reports have been prepared for all sites. However, a number of the Level 1 FRA have concluded that further Level 2 or 3 work is not required.

14.5 Assumptions and limitations

14.5.1 A number of limitations on data availability and collection have occurred during the production of the Level 1 FRAs. However, the nature of the Level 1 FRA is to utilise all currently available data, and identify additional data sets which are required. These can then be incorporated within the following flood risk work, namely the Level 2 or 3 FRA to be included within the final Environmental Statement.

14.5.2 This section of the report states relevant assumptions and limitations for the Level 1 FRAs. For example, both the 2d and physical modelling studies have not been completed and issued as final; therefore consultation with the EA cannot be reported within this document. This consultation will be reported in the FRA sections of the ES.

14.5.3 Generic methodology and limitations are covered in Section 2 and specific assumptions and limitations are discussed below.

14.5.4 All of the 2D model results and physical modelling results are not available. The results that are available will be used in this Level 1 FRA but they have not been completed.

14.5.5 Consultation on 2D and physical modelling may be delayed. This may lead to further discussions with the EA regarding results.

14.5.6 The assessment team unable to gain site access to all sites in a timely manner.

14.5.7 It is assumed all data provided by the EA is the most up to date and relevant to the requests made and the project.

14.6 Flood sources

14.6.1 The assessment of flood risk within this Level 1 FRA is under the following headings, in line with PPS25:

**Flooding from the sea**

14.6.2 The River Thames flows through the study area from west to east. The river is tidally influenced up to Teddington Weir.
14.6.3 The main risk from tidal flooding is through a combination of high tides and storm surges. Water levels within the Thames Estuary can also be exacerbated through wind generated waves.

14.6.4 London is defended by the Thames Tidal Defence networks which includes the Thames Barrier at Woolwich Reach and over 300km of walls and embankments and associated flood gates and barriers. The Thames Barrier is designed to prevent large storm surges which overtop the flood defences from propagating upstream of the Barrier.

14.6.5 There is however a residual risk of flooding, defined as the risk that remains after flood avoidance and alleviation measures have been put in place. This could occur through a breach in the defences or the overtopping of the defences.

**Breach**

14.6.6 An example of residual risk is a localised breach/failure of the floodwalls located along the banks of a watercourse. A breach can occur in any situation where a defence is present with a crest raised above adjacent land levels. Failure could occur under a number of scenarios, e.g., collision of river traffic, terrorist action and/or hydrostatic water pressure during high tides (breaches are more likely during extreme tides or periods of high river flow when loads on the defence will be greater).

14.6.7 Other more likely causes of a breach or defence failure include development works adjacent to flood defences such as excavations, and structural failure as a result of the defences coming to the end of their design life.

14.6.8 If a localised breach or defence failure as described above was to occur, it is unlikely that appropriate warning time would be available due to the sudden and unexpected nature of the event.

14.6.9 A flood defence failure would result in high velocities and volumes of flood water flowing through the breach and into low lying areas which could result in significant disruption and damage. The time taken for a breach to be sealed can have a major effect on the extent and depth of flooding.

14.6.10 In the unlikely event of a failure in the flood defences, it is likely that the Thames Barrier would be closed to enable the breached defences to be repaired, reducing the potential volume of water that could flow through a breach and allowing emergency services to evacuate areas affected.

14.6.11 It is however possible that the Thames Tunnel and the connecting shafts could create pathways for transmission of floodwaters, during a breach scenario. An assessment of the potential impacts of creating this additional pathway will be undertaken for all sites. This will involve estimation of likely breach inflow volumes and topographic analysis to initially assess the risk.

14.6.12 If the initial analysis highlights that the shaft could potentially be inundated with a significant volume of water, which could then potentially be conveyed to other areas, then a more detailed assessment will be required. This could involve more detailed inflow volume calculations and/or reference to existing breach modelling information, which has often
been completed as part of borough-specific SFRAs, and additional breach modelling can also be completed where considered necessary.

**Overtopping**

14.6.13 Overtopping occurs when water passes over a flood defence. Low levels of overtopping may arise even when the defence crest level is higher than the water level, due to the action of winds, waves and spray. Higher levels of overtopping occur when water levels exceed the defence level and overflowing occurs, ie, capacity of the channel is exceeded. Tidal sources result in the most severe overtopping. The defences could also be overtopped if the Thames Barrier failed to close and a storm surge travelled up the estuary into Central London.

14.6.14 As sea levels rise over time, the Barrier will have to close with increasing frequency, and not just in response to surge tides. With operational constraints limiting the number of closures in any one year, the risk of overtopping will increase (Thames Barrier closure rule).

14.6.15 Flood defences are usually designed with a degree of ‘freeboard’, the height by which the crest level of the defence exceeds the design flood level. Defences along the River Thames are maintained at approximately the 0.1% AEP standard and are designed to have a constant freeboard above their design level (the crest height of these defences are therefore above the 0.1% AEP water level). As a result, any overtopping should be small in volume and of uniform depth along the localised length of the defence.

14.6.16 Overtopping can also be assessed through 2-D modelling. Where this has been undertaken as part of Borough specific SFRAs it will be referred to within this Level 1 FRA.

**Flooding from rivers**

14.6.17 It is considered that a fluvial flood event on the River Thames with a return period of 1% AEP would result in lower water levels on the River Thames than those experienced during an extreme tidal flood event. Therefore, the greatest risk posed by the River Thames is a tidal flood risk.

14.6.18 There are however a number of other rivers within the study area:

a. River Ravensbourne/Deptford Creek: flows from south to north through south east London (LBs of Bromley, Lewisham and Greenwich) before discharging into the River Thames via Deptford Creek in Greenwich. The channel is predominantly of concrete/engineered construction in the northern urban areas.

b. River Wandle: flows from south to north through the LBs of Croydon, Sutton, Merton and Wandsworth and discharges into the River Thames at Bell Lane Creek in Wandsworth. The northern area of the catchment is underlain with London Clay so has limited infiltration. The channel is heavily managed with concrete channels and sections of culvert.

c. River Roding: flows from north to south (and marks much of the boundary between the LBs of Barking and Dagenham and Newham)
and discharges into the River Thames via Barking Creek at Creekmouth.

d. River Lee: flows from north to south through the Lee Valley and discharges into the River Thames through Bow Creek. The southern extent of the River Lee is heavily urbanised and managed through a network of channels and locks.

e. Beverley Brook: flows from south to north east through the west of study area (LBs of Sutton, Merton, Richmond and Wandsworth) and discharges into the River Thames at Barn Elms.

Flooding from land

14.6.19 Surface water flooding arises when water cannot infiltrate into the ground, through the conversion of land to an impermeable surface or due to the intensity of the storm, antecedent conditions or underlying geological conditions. Rain water can pond on the ground surface and travel via overland flow under the force of gravity to low areas, predominantly the local river or surface water network.

Flooding from groundwater

14.6.20 Groundwater flooding arises when the water table meets the ground surface, leading to the presence of groundwater at the surface. Water tables may be perched or in hydraulic conductivity with local watercourses. Many water courses are derived from this mechanism, which is also an important drinking water source.

Flooding from sewers

14.6.21 Sewer flooding arises when the local sewer network is exceeded or a problem arises such as a blockage or fracture. This can be unpredictable.

14.6.22 Exceedance arises when the quantity of water entering the network exceeds the capacity of the system (drainage systems are typically constructed to accommodate storm events with an AEP of 3.3% or more). This can occur during intense or prolonged rainfall events and in extreme circumstances can lead to backing up, localised flooding and the presence of foul water above ground.

14.6.23 Temporary works associated with diversion and interception of CSOs could potentially result in temporary increases in sewer flood risk to upstream areas. Therefore appropriate assessment of potential impacts of both the permanent and temporary works on sewer flood risk will be required.

Flooding from artificial sources

14.6.24 Artificial flood sources include raised channels such as canals or storage features such as ponds and reservoirs.

14.7 Surface water management

14.7.1 Development often has the effect of reducing the permeability of the land surface, through the formation of hard and impermeable surfaces. This has the potential to increase the flood risk to the surrounding area by
reducing the potential for rainwater to infiltrate into the ground on the site and soak away. This water may travel as overland flow onto surrounding areas and lead to surface water flooding.

14.7.2 In order to prevent this arising it is best practice to employ SUDS techniques within the site to retain rainwater and promote infiltration. PPS25 states that runoff post development should not be greater than runoff pre development.

14.7.3 The London Plan aims towards greenfield runoff rates and the Mayor’s Draft Water Strategy also aims for greenfield runoff and has an ‘essential’ standard of 50% attenuation of the undeveloped site’s surface water runoff at peak times). Wherever possible, a development should aim towards greenfield runoff rates and justification must be provided when this aim is not achieved.

14.7.4 The approach within the Level 1 FRA contained within the PEIR is to:

a. determine the general requirements for run-off attenuation from the proposed development and the implications for storm water attenuation / storage

b. list options for the management and disposal of surface water run-off from the development, including provision for SUDS in line with the principles of the Management Train (presented in CIRIA C697108).

Methodology and assumptions

14.7.5 In order to determine surface water mitigation for each site the existing surface water runoff rates have to be estimated. The existing surface water runoff rates form the basis for the allowable post development discharge rates necessary to comply with PPS25 and the other policy documents identified in the above section.

14.7.6 For undeveloped ‘greenfield’ sites the 1% AEP surface water runoff rate has been calculated using the ICP SUDS rural runoff method using the Micro Drainage WinDes® Version 12.5 software. This method is recommended for sites < 50 ha. Soil infiltration coefficients ranging from 0.15 (sandy, well drained) to 0.5 (steep, rocky areas) have been estimated using soil and geological information.

14.7.7 For previously developed sites the 1% AEP surface water runoff rate from hardstanding areas has been calculated using the Modified Rational Method. The equation for the Modified Rational Method is provided below:

\[ Q = C_v \times C_r \times (2.78 \times i \times A) \]

Where:

- \( Q \) = Runoff rate (l/s)
- \( C_v \) = Volumetric runoff coefficient, typically 0.75
- \( C_r \) = Routing factor of 1.3
- \( i \) = Rainfall intensity (based on rainfall profile derived from FEH CD-ROMv3 catchment descriptors)
- \( A \) = Area of impermeable land (ha).
14.7.8 For sites consisting of undeveloped ‘greenfield’ areas and previously developed impermeable areas the 1% AEP surface water runoff rate have been calculated for each area using the appropriate runoff rate method. The two runoff rates are then added together to provide an overall 1% AEP runoff rate for the site.

14.7.9 Based on the permanent works proposed at each site the 1% AEP post development runoff rate (without mitigation) has been calculated based on the impermeable area proposed at the site. In accordance with PPS25 Table B.2 the post development surface water runoff rate includes a 30% increase in peak rainfall intensity to account for the anticipated impact of climate change over the developments lifetime.

14.7.10 Without mitigation, the site would result in an increase in surface water runoff post development. Preliminary storage volume calculations have been undertaken using Micro Drainage WinDes® Version 12.5 software to ensure that, after the development has been carried out, the surface water runoff rates for each site are attenuated so as to comply with the requirements of relevant planning policy. At this stage all attenuation volumes are based on zero infiltration, as no infiltration rate information is currently available at the sites.

14.7.11 To take into account the effects of climate change over the developments lifetime a 30% increase in peak rainfall intensity has been included when considering post development runoff and the associated attenuation volumes.

14.7.12 The table below indicates the requirements of the relevant planning policy and how they have been applied within this study.

**Vol 5 Table 14.7.1 Flood risk - planning policy requirements**

*Note: for surface water management*

<table>
<thead>
<tr>
<th>Sites</th>
<th>Mayors Draft Water Strategy surface water management requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Preferred standard (attenuation to greenfield runoff rate)</td>
</tr>
<tr>
<td>Undeveloped 'greenfield' Sites</td>
<td>✓</td>
</tr>
<tr>
<td>Previously developed Sites</td>
<td>✓</td>
</tr>
</tbody>
</table>

14.7.13 Vol 5 Table 14.7.1 shows that for undeveloped ‘greenfield’ sites preliminary storage volume calculations have been undertaken to ensure the Mayor’s preferred standard is achieved. For previously developed sites preliminary calculations have been undertaken to ensure both the Mayor’s preferred and essential standards are achieved.
14.7.14 Once preliminary storage volumes have been calculated the implementation of suitable SUDS techniques have been considered at each site. Where appropriate SUDS techniques have been recommended, taking into account the EA’s SUDS hierarchy, together with site location, ground conditions and topography.

14.7.15 Where sites are located within the foreshore area, storage volumes have been calculated to ensure the relevant planning requirements are achieved. However, no SUDS options have been recommended for these sites as it is assumed that direct discharge to the River Thames without attenuation will be achievable.

14.7.16 This is considered to be an appropriate approach given that any precipitation falling on foreshore sites currently lands directly within the River Thames, and the discharge of runoff therefore effectively occurs instantaneously, and with no attenuation.

14.7.17 The flood risk reduction benefits of surface water attenuation provision on foreshore sites are therefore minimal given the foreshore site’s location at the downstream extent of the catchment, immediately adjacent to the discharge point to the Tideway.

14.7.18 It is widely appreciated that SUDS features can provide additional water quality, biodiversity and amenity/recreational benefits. However it is considered unlikely that opportunities to realise any significant benefits from these aspects whilst also allowing the development sites to operate efficiently as an essential piece of infrastructure will be available.

14.7.19 However all potential opportunities for implementation of sustainable drainage techniques will be highlighted and considered to ensure the multiple benefits can be achieved.

14.8 Approach to mitigation

Flood risk prevention and mitigation

14.8.1 The FRA process involves the development of effective prevention and mitigation measures for both construction and operation phases of the project in order to reduce the significance of flood risk effect by removing one element of the S-P-R model. For example, by defending against the flood source, removing the pathway, incorporating flood management or flood resilient measures into building receptors, or providing safe access and egress and flood evacuation plans for human receptors.

14.8.2 Flood prevention and mitigation measures will be developed in accordance with the recommendations of current best practice documents and suitable for the intended use (this will be included in Level 2 and Level 3 FRA which will form part of the ES). Flood prevention and mitigation methods are discussed below for both construction and operation phases and both additive and site specific scales.

14.8.3 It is important that residual risk is taken into consideration in the Level 1 FRA process. In order to suggest prevention and mitigation, the risk must be understood. This should be agreed and commensurate with the level of risk the project can adopt.
14.8.4 If there was a localised breach in the defences adjacent to a site, flood water could flow on to the site, cover the shaft and inundate any ventilation, monitoring or associated operation equipment.

14.8.5 As the shafts are covered, although not watertight, there would be a limited volume of water that could enter the tunnel though the space between the cover and the shaft.

14.8.6 It is highly unlikely that the volume of water would jeopardise the operation of the tunnel. Ventilation and monitoring equipment may be damaged by flood water (if not installed above the flood level). This equipment could therefore require subsequent replacement; however failure of this equipment during a flood event would not endanger the function of the tunnel. The project is therefore accepting these potential residual flood risk impacts, as the consequences of occurrence are not considered to be significant enough to require further design consideration.

14.8.7 The residual flood risk associated with foreshore sites where the tunnel shaft effectively forms the new flood defence line, and during the temporary cofferdam construction phases will require full assessment and consideration of all potential breach scenarios including possible ship or barge impact.

**Flood prevention**

14.8.8 Flood prevention methods are used in an attempt to stop flooding from occurring to a particular receptor or lessening the effect of a flood on a receptor. This can be in the form of defences or flood resistant, resilient methods. In the context of this project, where a Thames Tidal Defence has been removed it must be replaced in order to provide flood protection to the surrounding area (to a commensurate level). As discussed above, the impact of a flood on a site is within the adopted risk accepted by the project. As such, flood resistant and resilient measures are merely suggested as possible to reduce any damage caused by a flood. These measures are not included in the design of sites at this stage but may be considered in later design stages.

**Flood defences**

14.8.9 The EA requires that flood defences be retained throughout the study area. If, through construction, defences have to be removed the replacement defence must be constructed and ‘tied in’ to the original defences prior to breaching the original defence. There should also be continuity in defence standard. This is the responsibility of the contractor and will ensure flood risk is not increased to the surrounding area.

14.8.10 Riparian developments are required to have flood defences renewed / made good for the life of the development. Where the development site is not defended to the 1% AEP with climate change standard, a hydraulic modelling investigation must be carried out to determine the effects of raising the banks to protect the development to this standard. This should identify changes in water level and where flooding is being alleviated and exacerbated in order to demonstrate that ‘flood risk is not increased elsewhere’ and compliance with PPS25. Where flood risk is increased flood mitigation measures will be required. This will be explored for
individual sites where the level of protection falls below the 1% AEP standard.

**Flood resistance and resilience**

14.8.11 Flood risk can be lessened by reducing either the probability or consequences of flooding, and preferably both. The provision of resistance measures or increased resilience to flood damage reduces the consequences and ensures that a development can be swiftly returned to use following a flood event.

14.8.12 PPS25 recommends that a sequential approach should be applied to new developments to direct more vulnerable uses to parts of the site at lower probability of flooding. Flood resistant and/or resilient construction may then be considered if flooding remains within the development location and the potential risk to the development is too high.

14.8.13 Flood resistance and resilience measures are not required but are advised to lessen the consequences of a flood to a receptor.

**Secondary defences and land raising**

14.8.14 Secondary defences, eg, embankments, raised areas behind flood defence walls and raised infrastructure, exist on the dry side of primary defences and reduce the risk of residual flooding following a failure or overtopping of the primary defences. It is essential to ensure that any diversion of flood waters as a result of secondary defences does not increase flood risk to other people and properties in other areas.

14.8.15 Land raising above the predicted flood level can be an effective method of reducing flood inundation at a specific location. This method will however reduce flood storage volume on the floodplain and may exacerbate flooding elsewhere. Compensatory storage, and where possible an increase in storage, must therefore be provided to ensure there is no loss of floodplain storage (flood mitigation method).

**Finished floor levels**

14.8.16 Where developing in flood risk areas is unavoidable, raising finished floor levels above the flood level can reduce the flood risk to people and property. Within the defended tidal floodplain for less vulnerable developments (including water compatible developments applicable throughout the project) finished floor levels do not need to be raised. It is strongly recommended where possible that access to a level above the flood level is provided to grant safe refuge for site employees during a flood event.

14.8.17 Within the undefended fluvial floodplain for all developments, finished floor levels should be set a minimum of 300mm above the 1% AEP climate change flood level.

14.8.18 Where possible, these requirements should be adhered to, particularly during the construction phase.

**Recreation, amenity and ecology**

14.8.19 There are many different ways that recreation, amenity and ecological improvements can be used to mitigate the residual risk of flooding either
by substituting less vulnerable land uses or by increased flood storage and the storage or conveyance of rainwater or both. They range from the development of parks and open spaces through to the inclusion of ponds, and ditches and river restoration schemes. In addition, they have wider ecological, biodiversity and sustainability benefits.

**Flood mitigation**

14.8.20 Flood mitigation methods are used to alleviate the effect of the development of a site on any consequential (increase in) flood risk. It is necessary to mitigate against the impact (in terms of flood risk) caused by a development. This could be in the form of compensation storage or surface water attenuation.

**Floodplain compensation and flood routing**

14.8.21 Any development within the undefended floodplain which includes raising of ground levels may need to provide floodplain compensation on a 'level for level' or 'volume for volume' (in order of preference) basis to the 1% AEP level with climate change to ensure there is no loss of floodplain storage which would increase flood levels in other areas.

14.8.22 Provision of compensation storage could require lowering of areas of land that currently lie outside the floodplain to allow them to flood and store water during flood events, or landscaping areas already flooded to increase storage. Any areas of floodplain compensation must be in hydraulic continuity with the watercourse.

14.8.23 If the site is entirely within the floodplain, off-site compensation within the local area may have to be provided. This will be subject to detailed investigations and agreement with the EA to demonstrate that the proposals would not increase risks compared with the existing flooding situation.

14.8.24 Additionally, in order to demonstrate that 'flood risk is not increased elsewhere' any development in the undefended floodplain should prove that flood routing (from any source) is not adversely affected by the development, eg, diverting floodwaters onto other properties.

**Surface water mitigation**

14.8.25 Surface water mitigation is required to reduce the risk of surface water flooding to both the development sites and surrounding areas.

14.8.26 PPS25 states that runoff post development should not be greater than runoff pre development. The London Plan 2011 aims towards greenfield runoff rates and the Mayors Draft Water Strategy (Mayor of London and Greater London Authority, August 2009, The Mayor’s Draft Water Strategy) also aims for greenfield runoff and has an ‘essential’ standard of

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**viii** This will be assessed on a site by site basis, using all relevant available information and where necessary, modelling will be undertaken. Prior to the provision of flood compensation storage, it will be determined whether development of the site increases flood risk to the wider area. Appropriate flood compensation storage will then be configured to ensure that this the provision of essential infrastructure does not increase flood risk.
50% attenuation to the undeveloped site’s surface water runoff at peak times (Section 4).

14.8.27 Attenuation may therefore need to be incorporated within a site design to attenuate runoff rates and volumes. This will be determined based on the local receptor for surface water drainage:

a. The surface water drainage within each site will be designed to accommodate the 3.3% AEP rainfall event.

b. Where the site is self contained and no pathways to surrounding receptors have been identified, no attenuation will be required. For example, on foreshore sites any precipitation which exceeds the 3.3% AEP rainfall event will be discharged directly to the Tideway with no attenuation.

c. For inland sites where pathways and receptors have been identified, any precipitation which exceeds the 3.3% AEP rainfall event will be stored within the site up to the 1% AEP climate change rainfall event, with discharge limited either to greenfield runoff rates or 50% of the existing rate. Discharge is likely to be to on site SUDS, the existing sewer network, or during extreme rainfall events, excess runoff may be discharged to the Thames Tunnel itself.

14.8.28 Wherever possible sustainable drainage solutions will be utilised.

Sustainable approaches to surface water drainage include:

a. Prevention (good site design and housekeeping to prevent runoff and pollution): rainwater harvesting and reuse

b. Source control (managing runoff at or very near the source): rainwater harvesting, recycling and drainage, green roofs, porous paving

c. Site control (managing the risk within the site): infiltration, eg, soakaways, filter strips and swales, filter drains and porous pavement, ponds

d. Regional control (managing the risk from several sites): infiltration, eg, communal facilities, basins and wetlands

14.8.29 The EA have a preferred SUDS hierarchy within the South East Region (see the table below).

<table>
<thead>
<tr>
<th>Vol 5 Table 14.8.1 Flood risk - EA SUDS hierarchy</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>SUDs Feature</strong></td>
</tr>
<tr>
<td>Living/Green Roofs</td>
</tr>
<tr>
<td>Constructed Wetlands/Retention Pond</td>
</tr>
<tr>
<td>Detention Basins</td>
</tr>
<tr>
<td>Filter strips and Swales</td>
</tr>
<tr>
<td>Soakaways</td>
</tr>
<tr>
<td>Infiltration Trenches</td>
</tr>
<tr>
<td>Gravelled Areas</td>
</tr>
</tbody>
</table>
14.8.30 Any SUDS should be managed over the lifetime of the development to ensure continuing efficiency.
Appendix A: Ecology mitigation hierarchy

A.1.1 The approach to mitigation will continue to be discussed with stakeholders throughout the EIA, since any negative effects will need to be set against the overall benefits of the project. The Thames Tunnel Biodiversity Working Group will form the primary vehicle for doing this. Where a need for compensation is identified opportunities for habitat creation and restoration will be considered. A pallet of options will be sought, which may include identifying a single larger ‘mitigation’ site, rather than seeking to compensate on a smaller scale at each individual work site. Materials and plant available on the project for any habitat creation measures would also be used where possible in order to maximise sustainability.

A.1.2 The use of the ‘Mitigation and Compensation Hierarchy’ illustrated in Figure 1 as a systematic and transparent decision-making process has been discussed and agreed in principle at the March 2011 Biodiversity Working Group. The hierarchy is sequential, and seeks to avoid adverse environmental effects.

A.1.3 The hierarchy of ‘avoid impact’, ‘mitigate’, ‘compensate’, and ‘enhance’ should be strictly applied in this sequence. A clearly documented justification will be provided in the Environmental Statement each time a step down the hierarchy is taken. Enhancement opportunities will be taken at every stage of the hierarchy.

A.1.4 Ideally, mitigation, compensation and enhancement measures will be implemented wherever possible within the site, or otherwise, close to the site of adverse impact. There may be instances where appropriate mitigation or compensation cannot be provided within the site and it has to be provided elsewhere along the Lower Thames Tideway.

A.1.5 This hierarchy provides a framework only; each site/case will need to be examined individually to determine the most sustainable final approach.
A.1.6 The preferred approach is to avoid the feature that would lead to a negative impact. There are some natural assets that are of such value that it is not acceptable to mitigate or compensate for their loss or damage (e.g., nationally and internationally protected sites or other irreplaceable environmental features). Impacts on these assets should always be avoided.

A.1.7 The evolution of the design for some sites will have arisen through the aim of ‘avoidance’ (since the design will have evolved to avoid as many impacts as possible) and the ES will describe those situations where the final design has evolved to avoid impacts.

A.1.8 Where adverse impacts cannot be avoided, the aim is to reduce the impact to the absolute minimum possible.

Compensation in kind (restore, create)

A.1.9 Compensation for residual adverse impacts will be evaluated once the “avoid” and “reduce” options have been fully explored. For all residual adverse effects, compensation should be considered, although a decision may be reached that some effects that are classed as ‘minor’ and/or of a temporary or reversible nature may not require compensation and
compensation will be particularly focussed on moderate to high adverse effects.

A.1.10 Compensation will aim to restore the quality and/or quantity of the environmental assets damaged or lost. The most desirable option provides a matching quality of compensation (eg, area of foreshore) as close to the site of loss as possible.

A.1.11 To strategically manage the potential effects on biodiversity arising from the project within the Thames Tideway an ‘ecology balance sheet’ will be developed, in line with Environment Agency guidance provided to the project team through the Biodiversity Working Group and other fora. The balance sheet will account for losses and gains during both the construction and operation of the project of both aquatic and terrestrial habitats and, potentially, attributes (eg, fish spawning grounds etc.).

**Restore assets**

A.1.12 Any areas where temporary works are undertaken will be restored to a state as close as possible to their previous condition. This option also aims to restore the functions and value of a degraded or lost environmental asset. To achieve this, the aim is to seek sites where such an asset once existed and restore it to its former condition. In other words, to restore like with like wherever possible.

**Create assets**

A.1.13 Where opportunities to restore environmental assets to their former condition do not exist, it may be appropriate to try to create environmental assets. It may be difficult to create new, fully functioning habitat at a site where it has not existed previously, and so this option should be pursued with due caution.

**Compensate by other means or enhance**

A.1.14 Environmental policy encourages local authorities to seek an ecological gain be sought from all development wherever possible. For example, ‘enhancing’ the ecological value of river banks adjacent to a construction site. This may include planting reed-beds, which provide greater habitat diversity for invertebrates, fish and birds than the existing habitat, as well as being a Biodiversity Action Plan priority habitat. The result is that even in areas where the potential to create new expanses of conventional habitat is limited, the potential can nonetheless exist to create new features and attributes which can sufficiently improve the ecological quality. One example of ‘compensating by other means’ might be the removal of weirs preventing fish passage on watercourses adjacent to the development site – although the removal would not be directly linked to the impact to which it was a response, it would result in an ecological qualitative gain that was considered to balance and offset the adverse effect.
Appendix B: Review of Juvenile Fish Migration Issues and Modelling Approaches for Cumulative Impact Assessment
Appendix C: Transport assessment scenarios

Introduction

C.1.1 The Preliminary Environmental Information Report has been assessed based on a logistics strategy which assumes that certain materials are transported by water, and the remainder by road. An alternative logistics strategy has also been identified to ensure that a reasonable worst case is considered in future assessments. This technical note sets out both strategies and highlights the key differences between them.

Logistics scenarios

C.1.2 The two logistics scenarios are as follows:

a. all By Road Scenario
b. phase two consultation logistics strategy

C.1.3 The Thames Tunnel Project Team has undertaken detailed assessments of the number of construction vehicles required over the life of the project. This has been done based on the principal material quantities, broken down by each month, and then converted to the number of construction vehicles. This information has been determined for both scenarios.

C.1.4 For the All By Road Scenario, all materials and activities are transported to and from all construction sites by road throughout the project. The Phase two consultation Logistics Strategy involves transporting some materials by water, at sites which are accessible by water. Table C.1 shows the construction sites and materials that would be transported by water for this scenario, and hence the differences with the All By Road scenario.

Table C.1 Transport - phase two consultation logistics strategy

<table>
<thead>
<tr>
<th>Site</th>
<th>90% of excavated material from main tunnel out by barge</th>
<th>90% of cofferdam material in by barge</th>
<th>90% of cofferdam fill material out by barge</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acton Storm Tanks</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hammersmith PS</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Barn Elms</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Putney Bridge FS</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Carnwath Road Riverside</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dormay Street</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>King George’s Park</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Falconbrook PS</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cremorne Wharf</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chelsea Embankment FS</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Kirtling Street</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Appendix C: Transport assessment

#### C.1.5

As is evident, only certain sites are accessible by water, and therefore a number of sites are not able to transport any materials by water. In addition, the only materials that have been assumed to be transported by water are excavation and cofferdam material, with all other materials transported by road.

#### C.1.6

Based on the information, the peak month across the entire project for both scenarios has been identified, based on the highest level of average daily movements. In both scenarios, the project peak month is July 2019, with a combined average of 648 and 316 construction vehicle trips for the All By Road Scenario and phase two consultation logistics strategy respectively.

#### C.1.7

The breakdown of vehicle numbers at each construction site during the project peak month is summarised below in Table C.2.

#### C.1.8

This shows that a number of construction sites generate identical numbers of vehicles in both scenarios. A small number of sites (particularly the main drive and reception sites Carnwath Road; Kirtling Street; and Chambers Wharf) generate a significantly lower number of vehicles in the peak month (July 2019) for the phase two consultation logistics strategy.

<table>
<thead>
<tr>
<th>Site</th>
<th>90% of excavated material from main tunnel out by barge</th>
<th>90% of cofferdam material in by barge</th>
<th>90% of cofferdam fill material out by barge</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heathwall PS</td>
<td>√</td>
<td>√</td>
<td>√</td>
</tr>
<tr>
<td>Albert Embankment FS</td>
<td>√</td>
<td>√</td>
<td>√</td>
</tr>
<tr>
<td>Victoria Embankment FS</td>
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<td>√</td>
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<tr>
<td>Blackfriars Bridge Foreshore</td>
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<td>√</td>
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<tr>
<td>Chambers Wharf</td>
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<td>√</td>
<td>√</td>
</tr>
<tr>
<td>King Edward Memorial Park FS</td>
<td>√</td>
<td>√</td>
<td>√</td>
</tr>
<tr>
<td>Earl Pumping Station</td>
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<td></td>
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</tr>
<tr>
<td>Deptford Church Street</td>
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<tr>
<td>Beckton</td>
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<td></td>
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</tbody>
</table>

(✓ identifies for which sites it is assumed that materials are transported by water for each of the three activities)
<table>
<thead>
<tr>
<th>Construction Sites</th>
<th>All road peak (July 2019)</th>
<th>Phase two consultation logistics strategy peak (July 2019)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Average daily lorry vehicles</td>
<td>Average daily lorry vehicles</td>
</tr>
<tr>
<td>Acton Storm Tanks</td>
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<td>6.3</td>
</tr>
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<td>Hammersmith PS</td>
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<tr>
<td>Barn Elms</td>
<td>4.0</td>
<td>4.0</td>
</tr>
<tr>
<td>Putney Bridge FS</td>
<td>9.6</td>
<td>9.6</td>
</tr>
<tr>
<td>Carnwath Road Riverside</td>
<td>111.2</td>
<td>30.3</td>
</tr>
<tr>
<td>Dormay Street</td>
<td>4.1</td>
<td>4.1</td>
</tr>
<tr>
<td>King George’s Park</td>
<td>4.1</td>
<td>4.1</td>
</tr>
<tr>
<td>Falconbrook PS</td>
<td>6.2</td>
<td>6.2</td>
</tr>
<tr>
<td>Cremorne Wharf</td>
<td>2.3</td>
<td>2.3</td>
</tr>
<tr>
<td>Chelsea Embankment FS</td>
<td>2.3</td>
<td>2.3</td>
</tr>
<tr>
<td>Kirtling Street</td>
<td>238.4</td>
<td>61.5</td>
</tr>
<tr>
<td>Heathwall PS</td>
<td>4.6</td>
<td>4.6</td>
</tr>
<tr>
<td>Albert Embankment FS</td>
<td>18.2</td>
<td>18.2</td>
</tr>
<tr>
<td>Victoria Embankment FS</td>
<td>4.7</td>
<td>4.7</td>
</tr>
<tr>
<td>Blackfriars Bridge Foreshore</td>
<td>9.2</td>
<td>9.2</td>
</tr>
<tr>
<td>Chambers Wharf</td>
<td>101.1</td>
<td>26.7</td>
</tr>
<tr>
<td>King Edward Memorial Park FS</td>
<td>13.9</td>
<td>13.9</td>
</tr>
<tr>
<td>Earl Pumping Station</td>
<td>4.0</td>
<td>4.0</td>
</tr>
<tr>
<td>Deptford Church Street</td>
<td>2.4</td>
<td>2.4</td>
</tr>
<tr>
<td>Greenwich PS</td>
<td>53.7</td>
<td>53.7</td>
</tr>
<tr>
<td>Abbey Mills</td>
<td>25.8</td>
<td>25.8</td>
</tr>
<tr>
<td>Beckton</td>
<td>14.8</td>
<td>14.8</td>
</tr>
<tr>
<td>OVERALL SCHEME</td>
<td>648.1</td>
<td>315.9</td>
</tr>
</tbody>
</table>

C.1.9 In addition, Table C.3 outlines the vehicle numbers at each construction site, for each site specific peak month.

C.1.10 Similarly to the project-wide peak month, this shows that a number of construction sites experience an identical number of vehicles in both scenarios, and have peaks which occur in the same month.

C.1.11 However a number of sites, including Putney Bridge; Carnwath Road; Chelsea Embankment; Kirtling Street; Victoria Embankment; Blackfriars Bridge; Chambers Wharf; and King Edward Memorial Park all have fewer vehicles and differing peak periods in the phase two consultation logistics strategy.
Table C.3  Transport - site specific peak month construction vehicles

<table>
<thead>
<tr>
<th>Construction Sites</th>
<th>All road peak</th>
<th>Phase two consultation logistics strategy peak</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Average daily lorry vehicles in peak month</td>
<td>Date</td>
</tr>
<tr>
<td>Acton Storm Tanks</td>
<td>16</td>
<td>01/04/2020</td>
</tr>
<tr>
<td>Hammersmith PS</td>
<td>13</td>
<td>01/11/2018</td>
</tr>
<tr>
<td>Barn Elms</td>
<td>10</td>
<td>01/02/2018</td>
</tr>
<tr>
<td>Putney Bridge FS</td>
<td>40</td>
<td>01/08/2017</td>
</tr>
<tr>
<td>Carnwath Road Riverside</td>
<td>112</td>
<td>01/07/2018</td>
</tr>
<tr>
<td>Dormay Street</td>
<td>16</td>
<td>01/07/2018</td>
</tr>
<tr>
<td>King George’s Park</td>
<td>7</td>
<td>01/12/2017</td>
</tr>
<tr>
<td>Falconbrook PS</td>
<td>9</td>
<td>01/11/2019</td>
</tr>
<tr>
<td>Cremorne Wharf</td>
<td>12</td>
<td>01/12/2018</td>
</tr>
<tr>
<td>Chelsea Embankment FS</td>
<td>76</td>
<td>01/05/2020</td>
</tr>
<tr>
<td>Kirtling Street</td>
<td>258</td>
<td>01/11/2019</td>
</tr>
<tr>
<td>Heathwall PS</td>
<td>27</td>
<td>01/02/2018</td>
</tr>
<tr>
<td>Albert Embankment FS</td>
<td>85</td>
<td>01/11/2017</td>
</tr>
<tr>
<td>Victoria Embankment FS</td>
<td>115</td>
<td>01/05/2018</td>
</tr>
<tr>
<td>Blackfriars Bridge Foreshore</td>
<td>125</td>
<td>01/03/2021</td>
</tr>
<tr>
<td>Chambers Wharf</td>
<td>203</td>
<td>01/06/2022</td>
</tr>
<tr>
<td>King Edward Memorial Park FS</td>
<td>97</td>
<td>01/02/2021</td>
</tr>
<tr>
<td>Earl Pumping Station</td>
<td>24</td>
<td>01/01/2019</td>
</tr>
<tr>
<td>Deptford Church Street</td>
<td>24</td>
<td>01/06/2018</td>
</tr>
<tr>
<td>Greenwich PS</td>
<td>54</td>
<td>01/07/2019</td>
</tr>
<tr>
<td>Abbey Mills</td>
<td>30</td>
<td>01/05/2019</td>
</tr>
<tr>
<td>Beckton</td>
<td>20</td>
<td>01/08/2018</td>
</tr>
</tbody>
</table>

C.1.12  This note summarises the scale of the difference in vehicle numbers and peaks between the two scenarios, over the project as a whole and at each individual construction site. Both scenarios will be progressed and assessed moving forward in order to ensure a reasonable worst case is assumed.
Appendix D: Groundwater dewatering assessment method

Project-wide effects – groundwater methodology

D.1.1 Outline method statement for quantifying the impact of construction dewatering activities on a project-wide basis.

D.1.2 A layered Modflow model will be prepared for each site.

D.1.3 The geometry of the model will reflect the depths and thickness of strata anticipated at the site and will extend to a distance beyond which there impact is insignificant. Horizontal layers will be used.

D.1.4 Hydraulic parameters. The lower aquifer (Chalk, Thanet, Upnor) will be assigned a combined overall transmissivity used in the London Basin model (owned by the EA). The hydraulic conductivity of the individual layers that comprise the lower aquifer will be adjusted to reflect appropriate values. It is anticipated that more than one layer may be required to simulate the Chalk.

D.1.5 The model will be radially symmetrical about the centre of the site. A quarter segment of the radial system will be modelled.

D.1.6 The existence of d-walls will be incorporated into the model to the designer’s depth. They will be represented as either impermeable or of very low conductivity.

D.1.7 Dewatering can be simulated from both within the shaft and/or external to the d-wall.

D.1.8 The dewatering will be simulated in a transient manner for durations advised by the current design and any future updates of the design.

D.1.9 Following dewatering the recovery of water levels is simulated.

D.1.10 The drawdown simulated by the model for all shafts will be combined within a spreadsheet (ie, outside the model) to derive the combined drawdown impact at the receptors (eg, abstraction boreholes or GSHP schemes) that have been identified in the PEIR.

D.1.11 The quantified impacts will be combined with detailed information on the receptors, such as the depth of the boreholes and the height of water table above the pump, in order to assess the significance of the predicted effects.
## Glossary

<table>
<thead>
<tr>
<th>Term</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>A-weighted sound</td>
<td>A-weighted decibels, abbreviated dBA, or dBa, or dB(a), are an expression of the relative loudness of sounds in air as perceived by the human ear.</td>
</tr>
<tr>
<td>Above Ordinance Datum</td>
<td>Ground elevation is measured relative to the mean sea level at Newlyn in Cornwall, referred to as Ordnance Datum (OD), such that heights are reported in metres above or below OD.</td>
</tr>
<tr>
<td>abstraction</td>
<td>Removal of water from a source of supply (surface or groundwater).</td>
</tr>
<tr>
<td>Air Quality Management Area</td>
<td>Areas where the local authority determines the national air quality objectives are not likely to be achieved by the relevant deadlines.</td>
</tr>
<tr>
<td>air quality sensitive receptors</td>
<td>People, property or designated sites for nature conservation that may be at risk from exposure to air pollutants that could potentially arise as a result of the proposed development/project.</td>
</tr>
<tr>
<td>alluvium</td>
<td>Sediment laid down by a river. Can range from sands and gravels deposited by fast flowing water and clays that settle out of suspension during overbank flooding. Other deposits found on a valley floor are usually included in the term alluvium (eg, peat).</td>
</tr>
<tr>
<td>Annual Mean Concentration</td>
<td>The average (mean) of the hourly pollutant concentrations measured or predicted for a one year period.</td>
</tr>
<tr>
<td>anthropogenic</td>
<td>Originating as a result of human activities.</td>
</tr>
<tr>
<td>aquiclude</td>
<td>A hydrogeological unit which, that allows groundwater movement at negligible rates, even though porous and capable of storing water. Groundwater movement insufficient to allow appreciable supply to a borehole or spring. Aquicludes tend to act as an impermeable barrier.</td>
</tr>
<tr>
<td>aquifer</td>
<td>A permeable geological stratum or formation that is capable of both storing and transmitting water in significant amounts.</td>
</tr>
<tr>
<td>Archaeological Priority Area/Zone</td>
<td>Areas of archaeological priority, significance, potential or other title, often designated by the local authority.</td>
</tr>
<tr>
<td>background concentration</td>
<td>The contribution to the total measured or predicted concentration of a pollutant that does not originate directly from local sources of emissions.</td>
</tr>
<tr>
<td>Basal Sands</td>
<td>The Upnor Beds (the lower unit of the Lambeth Group) and the Thanet Sands.</td>
</tr>
<tr>
<td>base case</td>
<td>The base case for the assessment is a future case, without the project, in a particular assessment year.</td>
</tr>
<tr>
<td>Term</td>
<td>Description</td>
</tr>
<tr>
<td>--------------------</td>
<td>------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>baseflow</td>
<td>The component of river flow derived from groundwater sources rather than surface run-off.</td>
</tr>
<tr>
<td>baseline</td>
<td>The existing conditions against which the likely significant effects due to a proposed development are assessed.</td>
</tr>
<tr>
<td>benthic invertebrates</td>
<td>Invertebrates which are found within or on the river bed.</td>
</tr>
<tr>
<td>Bentonite</td>
<td>An absorbent aluminium phyllosilicate, in general, impure clay consisting mostly of montmorillonite. Mixed with water, it forms a slurry commonly used as drilling fluid and ground support in tunnelling.</td>
</tr>
<tr>
<td>borehole</td>
<td>A hole drilled into the ground for geological investigation or for the exploitation of geological deposits or groundwater. An abstraction borehole is a well sunk into an aquifer from which water will be pumped.</td>
</tr>
<tr>
<td>brick earth</td>
<td>Wind-blown dust deposited under extremely cold, dry post-glacial conditions suitable for making bricks.</td>
</tr>
<tr>
<td>British Standard</td>
<td>Produced by the BSI Group in order to set up standards of quality for goods and services.</td>
</tr>
<tr>
<td>Bronze Age</td>
<td>2,000–600 BC.</td>
</tr>
<tr>
<td>Building recording</td>
<td>Recording of historic buildings (by a competent archaeological organisation) is undertaken ‘to document buildings, or parts of buildings, which may be lost as a result of demolition, alteration or neglect’, amongst other reasons. Four levels of recording are defined by Royal Commission on the Historical Monuments of England (RCHME) and English Heritage. Level 1 (basic visual record); Level 2 (descriptive record), Level 3 (analytical record), and Level 4 (comprehensive analytical record).</td>
</tr>
<tr>
<td>bunding</td>
<td>Also called a bund wall, bunding is a separated area within a structure designed to prevent inundation or breaches of various types.</td>
</tr>
<tr>
<td>campshed</td>
<td>An area of stone, concrete or timber laid on the river / sea bed, that is exposed at low tide, allowing vessels to rest safely and securely in place.</td>
</tr>
<tr>
<td>catchment</td>
<td>The area from which surface water and/or groundwater will collect and contribute to the flow of a specific river, abstraction or other specific discharge boundary. Can be prefixed by ‘surface water’ or ‘groundwater’ to indicate the specific nature of the catchment.</td>
</tr>
<tr>
<td>Term</td>
<td>Description</td>
</tr>
<tr>
<td>-----------------------------------------------------------</td>
<td>-------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Catchment Abstraction Management Strategy (CAMS)</td>
<td>The Environment Agency’s strategy for water resources management in England and Wales through licensing water abstraction. CAMS is used to inform the public on water resources and licensing practice; provide a consistent approach to local water resources management; and help to balance the needs of water-users and the environment.</td>
</tr>
<tr>
<td>catenary</td>
<td>A curve formed by a perfectly flexible, uniformly dense, and inextensible cable suspended from its endpoints.</td>
</tr>
<tr>
<td>Cetaceans</td>
<td>Whales, dolphins and porpoises.</td>
</tr>
<tr>
<td>Chalk</td>
<td>A soft white limestone (calcium carbonate) formed from the skeletal remains of sea creatures.</td>
</tr>
<tr>
<td>Community Conservation Index (CCI)</td>
<td>Method for evaluating invertebrate communities based on species rarity, diversity and abundance.</td>
</tr>
<tr>
<td>cofferdam</td>
<td>A temporary or permanent enclosure built across a body of water to allow the enclosed area to be pumped out creating a dry work environment.</td>
</tr>
<tr>
<td>combined sewer</td>
<td>A sewer conveying waste water of domestic or industrial origin and rain water.</td>
</tr>
<tr>
<td>combined sewer overflow (CSO)</td>
<td>A structure, or series of structures, designed to allow spillage of excess waste water from a combined sewer under high rainfall conditions. Flows may discharge by gravity or by pumping.</td>
</tr>
<tr>
<td>conceptual model</td>
<td>A simplified representation or qualified description of the behaviour of the hydrogeological system. A quantitative conceptual model includes preliminary calculations and flow and mass balances.</td>
</tr>
<tr>
<td>Conservation area</td>
<td>Conservation areas defined by Local Planning Authorities according to the provisions of the Planning (Listed Buildings and Conservation Areas) Act 1990.</td>
</tr>
<tr>
<td>construction site</td>
<td>The area of site that would be used during the construction phase.</td>
</tr>
<tr>
<td>Core Strategy</td>
<td>The statutory plan which sets out a borough’s planning policies in relation to the management of development and land use. Supersedes the Unitary Development Plan in Boroughs where it has been adopted.</td>
</tr>
<tr>
<td>crawler crane</td>
<td>A mobile crane, usually with caterpillar tracks.</td>
</tr>
<tr>
<td>CSO connection culvert</td>
<td>The flow from the existing CSO is diverted to the location of the drop shaft. The drop shaft location requires suitable access for construction and maintenance.</td>
</tr>
<tr>
<td>Term</td>
<td>Description</td>
</tr>
<tr>
<td>-------------------------------------------</td>
<td>------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>CSO connection tunnel</td>
<td>The flow from the drop shaft is transferred to the Thames Tunnel through a connection tunnel. These vary in diameter from 2.2m to 5.0m. Long connection tunnels can be up to 4,615m in length.</td>
</tr>
<tr>
<td>CSO drop shaft</td>
<td>The shaft connects the flow down to the Thames Tunnel. The shaft sizes depend on the amount of flow to be intercepted and the de-aeration requirements and the depth depends on the location of the Thames Tunnel. The size ranges from 6m to 25m and depth from 25 to 75m.</td>
</tr>
<tr>
<td>CSO interception site</td>
<td>Site where the flows from an existing CSO would be redirected to the main Thames Tunnel.</td>
</tr>
<tr>
<td>curtilage</td>
<td>An area of land or structures around a dwelling or other structure.</td>
</tr>
<tr>
<td>cut</td>
<td>Excavated material to be re-used within the development as ‘fill’ or removed off-site.</td>
</tr>
<tr>
<td>dB LAeq,T</td>
<td>the equivalent continuous A-weighted sound pressure level having the same energy as a fluctuating sound over a specified time period T.</td>
</tr>
<tr>
<td>de-aeration chamber</td>
<td>An area within the shaft and/or associated pipe work, where air is removed from liquids.</td>
</tr>
<tr>
<td>decibel (dB)</td>
<td>Logarithmic ratio used to relate sound pressure level to a standard reference level.</td>
</tr>
<tr>
<td>determinands</td>
<td>Influencing or determining elements or factors.</td>
</tr>
<tr>
<td>Development Plan</td>
<td>In London these refer to the borough Unitary Development Plans.</td>
</tr>
<tr>
<td>dewatering wells</td>
<td>A system used to locally lower groundwater levels around the worksite to provide stable working conditions when excavating.</td>
</tr>
<tr>
<td>diaphragm wall</td>
<td>A diaphragm wall is a reinforced concrete retaining wall that is constructed in-situ. A deep trench is excavated and supported with bentonite slurry, and then reinforcing steel is inserted into the trench. Concrete is poured into the trench and only after this does excavation in front of the retained earth commence.</td>
</tr>
<tr>
<td>discharge</td>
<td>The release of substances (eg, water, sewage, etc.) into surface waters, ground or sewer.</td>
</tr>
<tr>
<td>drawdown</td>
<td>A lowering of the water level in a borehole or aquifer, usually in response to abstraction.</td>
</tr>
<tr>
<td>Term</td>
<td>Description</td>
</tr>
<tr>
<td>-------------------------------------------</td>
<td>---------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>early medieval</td>
<td>AD 410 – 1066. Also referred to as the Saxon period.</td>
</tr>
<tr>
<td>effect</td>
<td>The result of an impact on a particular resource or receptor.</td>
</tr>
<tr>
<td>effluent</td>
<td>The treated wastewater discharged from the Sewage Treatment Works.</td>
</tr>
<tr>
<td>Environmental Impact Assessment (EIA)</td>
<td>An assessment of the likely significant effects that a proposed project may have on the environment, considering natural, social and economic aspects, prepared in accordance with the 2009 Infrastructure Planning EIA Regulations.</td>
</tr>
<tr>
<td>Environmental Quality Standards (EQS)</td>
<td>The concentration of chemical pollutants assessed to have detrimental effects on water quality in terms of the health of aquatic plants and animals. EQS are established in the WFD (Annex V) through the testing of the toxicity of the substance on aquatic biology.</td>
</tr>
<tr>
<td>Environmental Statement (ES)</td>
<td>A document to be prepared following an EIA which provides a systematic and objective account of the EIA’s findings, prepared in accordance with the 2009 Infrastructure Planning EIA Regulations.</td>
</tr>
<tr>
<td>Evaluation (archaeological)</td>
<td>A limited programme of non–intrusive and/or intrusive fieldwork which determines the presence or absence of archaeological features, structures, deposits, artefacts or ecofacts within a specified area.</td>
</tr>
<tr>
<td>Excavation (archaeological)</td>
<td>A programme of controlled, intrusive fieldwork with defined research objectives which examines, records and interprets archaeological remains, retrieves artefacts, ecofacts and other remains within a specified area. The records made and objects gathered are studied and the results published in detail appropriate to the project design.</td>
</tr>
<tr>
<td>fault</td>
<td>A structural planar fracture or discontinuity within lithological strata due to strain or compression, in which significant displacement is observable.</td>
</tr>
<tr>
<td>FIDOR</td>
<td>Factors that will determine the severity of an odour as defined by the Environment Agency; Frequency, Intensity, Duration, Offensiveness, Receptor.</td>
</tr>
<tr>
<td>fill</td>
<td>Material required to raise existing ground levels. This can utilise ‘cut’ material generated within the site, or necessitate the importation of material.</td>
</tr>
<tr>
<td>findspot</td>
<td>The location at which an item was found.</td>
</tr>
<tr>
<td>foul sewer</td>
<td>A sewer conveying waste water of domestic and/or industrial origin, but little or no rain water.</td>
</tr>
<tr>
<td>fracture</td>
<td>A breakage in a rock mass. Present at any scale, but is generally used for large scale discontinuities.</td>
</tr>
<tr>
<td>Term</td>
<td>Description</td>
</tr>
<tr>
<td>-----------------------------</td>
<td>---------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>GARDIT</td>
<td>General Aquifer Research Development and Investigation Team (Thames Water, the Environment Agency and London Underground with the support of organisations such as the Corporation of London, Envirotech, the Association of British Insurers (ABI) and BT).</td>
</tr>
<tr>
<td>global warming</td>
<td>The gradual increase in the temperature of the earth’s atmosphere, believed to be due to the greenhouse effect, caused by increased levels of carbon dioxide, chlorofluorocarbons, and other pollutants.</td>
</tr>
<tr>
<td>Green Flag</td>
<td>Benchmark national quality standard for parks and green spaces in the United Kingdom.</td>
</tr>
<tr>
<td>groundwater</td>
<td>Water contained in underground strata, predominantly in aquifers.</td>
</tr>
<tr>
<td>groundwater flooding</td>
<td>Inundation of land or basements as groundwater levels rise and the groundwater discharges to the surface or underground structures.</td>
</tr>
<tr>
<td>groundwater rebound</td>
<td>The rise in groundwater level that occurs after cessation of abstraction.</td>
</tr>
<tr>
<td>GWB</td>
<td>Groundwater Body: distinct volume of groundwater within an aquifer or aquifers.</td>
</tr>
<tr>
<td>Harwich Formation</td>
<td>A dark brown slightly glauconitic clay with localised fine sand.</td>
</tr>
<tr>
<td>haul roads</td>
<td>Temporary roads provided within the contractors site area to allow the transportation of material around the site.</td>
</tr>
<tr>
<td>heritage asset</td>
<td>A building, monument, site, place, area or landscape positively identified as having a degree of significance meriting consideration in planning decisions. Heritage assets are the valued components of the Historic environment. They include designated heritage assets and assets identified by the local planning authority (including local listing).</td>
</tr>
<tr>
<td>Historic environment Record (HER)</td>
<td>Archaeological and built heritage database held and maintained by the County authority. Previously known as the Sites and Monuments Record.</td>
</tr>
<tr>
<td>Homezone</td>
<td>Designated residential area with streets designed to operate primarily as a space for social use.</td>
</tr>
<tr>
<td>Holywell Nodular Chalk</td>
<td>Generally hard nodular chalks with thin flaser marls. In parts, there are significant proportions of shell debris. Inter-bedded coloured marl and chalk succession characteristic of the Plenus Marls Member are found at its base. Above this, the Melbourn Rock Member is distinguishable by its lack of shell material.</td>
</tr>
<tr>
<td>Term</td>
<td>Description</td>
</tr>
<tr>
<td>-------------------------</td>
<td>-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>hydraulic conductivity</td>
<td>A constant of proportionality in Darcy’s law that allows the calculation of the rate of groundwater flow from the hydraulic gradient. For a unit hydraulic gradient, the higher the hydraulic conductivity the higher the rate of groundwater flow.</td>
</tr>
<tr>
<td>hydraulic gradient</td>
<td>In an aquifer this is the rate of change of groundwater level per unit distance in a given direction. Groundwater flows in the direction of the decline in hydraulic gradient.</td>
</tr>
<tr>
<td>hydrograph</td>
<td>A graph showing a plot of water flow or level with time, applicable to both surface water and groundwater.</td>
</tr>
<tr>
<td>impact</td>
<td>A physical or measurable change to the environment attributable to the project.</td>
</tr>
<tr>
<td>interception chamber</td>
<td>This structure is required to be built around the existing overflow either on land or at the discharge point in the foreshore. The chamber has a weir and valves to divert the flow in to the Thames Tunnel system. It is likely to be a reinforced concrete cut and cover box structure. In some other cases the structure is required to be built adjacent to an inlet or sump of a pump station from which the flow is diverted</td>
</tr>
<tr>
<td>Iron Age</td>
<td>600 BC – AD 43.</td>
</tr>
<tr>
<td>jacked caisson</td>
<td>A caisson is a retaining, water-tight structure open to the air. A jack is used to push the caisson into the ground, with the internal area then excavated.</td>
</tr>
<tr>
<td>$L_{Aeq(T)}$</td>
<td>Equivalent continuous sound level is a notional steady sound level which would cause the same A-weighted sound energy to be received as that due to the actual and possibly fluctuating sound over a period of time (T). It can also be used to relate periods of exposure and noise level. Thus, for example, a halving or doubling of the period of exposure is equivalent in sound energy to a decrease or increase of 3dB(A) in the sound level for the original period.</td>
</tr>
<tr>
<td>$L_{Amax}$</td>
<td>The maximum sound level measured on the A-weighted scale occurring during an event.</td>
</tr>
<tr>
<td>Lambeth Group</td>
<td>Complex sequence of highly variable inter-bedded sediments which include clay, sands, pebble beds and Shelly beds.</td>
</tr>
<tr>
<td>Laminated Beds</td>
<td>Fine to coarse sand or clay with occasional black organic matter.</td>
</tr>
<tr>
<td>later medieval</td>
<td>AD 1066 – 1500.</td>
</tr>
<tr>
<td>Lee Tunnel</td>
<td>The Lee Tunnel comprises a 7.2m diameter storage and transfer tunnel from Abbey Mills Pumping Station to Beckton STW and the interception of the Abbey Mills CSO.</td>
</tr>
<tr>
<td>Term</td>
<td>Description</td>
</tr>
<tr>
<td>----------------------------------</td>
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</tr>
<tr>
<td>Lewes Nodular Chalk</td>
<td>Hard to very hard nodular chalks and hardgrounds with interbedded soft to medium hard chalks and marls. More abundant softer chalks towards the top.</td>
</tr>
<tr>
<td>licence</td>
<td>Formal permit allowing the holder to engage in an activity (in the context of this report, usually abstraction), subject to conditions specified in the licence itself and the legislation under which it was issued.</td>
</tr>
<tr>
<td>listed building</td>
<td>A structure of architectural and/or historical interest. These are included on the Secretary of State’s list, which affords statutory protection. These are subdivided in to Grades I, II* and II (in descending importance).</td>
</tr>
<tr>
<td>lithology</td>
<td>The general characteristics of a rock or sedimentary formation.</td>
</tr>
<tr>
<td>Local Air Quality Management (LAQM)</td>
<td>Local areas where the local authority determines the national air quality objectives are not likely to be achieved by the relevant deadlines.</td>
</tr>
<tr>
<td>Local Development Framework (LDF)</td>
<td>Collection of planning documents prepared by the Local Planning Authority outlining the management of development and land use in a Borough.</td>
</tr>
<tr>
<td>locally listed building</td>
<td>A structure of local architectural and/or historical interest. These are structures that are not included in the Secretary of State’s Listing but are considered by the local authority to have architectural and/or historical merit.</td>
</tr>
<tr>
<td>Local Plan</td>
<td>An area specific plan to interpret and apply the strategy set out in the Structure Plan, to provide a detailed basis for the control of development, to provide a basis for co-ordinating new development and to bring planning issues before the public.</td>
</tr>
<tr>
<td>London Clay</td>
<td>Fine sandy silty clay to silty clay.</td>
</tr>
<tr>
<td>London Tideway Improvements (LTI)</td>
<td>The LTI comprise five separate improvement projects at Thames Water’s five Tideway sewage treatment works (STWs): Mogden, Beckton, Crossness, Riverside and Long Reach.</td>
</tr>
<tr>
<td>Lower aquifer</td>
<td>Consisting of the Upnor Beds (the lowest unit of the Lambeth Group), the Thanet Sands and the Chalk.</td>
</tr>
<tr>
<td>made ground</td>
<td>Artificial deposit. An archaeologist would differentiate between modern made ground, containing identifiably modern inclusion such as concrete (but not brick or tile), and undated made ground, which may potentially contain deposits of archaeological interest.</td>
</tr>
<tr>
<td>Term</td>
<td>Description</td>
</tr>
<tr>
<td>-------------------------------------------</td>
<td>--------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>main tunnel drive shaft site</td>
<td>Site that would be used to insert and then drive the TBM.</td>
</tr>
<tr>
<td>main tunnel reception shaft site</td>
<td>Site that would be used to remove the TBM from the Thames Tunnel at the end of the drive.</td>
</tr>
<tr>
<td>Mesolithic</td>
<td>12,000 – 4,000 BC.</td>
</tr>
<tr>
<td>mitigation measures</td>
<td>Actions proposed to prevent or reduce adverse effects arising from the whole or specific elements of the development.</td>
</tr>
<tr>
<td>Neolithic</td>
<td>4,000 – 2,000 BC.</td>
</tr>
<tr>
<td>New Pit Chalk</td>
<td>Non-nodular chalk, massively bedded, with fairly regularly developed marl seams and sporadic flints.</td>
</tr>
<tr>
<td>nitrogen dioxide (and oxides NO₂ and NO)</td>
<td>A product of combustion processes. Nitrogen dioxide is associated with adverse effects on human health.</td>
</tr>
<tr>
<td>Non-Technical Summary (NTS)</td>
<td>A report which briefly describes the main points discussed in the Environmental Statement in a clear manner without the use of technical jargon and phraseology. This report is a requirement of the 2009 Infrastructure Planning EIA Regulations.</td>
</tr>
<tr>
<td>Ofwat</td>
<td>The Water Services Regulations Authority, a government body set up in 1989 to regulate the activities of the water companies in England and Wales.</td>
</tr>
<tr>
<td>olfactometry</td>
<td>Odour panel sampling carried out in laboratory conditions.</td>
</tr>
<tr>
<td>Palaeo-environmental</td>
<td>Related to past environments, ie, during the prehistoric and later periods. Such remains can be of archaeological interest, and often consist of organic remains such as pollen and plant macro fossils which can be used to reconstruct the past environment.</td>
</tr>
<tr>
<td>Palaeolithic</td>
<td>700,000–12,000 BC.</td>
</tr>
<tr>
<td>palstave</td>
<td>A Middle Bronze Age axe.</td>
</tr>
<tr>
<td>particulate matter (PM)</td>
<td>Solid particles or liquid droplets suspended or carried in the air and includes the same matter after it has deposited onto a surface. For the purposes of this assessment the term includes all size fractions of suspended matter, such as dust, PM10 and PM2.5.</td>
</tr>
<tr>
<td>passive filter chamber</td>
<td>A structure containing carbon which absorbs odour from air flowing out of the Tunnel, without the assistance of mechanical pumping.</td>
</tr>
<tr>
<td>PEIR</td>
<td>Preliminary Environmental Information Report is a document setting out initial environmental information. In accordance with the Planning Act 2008, it is a requirement that this is the subject of pre-application consultation.</td>
</tr>
<tr>
<td><strong>Term</strong></td>
<td><strong>Description</strong></td>
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</tr>
<tr>
<td>pelagic invertebrates</td>
<td>Invertebrates which are found in the water column.</td>
</tr>
<tr>
<td>perched water</td>
<td>Is groundwater in an aquifer present above the regional water table, as a result of a (semi-)impermeable layer of rock or sediment above the main water table/aquifer, below the ground surface.</td>
</tr>
<tr>
<td>permeability</td>
<td>The capacity of soil or porous rock to transmit water.</td>
</tr>
<tr>
<td>pH</td>
<td>A measure of the acidity or basicity of an aqueous solution.</td>
</tr>
<tr>
<td>piezometer</td>
<td>A borehole designed specifically to allow the measurement of groundwater level.</td>
</tr>
<tr>
<td>piezometric surface</td>
<td>The level or head to which groundwater would rise in a piezometer if it is free to seek equilibrium with the atmosphere.</td>
</tr>
<tr>
<td>Pollution Incident</td>
<td>Written procedures put in place for dealing with spillages and pollution.</td>
</tr>
<tr>
<td>Control Plan</td>
<td></td>
</tr>
<tr>
<td>porous</td>
<td>Containing void spaces. Most sedimentary rocks are porous to some extent, and the term is commonly applied in a relative sense, generally restricted to rocks which have significant effective porosity.</td>
</tr>
<tr>
<td>preferred route</td>
<td>Refers to Option 3 – Abbey Mills route, which runs from Action Storm Tanks in west London to Limehouse then turns northeast to Abbey Mills Pumping Station, where it connects with the Lee Tunnel.</td>
</tr>
<tr>
<td>preferred scheme</td>
<td>Refers to the preferred route and construction sites.</td>
</tr>
<tr>
<td>preferred site</td>
<td>Sites assessed as most suitable following review of suitability of each shortlisted site by taking in to account engineering, planning, environment, property and community considerations.</td>
</tr>
<tr>
<td>preservation by record</td>
<td>Preservation by recording and advancement of understanding of asset significance. This is a standard archaeological mitigation strategy where heritage assets remains are fully excavated and recorded archaeologically and the results published. For remains of lesser significance, preservation by record might comprise an archaeological watching brief.</td>
</tr>
<tr>
<td>preservation in situ</td>
<td>Archaeological mitigation strategy where nationally important (whether designated or not) heritage assets are conserved in situ for future generations, typically through modifications to design proposals to avoid damage or destruction of such remains.</td>
</tr>
<tr>
<td>Term</td>
<td>Description</td>
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</tr>
<tr>
<td>Principal Aquifer</td>
<td>A geological stratum that exhibits high inter-granular and/or fracture permeability. This strata has the ability to support water supply and/or river base flow on a strategic scale. Principal Aquifers equate in most cases to aquifers previously referred to as Major Aquifers.</td>
</tr>
<tr>
<td>Public Water Supply</td>
<td>Term used to describe the supply of water provided by a water company.</td>
</tr>
<tr>
<td>Putty Chalk</td>
<td>Putty chalk (clay characteristics) near the surface of the unit above firm to soft non-nodular chalk with flint (Upper Chalk undivided) above hard nodular chalk with flints (Lewes Chalk).</td>
</tr>
<tr>
<td>RAMSAR</td>
<td>An international treaty for the conservation and sustainable utilisation of wetlands.</td>
</tr>
<tr>
<td>RBMP</td>
<td>River Basin Management Plans – these are the relevant plans that outline the state of water resources within a River Basin District relevant to the objectives of the WFD.</td>
</tr>
<tr>
<td>RDB3</td>
<td>The rarest and most threatened species are often listed in the Red Data Book of Insects\textsuperscript{ix}, within which there are three categories. Taxa in danger of extinction are referred to as RDB 1 species; those considered to be vulnerable and likely to move into the endangered category are listed under RDB 2, whilst rare species occur on RDB 3.</td>
</tr>
<tr>
<td>reach</td>
<td>Section of river between two points.</td>
</tr>
<tr>
<td>River Terrace Deposits</td>
<td>Extensive alluvial sand and gravel deposits laid down in a braided river system in river terraces since the Anglian glaciations.</td>
</tr>
<tr>
<td>real time control (RTC)</td>
<td>Where live data is used to manipulate control equipment in order to best manage the flow of storm water and sewage within the capacity of the system.</td>
</tr>
<tr>
<td>receptors</td>
<td>People (both individually and communally) and the socio-economic systems they support.</td>
</tr>
<tr>
<td>recharge</td>
<td>Water that percolates downwards from the surface to replenish the water table.</td>
</tr>
<tr>
<td>Red route</td>
<td>The red route is a network of roads designated by Transport for London that carry heavy volumes of traffic and are essential for the movement of traffic and public transport. These comprise mainly of major routes into and around London. Transport for London are responsible for enforcing the red routes which include clearways, parking and loading bays, bus lanes, yellow box junctions and banned turns.</td>
</tr>
</tbody>
</table>

\textsuperscript{ix} Bratton, (1991) Red Data Book for Insects
<table>
<thead>
<tr>
<th>Term</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>risk assessment</td>
<td>Assessment of the risks associated with an activity or object and possible accidents involving a source or practice. This includes assessment of consequence.</td>
</tr>
<tr>
<td>Roman</td>
<td>AD 43 – 410.</td>
</tr>
<tr>
<td>SAM</td>
<td>Scheduled Ancient Monument. More commonly referred to as ‘ Scheduled Monument’.</td>
</tr>
<tr>
<td>saline intrusion</td>
<td>Entry of brackish or salt water into an aquifer, from the sea or estuary. This may be natural or induced by excessive or uncontrolled groundwater abstraction.</td>
</tr>
<tr>
<td>saturated zone</td>
<td>The zone in which the voids in a rock or soil are filled with water at a pressure greater than atmospheric pressure.</td>
</tr>
<tr>
<td>Scheduled Monument</td>
<td>An ancient monument or archaeological deposits designated by the Secretary of State as a ‘Scheduled Ancient Monument’ and protected under the Ancient Monuments Act.</td>
</tr>
<tr>
<td>Scoping Opinion</td>
<td>The formal view of the determining authority on the range of topics and issues to be considered by the Environmental Impact Assessment, as referred to in the 2009 Infrastructure Planning EIA Regulations.</td>
</tr>
<tr>
<td>Scoping Report</td>
<td>The document prepared by the applicant setting out the proposed approach to the Environmental Impact Assessment, including the range of topics and issues to be addressed, as referred to in the 2009 Infrastructure Planning EIA Regulations.</td>
</tr>
<tr>
<td>Screening Opinion</td>
<td>The formal view of the determining authority on the need for an Environmental Impact Assessment to be undertaken, as referred to in the 2009 Infrastructure Planning EIA Regulations.</td>
</tr>
<tr>
<td>Seaford Chalk</td>
<td>The upper unit of the White Chalk, comprising of as firm to soft non-nodular Chalk with flint beds. Thin marl seams are found towards its base and absent higher up. A hard ground marks the top of the Seaford Chalk.</td>
</tr>
<tr>
<td>secant piles</td>
<td>Alternate piles in-filled with concrete to form a water-tight retaining wall.</td>
</tr>
<tr>
<td>Secondary Aquifers</td>
<td>Either permeable strata capable of supporting local supplies or low permeability strata with localised features such as fissures. The term Secondary Aquifer replaces the previously used name of Minor Aquifer. There are two classes of Secondary Aquifer. “Secondary A” are capable of supporting water supplies at a local rather than strategic scale and “Secondary B” are lower permeability layers which may store and yield limited amounts of groundwater due to localised features such as fissures, thin permeable horizons and weathering.</td>
</tr>
<tr>
<td>Term</td>
<td>Description</td>
</tr>
<tr>
<td>-------------------------------------------</td>
<td>-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>short listed sites</td>
<td>Sites identified following an assessment of long list sites in accordance with the Site Selection Methodology.</td>
</tr>
<tr>
<td>SINC (Grade B)</td>
<td>Site of Nature Conservation Importance (Grade II of Borough importance).</td>
</tr>
<tr>
<td>SINC (Grade L)</td>
<td>Site of Nature Conservation Importance (Grade I of Local importance).</td>
</tr>
<tr>
<td>SINC (Grade M)</td>
<td>Site of Nature Conservation Importance (Grade III of Metropolitan importance).</td>
</tr>
<tr>
<td>Site</td>
<td>For the purposes of the PEIR assessment, the “site” is deemed as the entire area located within the Limit of Land to be Acquired or Used. It should not be inferred that this entire ‘site’ area will be physically separated (ie, hoarded or fenced) for the construction duration.</td>
</tr>
<tr>
<td>Site of Special Scientific Interest (SSSI)</td>
<td>An area given a statutory designation by English Nature or the Countryside Council for Wales because of its nature conservation value.</td>
</tr>
<tr>
<td>site strip</td>
<td>Materials such as hard standing and vegetation including incidental topsoil (including potential contaminated soil).</td>
</tr>
<tr>
<td>Sites and Monuments Record</td>
<td>A record of sites of archaeological interest.</td>
</tr>
<tr>
<td>sprayed concrete lining</td>
<td>An efficient method for constructing the tunnel lining with a layer of sprayed concrete. This is instead of using pre-cast concrete segments.</td>
</tr>
<tr>
<td>strata</td>
<td>Layers of rock, including unconsolidated materials such as sands and gravels.</td>
</tr>
<tr>
<td>stratigraphy</td>
<td>The study of stratified rocks, their nature, their occurrence, their relationship to each other and their classification.</td>
</tr>
<tr>
<td>sulphur dioxide (SO₂)</td>
<td>A colourless gas with a choking smell, the main product of the combustion of sulphur contained in fuels.</td>
</tr>
<tr>
<td>superficial deposits</td>
<td>Overarching term for recent generally unconsolidated or loosely consolidated deposits of sand, gravel, silt, clay, etc on top of bedrock. Synonymous with ‘drift’ – generally supersedes the term.</td>
</tr>
<tr>
<td>surface water</td>
<td>This is a general term used to describe all water features such as rivers, streams, springs, ponds and lakes.</td>
</tr>
<tr>
<td>surface water runoff</td>
<td>Water that travels across the ground rather than seeping into the soil.</td>
</tr>
<tr>
<td>Term</td>
<td>Description</td>
</tr>
<tr>
<td>-----------------------------</td>
<td>-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Thames Tunnel</td>
<td>The Thames Tunnel comprises a full-length storage and transfer tunnel from Acton Storm Tanks to Beckton Sewage Treatment Works in East London and the interception of specific CSOs along the Thames Tideway with a diameter between 6.5m and 7.2m.</td>
</tr>
<tr>
<td>Thanet Sands</td>
<td>Coarsening upward sequence of well sorted fine grained sand which has a higher clay / silt content towards the lower part of the sequence, and evidence of intense bioturbation removing bedding structures.</td>
</tr>
<tr>
<td>The project</td>
<td>The Thames Tunnel project.</td>
</tr>
<tr>
<td>tidal excursion</td>
<td>Length of river channel swept by water from a discharge point in one tidal cycle. In the case of the River Thames this is considered to 13km up and downstream of the discharge point.</td>
</tr>
<tr>
<td>Tideway Fish Risk Model</td>
<td>Tool developed on behalf of Thames Water to assess the effects of lapses in water quality caused by CSO discharges on Tideway fish populations.</td>
</tr>
<tr>
<td>Transport Assessment (TA)</td>
<td>The formal assessment of traffic and transportation issues relating to the proposed development. The findings are usually presented in a report which accompanies the planning application.</td>
</tr>
<tr>
<td>truncate</td>
<td>Partially or wholly remove. In archaeological terms remains may have been truncated by previous construction activity.</td>
</tr>
<tr>
<td>typical year</td>
<td>A typical year relates to an actual year, eg, the corresponding meteorological dataset for that year used in the modelling which was 1979-80. The corresponding meteorological dataset is used as it would give a better indication of conditions rather than using a recent year of data where the meteorological data may not be consistent with a rainfall event leading to the tunnel emissions.</td>
</tr>
<tr>
<td>underground pressure release chamber</td>
<td>An enclosed space below the ground surface where air is released to atmosphere, should the pressure within the Tunnel exceed a set value.</td>
</tr>
<tr>
<td>Unitary Development Plan (UDP)</td>
<td>The statutory plan which sets out a unitary authority's planning policies.</td>
</tr>
<tr>
<td>unproductive strata</td>
<td>These are rocks which are generally unable to provide usable water supplies and are unlikely to have surface water and wetland ecosystems dependent upon them.</td>
</tr>
<tr>
<td>Upnor Formation</td>
<td>Variably bioturbated fine- to medium-grained sand with glauconite, rounded flint pebbles and minor clay, with distinctive pebble beds and base and top.</td>
</tr>
<tr>
<td>Term</td>
<td>Description</td>
</tr>
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<td>-------------------------------------------</td>
<td>-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Upper aquifer</td>
<td>Comprising the water bearing strata above the London Clay, namely the River Terrace Deposits and the Alluvium.</td>
</tr>
<tr>
<td>Upper Mottled Beds</td>
<td>A bluish grey mottled with greenish brown clay.</td>
</tr>
<tr>
<td>Upper Shelly Beds</td>
<td>Contains shell fragments within a flinty gravel or a sandy clay.</td>
</tr>
<tr>
<td>valve chamber</td>
<td>An underground structure on the sewer system containing valves which are used to isolate the flow between different parts of the sewer system. For example, flap valves prevent the flow from the river travelling back up the sewer or into the tunnel.</td>
</tr>
<tr>
<td>ventilation column</td>
<td>A stack through which air is released.</td>
</tr>
<tr>
<td>watching brief (archaeological)</td>
<td>An archaeological watching brief is a formal programme of observation and investigation conducted during any operation carried out for non–archaeological reasons.</td>
</tr>
<tr>
<td>water table</td>
<td>Level below which the ground is saturated with water. The water table elevation may vary with recharge and groundwater abstraction.</td>
</tr>
<tr>
<td>Waste Electrical and Electronic Equipment Directive (WEEE)</td>
<td>The WEEE Directive aims to reduce the amount of electrical and electronic equipment going to landfill and to encourage everyone to reuse, recycle and recover it.</td>
</tr>
<tr>
<td>White Chalk subgroup</td>
<td>Chalk with flints, with discrete marl seams, nodular chalk, sponge-rich and flint seams throughout. Flint typology and marl seam incidence is important for correlation. Comprises of Seaford Chalk, Lewes Nodular Chalk, New Pit Chalk and Holywell Nodular Chalk.</td>
</tr>
</tbody>
</table>
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Phase two consultation (Autumn 2011)

For further information see our website: www.thamestunnelconsultation.co.uk or call us on 0800 0721 086