

HS2 London and West Midlands

HS2 Berkswell and Balsall Common Tunnel Report

C254-ARP-EV-REP-040-000304

Contents

Contents	i
Executive Summary	2
1 Introduction	4
1.1 Report overview	4
1.2 Report structure	4
2 Design and development (2010-2012)	5
2.1 Introduction	5
2.2 Pre consultation route announcement	5
2.3 Post consultation route announcement	6
3 Design development and Bill deposit (2012-2013)	7
3.1 Introduction	7
3.2 Stakeholder consultation	7
3.3 Tunnel options	7
3.4 Bill Scheme	12
3.5 Summary	15
4 Bill petitioning and Select Committee (2014)	16
4.1 Introduction	16
4.2 Petitions	16
4.3 Tunnel options	16
4.4 Summary	31
5 List of acronyms and abbreviations	33
Appendix A: 2010 Consultation Route Drawing	34
Appendix B: 2012 Post Consultation Route Drawing	35
Appendix C: 2012 Tunnel Options Drawings	36
Appendix D: Bill Scheme Residual Significant Effects Drawings	37
Appendix E: 2014 Cost Comparison Tables	38
Appendix F: 2014 Tunnel Options Drawings	39

Executive Summary

In 2012 and 2014, following engagement with the Community Forum established for the Balsall Common and Hampton-in-Arden area and the receipt of petitions against the Bill respectively, a number of tunnel options were developed for the Burton Green, Berkswell and Balsall Common area. Each tunnel option was evaluated against the surface route (the post-consultation route in 2012 and the Bill Scheme in 2014) to determine the engineering and environmental benefits and disbenefits of each tunnel option, as well as the cost variance.

This report does not consider any changes proposed as a result of assurances provided to Warwickshire County Council on the revised vertical alignment of the railway in an extended green tunnel at Burton Green. These changes are yet to be brought forward and, for this reason, this report uses the Bill Scheme as a baseline.

In 2012, three tunnel options were developed and evaluated against the post-consultation route, as announced by the Secretary of State in 2012. At that stage the level of design was limited to that which could be evaluated alongside the post-consultation route and the evaluation was limited to desk-based data and professional judgement. The tunnel options developed and evaluated were:

- Option 1 – 2.5km long bored tunnel from south of Berkswell to north of Balsall Common;
- Option 2 – 4.8km long tunnel from south of Burton Green to north of Balsall Common; and
- Option 3 – 6.5km long tunnel from south of Burton Green to north of Sixteen Acre Wood.

In 2014, following the deposit of the Bill to Parliament in November 2013, a number of petitions against the Bill Scheme was received. Some of these petitions contained reference to the provision of a tunnel within the Berkswell and Balsall Common area as a means of avoiding some of the residual effects associated with the Bill Scheme. In response to requests made by petitioners, four options (two of which contained variants) were developed and an evaluation undertaken following the same approach as that undertaken in 2012.

The level of information used in this evaluation had increased significantly from the information available in 2012. Survey and other data for the Bill scheme, including ecology, archaeology, hydrology, hydrogeology, traffic, and noise monitoring, all fed into the evaluation. The tunnel options developed and evaluated were:

- Option A1 - 2.5km long bored tunnel from south of Berkswell to north of Balsall Common. The additional cost of this option would be £298m;
- Option A2 – as Option A1 with an additional approximately 500m of cut and cover tunnel to the south. The additional cost of this option would be £285m;
- Option B - 4.8km long bored tunnel from south of Burton Green to north of Balsall Common. The additional cost of this option would be £252m;
- Option C - 6.3km long bored tunnel and approximately 400m long cut and cover tunnel from south of Burton Green to north of Sixteen Acre Wood. The additional cost of this option would be £351m;

- Option D1: 1.6km long cut and cover tunnel from Lavender Hall Lane through Park Lane cutting. The additional cost of this option would be £126m; and
- Option D2: as Option D2 with an additional approximately 500m cut and cover tunnel to the north. The additional cost of this option would be £158m.

The overall outcomes of the 2012 and 2014 evaluation were very similar. Both evaluations concluded that there would be a number of community and environmental benefits associated with each tunnel option, with the magnitude of benefits increasing with the length of the tunnel. However, the tunnel options also present greater adverse impacts associated with the complexity of tunnelling activities, construction traffic and the concentration of activities at tunnel portals and intervention shafts. Mechanical, electrical and power systems, for example ventilation and drainage pumping systems, would be required within the tunnel adding to the maintenance required and operational costs.

Community and environmental benefits of tunnelling in this area include: reduced impact on landscape character and a reduction of visual effects; reduced impact on the setting of listed buildings and the Berkswell Conservation Area; and reduced impact on residential and non-residential properties experiencing noise, amenity and isolation effects. Bored tunnel options would also reduce the loss and fragmentation of ecological habitats and impacts on protected/notable species and reduce the loss of agricultural land and impacts on land holdings and agricultural buildings.

However, tunnel options are more complex than the surface route and the need for tunnelling equipment would increase the time to establish construction compounds. The tunnel options are likely to result in increased greenhouse gas emissions and energy during construction and operation. In addition, there would be a substantial increase in heavy goods movements on the highway network during the peak period. Combined with increased construction activity in the vicinity of portal locations and intervention shaft(s), where these are required, this could reduce tranquillity and air quality and result in an increase in noise, vibration, visual and amenity impacts on residential properties and users of the Public Rights of Way and highway network close to these works. Mounding and diversion of shallow groundwater flows around tunnel and tunnel portals is likely, however, it is unlikely that there would be significant adverse impacts on groundwater and the Berkswell Marsh Site of Special Scientific Interest.

The Bill Scheme has been subject to an iterative design and environmental assessment process and measures incorporated to avoid or reduce environmental effects. Measures have included: designing significant sections of the route in cutting and keeping viaducts and bridges as low as is practicably possible, both of which reduce visual and noise impacts; habitat creation; the provision of noise bunds and barriers and the provision of planting, using species native to the Arden landscape, to screen the route from sensitive views and assist in integrating the Bill Scheme into the local landscape.

Whilst it is recognised that there are certain environmental and community benefits of tunnel options when compared to the Bill Scheme, these are not considered to be substantial enough to justify the significantly higher cost.

1 Introduction

1.1 Report overview

- 1.1.1 This report has been prepared to provide a chronological account of the development of the HS2 route alignment in Burton Green, Berkswell and Balsall Common and, more specifically, an account of the consideration of tunnels as alternatives to a surface scheme. At particular points in the development of the design and in response to petitions against the Bill, a number of tunnel options have been developed and evaluated against the surface scheme. Engineering requirements, cost and potential environmental impacts of each option have been considered. This report details these tunnel options and the outcomes of the evaluation undertaken for each.
- 1.1.2 This report does not consider any changes proposed as a result of assurances provided to Warwickshire County Council on the revised vertical alignment of the railway in an extended green tunnel at Burton Green. These changes are yet to be brought forward and, for this reason, this report uses the Bill Scheme as a baseline.

1.2 Report structure

- 1.2.1 The structure of this report is as follows:
- 1.2.2 **Section 1:** This section.
- 1.2.3 **Section 2:** This section of the report provides an overview of how the route was developed in the Burton Green, Berkswell and Balsall Common area between initial route optioneering (2009) and announcement of the Scheme by the Secretary of State (2012).
- 1.2.4 **Section 3:** This section of the report provides details of three tunnel options developed in 2012 following engagement with the local communities. Each tunnel option has been evaluated alongside the post consultation route. The engineering and environmental benefits and disbenefits during construction and operation of the Scheme have been identified and reported here. A comparison of the cost of each option against the Bill Scheme has also been undertaken and is reported in this section.
- 1.2.5 In addition, Section 3 details the approach taken in the design of the Proposed Scheme to avoid or reduce environmental effects, including design and mitigation measures incorporated into the Bill Scheme.
- 1.2.6 **Section 4:** This section of the report provides details of four tunnel options (including two options with variants) at Burton Green, Berkswell and Balsall Common that were developed in 2014 following the receipt of petitions against the Bill. As with the 2012 tunnel options detailed in Section 3, engineering and environmental benefits and disbenefits have been included.

2 Design and development (2010-2012)

2.1 Introduction

2.1.1 This section of the report provides an overview of how the route was developed in the Burton Green, Berkswell and Balsall Common area between route optioneering (2009) and announcement of the Scheme by the Secretary of State (2012).

2.2 Pre consultation route announcement

2.2.1 Up to April 2009, HS2 Ltd undertook studies to generate and appraise, at a high level, a significant number of route alignment options which were grouped by geography. The West Midlands Options related to the section of the scheme from Burton Green to Lichfield and into Birmingham City Centre. The outcome of this process was a repeated sifting process whereby consideration was given to engineering, environmental and cost implications of each option in order that the number of options could be reduced. Shortlisted options were then developed further and the alignment amended in response to emerging environmental constraints. By late 2009 the number of route alignments under consideration had been reduced to three options. Further work was undertaken on developing the horizontal and vertical alignments for each of these options and further refining the design so as to avoid or reduce environmental effects. In addition, more cognisance was taken of constraints posed by existing major roads, railways and major watercourses. Of the three route alignments, one emerged as HS2 Ltd's preferred route and this was announced by the Secretary of State in January 2010.

2.2.2 In the Burton Green, Berkswell and Balsall Common area, the horizontal alignment selected avoided multiple crossings of the River Blythe and its floodplain, a Site of Special Scientific Interest (SSSI), and disruption to Berkswell Station (which serves the existing Rugby to Birmingham rail line). In order to achieve speeds of 400kph and accommodate an alignment that enabled a connection to Birmingham Interchange Station, there was limited flexibility in terms of alignment through this area.

2.2.3 As the route enters the Burton Green area, it follows the Kenilworth Greenway, passing under Cromwell Lane and parallel to Hodgett's Lane. Due to the depth of the route in this location the proposed route was to be in cutting, part of which is retained, up to the B4101 Waste Lane where a new overbridge would be constructed. The route then continues mainly on embankment to a bridge taking HS2 over the Rugby to Birmingham rail line.

2.2.4 East of Berkswell Station, the alignment diverges from the Kenilworth Greenway and crosses the Rugby to Birmingham rail line north of Balsall Common on a 50m long bridge 8m high. A major permanent diversion of the A452 Kenilworth Road will be required south of Hampton-in-Arden to lift the road over the route; this was considered to be visually less intrusive than lifting the HS2 route over the road.

2.2.5 A drawing showing the route as announced by the Secretary of State (the consultation route) in 2010 is provided in Appendix A.

2.3 Post consultation route announcement

- 2.3.1 Following consultation of the route in June 2011, a number of areas were investigated for possible route modifications intended to address concerns raised during the consultation period. Through a series of engineering reviews and workshops, various route modification options were developed and examined for viability. For a number of areas it was concluded that the modification options were not acceptable and that the consultation route proposals should remain. However, one area where an amendment was recommended for incorporation into the post-consultation route was in Berkswell and Balsall Common.
- 2.3.2 As a result of concerns raised during the consultation, the route alignment in the Burton Green, Berkswell and Balsall Common area was amended and the changes incorporated into the post consultation route announced by the Secretary of State in January 2012. At Burton Green the route was lowered and placed in a 520m long cut and cover tunnel. At Waste Lane the route alignment was amended so that it diverged eastward from the existing Kenilworth Greenway. After crossing the Rugby to Birmingham rail line, the alignment started to deviate eastward, further away from Balsall Common, and descend on a steeper gradient and therefore into a deeper cutting than the consultation route over a distance of approximately 4.5 km.
- 2.3.3 This resulted in the embankment and viaduct sections north-east of Balsall Common being up to 1.6m lower than the consultation route. North of Berkswell Station, the alignment was amended to pass alongside the Lavender Hall fishing lakes adjacent to the station on a 520m long viaduct crossing the floodplain and Truggist Lane. The alignment continued to move eastwards to achieve a maximum deviation of 90m from the consultation route in the vicinity of Park Lane. This change in alignment reduced the impact on the Grade II listed buildings at Lavender Hall Farm. The depth of cutting also increased to a maximum of approximately 14m compared with approximately 9m for the consultation route which reduced the visual impact on residential properties and users of the Public Rights of Way (PRoW) and highway network. The alignment of Park Lane was amended such that it was permanently diverted and re-joined Lavender Hall Lane on the west side of the route.
- 2.3.4 A drawing showing the route as announced by the Secretary of State (the post consultation route) in 2012 is provided in Appendix B.

3 Design development and Bill deposit (2012 - 2013)

3.1 Introduction

3.1.1 This section of the report provides details of three tunnel options developed in 2012 following engagement with the community. Each tunnel option has been designed to an outline preliminary level and evaluated against the section of the post consultation route which it would replace in terms of engineering and environmental benefits and disbenefits and cost variance. The information used in the evaluation of engineering and environmental benefits and disbenefits was limited to desk-based data, including hydrology, ecology and geology data, and professional judgement.

3.1.2 This section also provides details of the approach taken in the design of the Proposed Scheme to avoid or reduce environmental effects including measures incorporated into the scheme.

3.2 Stakeholder consultation

3.2.1 At the meeting held on 21 June 2012 at Balsall Common Village Hall the community forum requested that a design review of the vertical alignment of the Proposed Scheme was undertaken and requested that a deep bore tunnel be considered between a point north-west of B4101 Waste Lane to a location in close proximity to Berkswell Marsh SSSI.

3.2.2 Further engagement relating to tunnel options was held with Hampton-in-Arden Parish Council on 26 July 2012 and 11 January 2013.

3.3 Tunnel options

3.3.1 Following engagement with the community forum three bored tunnel options were developed and evaluated alongside the post consultation route announced in 2012. Bored tunnel was considered to be the preferred tunnelling method due to issues relating to the floodplain and the likelihood of reduced environmental impacts and when compared to the construction of a cut and cover tunnel.

3.3.2 The three tunnel options considered were as follows:

- Option 1 – 2.5km long bored tunnel from south of Berkswell to north of Balsall Common;
- Option 2 – 4.8km long bored tunnel from south of Burton Green to north of Balsall Common; and
- Option 3 – 6.5km long bored tunnel from south of Burton Green to north of Sixteen Acre Wood.

3.3.3 Drawings for each tunnel option are provided in Appendix C.

3.3.4 The level of design for each tunnel option was such that it could be evaluated alongside the post consultation route and any engineering and environmental benefits and disbenefits (during construction and operation) identified.

3.3.5 In developing each tunnel option, a number of general assumptions were made and limitations identified, as detailed below. Notwithstanding these assumptions and limitations, it was considered that, based on the information available at the time of undertaking the design and evaluation, the conclusions drawn were valid for selecting the surface-level alignment as the preferred option for the Proposed Scheme.

Assumptions

- the limits of land to be acquired beyond the tunnel construction compound areas are assumed as being generally the same as the post consultation route. However, on the approach to the tunnel portal further land would be required as the tracks would need to separate to run into the twin-bore arrangements of the tunnel;
- the cost of each tunnel option against the post consultation route was made over the same comparable length;
- costs include civil engineering, contractor's design, overheads and profit;
- internal tunnel diameter would be 11m;
- the geometrical design followed HS2 guidance for 400km/h design speed;
- at each portal there would be a construction compound;
- all options would require vehicular access to the portals for emergency access, and this would require connections to a suitable point on the highway network;
- a tunnel intervention shaft would be required where a tunnel is longer than 3km in length; and
- two tunnel boring machines being used for both tunnel bores.

Limitations

- the level of design was limited to that required for an evaluation. It was limited to defining the vertical alignment for the tunnel option, the length of the tunnel and tunnel approach cuttings;
- the design was based on a horizontal centre line design and therefore the full extent of land take was assumed from typical cross-sections;
- an assessment of operational journey impacts was not undertaken;
- an assessment of construction traffic impacts was not undertaken;
- no site investigation had been carried out and therefore an assessment of ground conditions for the tunnel options was based on limited desk-based information available at the time of the study;
- an assessment of ground movements was not undertaken and therefore the

impact of tunnelling under existing buildings and structures along the alignment of the tunnel was not considered;

- a high level assessment using industry standard tunnelling rates was undertaken to determine impacts on the construction programme;
- consideration of environmental benefits and disbenefits was limited to desk based information collated from third parties and professional judgement. No site surveys (ecology etc.) or monitoring (noise, groundwater etc.) were undertaken;
- costs exclude risk, optimisation bias, land compensation, VAT, design fees, third party costs, maintenance costs, Network Rail costs, legal fees, demolition works, disruption and possessions, fencing and environmental mitigation, and operational costs;
- the contribution of groundwater to Berkswell Marsh SSSI was not quantified; and
- no local or regional scale published hydrogeological mapping or groundwater level contour data for strata for the area of the tunnel option was available.

3.3.6 Bored tunnel options would result in a number of environmental and community benefits when compared to the post consultation route with benefits generally increasing with the length of the tunnel. The common environmental and engineering benefits and disbenefits associated with Option 1, 2 and 3 are detailed below. Where there would be additional benefits and disbenefits associated with a specific tunnel option these are detailed separately under that option.

Common bored tunnel engineering and environmental benefits

3.3.7 There would be reduced impacts on landscape character and reduced visual impacts on residential properties. The loss of heritage assets would be reduced as would the impact on listed buildings.

3.3.8 Noise levels at residential properties would be reduced as construction works would be contained underground for majority of the length of the tunnel. Reduced noise levels, dust and visual impacts would reduce overall amenity impacts on the community.

3.3.9 Reduced land required for the bored tunnel would reduce the amount of best and most versatile (BMV) agricultural land taken and there would be a reduced impact on land holdings and agricultural buildings. Reduced land take would also reduce the number of highway and PRow diversions and impacts on the floodplain.

Common bored tunnel engineering and environmental disbenefits

3.3.10 Bored tunnel options are likely to result in increased greenhouse gas emissions during construction due to increased earthworks and waste material generation. There would be a significant increase in surplus material generated which would either need to be re-used within the scheme or disposed of. There would be an increase in heavy goods

vehicle movements on the local highway network as a result of the increase in transportation of material.

- 3.3.11 The bored tunnel and tunnel portals could result in hydrogeological impacts on Berkswell Marsh SSSI and the River Blythe SSSI.

Option 1

Description

- 3.3.12 This proposed tunnel option is a 2.5km long twin bored tunnel with the southern portal in close proximity to Beechwood Farm, with a deep retained cut linking the proposed 500m long cut and cover tunnel at Burton Green. A new access road would be provided to the southern portal from the B4101 Waste Lane using the Kenilworth Greenway. The northern portal would be at the southern edge of Marlowes Wood with a new access road provided from Park Lane. The tunnel would pass underneath the Rugby to Birmingham rail line, Truggist Lane, Bayleys Brook, Lavender Hall Lane, Park Lane, and a number of PRow. The route would be broadly at ground level at the A452 Kenilworth Road, which would be re-aligned to pass over it. The route would be at almost the same horizontal alignment as the post consultation route near Hampton-in-Arden.
- 3.3.13 A drawing illustrating Option 1 is provided in Appendix C.

Option 2

Description

- 3.3.14 This proposed tunnel option is a 4.8km long twin bored tunnel with the southern portal in close proximity to Black Waste Wood and the northern portal would be located at the southern edge of Marlowes Wood with a new access road provided from Park Lane. This option would replace the cut and cover tunnel proposed at Burton Green. The tunnel would pass underneath Cromwell Lane, B4101 Waste Lane, the existing Beechwood Farm underpass, the Rugby to Birmingham rail line, Truggist Lane, Bayleys Brook, Lavender Hall Lane, Park Lane, and a number of PRow. The route would be broadly at ground level at the A452 Kenilworth Road, which would be re-aligned to pass over it. The route would be at almost the same horizontal alignment as the post consultation route near Patrick Farm and the Island Project School at Diddington Hall.
- 3.3.15 A tunnel intervention shaft¹ would be required as the tunnel is longer than 3km and would be located east of Lavender Hall Fisheries and accessed from a maintenance access track off Lavender Hall Lane.
- 3.3.16 Emergency access would be required at the southern portal from Red Lane and the northern portal from the A452 Kenilworth Road. At each portal an area of hard standing would be required for maintenance and emergency evacuation.
- 3.3.17 A drawing illustrating Option 2 is provided in Appendix C.

¹ A tunnel intervention shaft is a vertical opening connecting the tunnels to the surface and would provide access for maintenance, pressure relief from the rail tunnels and emergency intervention, and would require mechanical ventilation for smoke extraction purposes in the event of fire.

Engineering and environmental benefits

- 3.3.18 The extension of this tunnel option to the south of Burton Green would remove the need for a cut and cover tunnel and therefore reduce environmental impacts associated with cut and cover construction methods.

Engineering and environmental disbenefits

- 3.3.19 The tunnel intervention shaft would introduce visual and noise impacts to residential properties in close proximity to the shaft and would require a new access along the Kenilworth Greenway.

Option 3

Description

- 3.3.20 This proposed tunnel option is a 6.5km long twin bored tunnel with the southern portal in close proximity to Black Waste Wood and the northern portal at Cornets End Lane in close proximity to Mercote Mill Farm. This option would move the horizontal alignment further away from Balsall Common and Hampton-in-Arden. The tunnel would follow a route north-west and would pass underneath Cromwell Lane, Hodgett’s Lane, the Rugby to Birmingham rail line, Truggist Lane, Baulk Lane, and Lavender Hall Lane. Unlike Options 1 and 2 this option would probably need to pass over the A452 Kenilworth Road. The proposed cut and cover tunnel at Burton Green would be replaced with this option.
- 3.3.21 Two tunnel intervention shafts would be required as the tunnel is longer than 6km. The intervention shafts would be located between the B4101 Waste Lane and the Rugby to Birmingham rail line, with access off Hodgett’s Lane, and between Park Lane and the B4102 Meriden Road, with access off Lavender Hall Lane.
- 3.3.22 Emergency access would be required at the southern portal from Red Lane and the northern portal from the A452 Kenilworth Road via Mercote Hall Lane. At each portal an area of hard standing would be required for maintenance and emergency evacuation.
- 3.3.23 A drawing illustrating Option 3 is provided in Appendix C.

Engineering and environmental benefits

- 3.3.24 The extension of this tunnel option to the south of Burton Green would remove the need for a cut and cover tunnel and therefore reduce environmental impacts associated with cut and cover construction methods.
- 3.3.25 Passing over the A452 Kenilworth Road would reduce land take and associated loss of habitats that would be required if the road was realigned.

Engineering and environmental disbenefits

- 3.3.26 Impacts on the setting of the listed buildings at Mouldings Green Farm and Diddington Hall would increase due to their closer proximity to the route.

- 3.3.27 The alignment for this option would be closer to the Island Project School and therefore there is potential for greater noise and visual impacts and there is potential for increased noise and visual impacts to residential properties in close proximity to the tunnel intervention shafts.

3.4 Bill Scheme

- 3.4.1 The sensitivity of the Burton Green, Balsall Common and Berkswell area in terms of local communities, landscape character and unrestricted views, and historic and ecological interest has been a key consideration in the development of the design for the Proposed Scheme in the area.
- 3.4.2 As part of the iterative design and assessment process a number of local alternatives² have been considered and measures incorporated into the scheme to avoid or reduce environmental effects. Key measures have included:
- significant sections of the route are in cutting, which reduces visual and noise impacts on residential and recreational receptors and on the setting of heritage assets;
 - the crossing over the Rugby to Birmingham rail line (Carol Green underbridge) as a single span bridge structure, has been kept as low as possible to reduce the visual impact of the underbridge on neighbouring residential properties and users of Footpath M192, with landscaped embankments to integrate the structure into the local landscape character;
 - the structural form of viaducts as multi-span structures with concrete beams reduces the structural depth of the deck to minimise visual and noise impacts on local residential properties along with impacts on floodplains and flood flows, fauna and riparian habitats;
 - amending the Scheme to allow B4102 Meriden Road to remain open;
 - the permanent offline realignment of the A452 Kenilworth Road, which reduces impacts on Marsh Lane Nature Reserve and surrounding residential properties;
 - the diversion of Park Lane and provision of planting to reduce impacts on the Berkswell Estate; and
 - avoiding the loss of marshy grassland at Berkswell Marsh SSSI and semi-natural woodland on the Berkswell Estate.
- 3.4.3 An assessment has been undertaken of the likely significant environmental effects during construction and operation of the Scheme in this area.
- 3.4.4 As is commonplace with major infrastructure works, the scale of the construction activities in a predominantly rural setting means that works will have the potential to

² As part of the design development process a series of local alternatives have been reviewed. The main local alternatives considered for the Scheme in this area are reported in CFA 18: Kenilworth, Stoneleigh and Burton Green, and CFA 23: Balsall Common and Hampton-in-Arden, in Volume 2 of the Environmental Statement.

give rise to significant temporary and sometimes permanent effects. Where it is concluded that the Proposed Scheme will result in a significant change to the existing baseline conditions found within and around the route of the scheme, mitigation measures have been included where reasonably practicable in the design to either minimise or reduce the effect. Examples of specific mitigation measures incorporated in the scheme include:

- creation of the following habitats in the Balsall Common and Hampton-in-Arden area (Community Forum Area 23 (CFA 23³)):
 - approximately 3.8ha of marshy grassland, including locations to the east of the Blythe Bypass embankment and Patrick cutting, Farm Meadow Local Wildlife Site and, north of Marsh Lane Nature Reserve;
 - approximately 23ha of broadleaved woodland, including locations at Marsh Farm, within the Berkswell Estate at Marlowes Wood, and alongside the Kenilworth Greenway;
 - approximately 5.8km of native species-rich hedgerow, including locations alongside the Kenilworth Greenway, Park Lane cutting, and the diverted sections of Park Lane and the A452 Kenilworth Road; and
 - approximately 10ha of neutral grassland habitat on the south-west embankment on the existing A452 Kenilworth Road alongside Marsh Lane Nature Reserve and at Beechwood Farm embankment.
- maximising the retention and protection of existing trees and vegetation, where possible, and providing new planting, including native broad-leaved woodland, shrub and hedgerows, to aid integration of the Scheme into the local landscape and to assist in screening the route from residential properties and users of PRow. This will be implemented at areas such as:
 - Beechwood embankment;
 - land adjacent to Lavender Hall Lane;
 - Footpath M215 overbridge; and
 - A452 Kenilworth Road realignment.
- provision of noise barriers and bunds to avoid or reduce noise effects on residential and non-residential properties. Barrier heights vary dependant on form (i.e. fence, cutting or bund) but are typically designed to provide equivalent performance to a noise fence barrier with a top level 3m above the top of the rail and 5m to the side of the outer rail. Locations of noise mitigation include the following:

³ Phase 1 of the HS2 route is split geographically into 26 community forum areas.

- on both sides of the route alignment in the vicinity of Beechwood Farm and Truggist Lane;
- on both sides of the route alignment on the Balsall Common viaduct (higher 4m fence on the western side);
- on the west side of the route alignment adjacent to the villages of Balsall Common and Wootton Green;
- on the west side of the route alignment adjacent to the village of Hampton-in-Arden (higher 4m fence); and
- on both sides of the route alignment in the vicinity of the Island Project School, Diddington Farm and Pasture Farm.

3.4.5 Notwithstanding the design and mitigation measures incorporated into the Scheme, some significant residual effects will remain during both construction and operation phases. The majority of the significant residual effects relate to the construction stage, and these effects are consequently largely temporary in nature, lasting only for the duration of the construction works. Examples of residual significant effects during construction and operation are detailed below. A drawing showing the Bill Scheme residual significant effects is provided in Appendix D.

Residual significant effects

Construction stage effects

- loss of best and most versatile agricultural land and impacts on agricultural holdings;
- effects on the amenity of residents at properties on Truggist Lane, Lavender Hall Lane, Park Lane and properties off the A452 Kenilworth Road and the staff and pupils at The Island Project School at Diddington Hall, users of the Lavender Hall Fisheries and the diverted Kenilworth Greenway;
- loss of Berkswell Clay Pigeon Shooting Club and Heart of England Aeromodellers Club;
- effects on the setting of listed buildings and the permanent loss of archaeological assets;
- effects on landscape character and views from PRow and isolated residential properties on higher ground in the vicinity of Lavender Hall Lane and Marsh Lane;
- noise effects on residential properties/communities that are closest to construction activity including; Truggist Lane, Lavender Hall Lane, A452 Kenilworth Road (section north of Balsall Common), British Legion club, Bibury House guest house, Patrick Farm, and the Island Project School; and
- delays and congestion for motorised users of the A452 Kenilworth Road, Park Lane, Truggist Lane and Spencer Lane and non-motorised users of footways and PRow, including the Kenilworth Greenway.

Operational stage effects

- effects on the amenity of residents of properties on Truggist Lane, Old Waste Lane and Diddington Lane;
- effects on landscape character, and views from residential properties on Baulk Lane, Lavender Hall Lane and Diddington Lane and users of PRow, which will reduce over time as mitigation planting matures;
- noise effects on residential properties closest to scheme in the following locations:
 - B4101 Waste Lane, Old Waste Lane and Hodgett's Lane;
 - Truggist Lane and Baulk Lane; and
 - Diddington Lane.
- increased journey times for users of Diddington Lane and Marsh Lane, and increased severance for pedestrians and cyclists on sections of the A452 Kenilworth Road, and on the B4102 Meriden Road.

3.5 Summary

- 3.5.1 The evaluation of the options determined that the surface-level solution was to be taken forward as the Proposed Scheme.
- 3.5.2 All three alternative tunnel options would have benefits in comparison to the Proposed Scheme including reducing the loss of agricultural land, reduced disruption to field patterns, reduced archaeological impacts and reduced visual and amenity impacts on neighbouring residential properties and users of PRow. However, the alternative tunnelling options would have potentially greater adverse impacts on the groundwater regime and indirectly on Berkswell Marsh SSSI. The tunnel portals would require access and hard standing areas, with the access track to the exit portal located within Berkswell Marsh SSSI. In addition, the tunnel options would be likely to result in increased greenhouse gas emissions and generate more waste material and waste water during construction and cause greater air quality, noise and vibration and traffic impacts during movement of excavated material (including tunnel arisings). Permanent pumping facilities might need to be constructed where passive drainage of water was not possible.
- 3.5.3 The three alternative tunnel options would also be substantially more expensive than the Proposed Scheme. While the alternatives were considered to have environmental and community benefits, they would present other environmental effects. While the magnitude of the benefits would increase with tunnel length, these were not considered to be substantial enough to justify the increased cost.

4 Bill petitioning and Select Committee (2014)

4.1 Introduction

- 4.1.1 This section of the report provides details of four tunnel options at Burton Green, Berkswell and Balsall Common that have been developed in 2014 following the receipt of petitions against the Bill in which requests have been made for tunnelling along this section of the route. Each tunnel option has been designed to an outline preliminary level and evaluated against the section of the Bill Scheme which it would replace in terms of engineering and environmental benefits and disbenefits and cost variance. A cost comparison for each tunnel option is provided in Appendix E.
- 4.1.2 The level of information used in this evaluation has increased significantly from the information used to evaluate the three tunnel options developed in 2012. Since 2012 a number of surveys have been undertaken throughout Burton Green, Berkswell and Balsall Common and the surrounding areas, including those relating to ecology, archaeology, flood, open space and PRoW usage, traffic, and noise monitoring. In addition, work has been undertaken in relation to Berkswell Marsh SSSI, including considering the hydraulic continuity between superficial deposits and Bayleys Brook and the extent of surface and groundwater catchment areas.

4.2 Petitions

- 4.2.1 Within the Metropolitan Borough of Solihull, a number of petitions against the Bill were made. Some of these petitions contained a request that, at a location specified by the petitioner, the surface Scheme be replaced by a tunnel so as to avoid some of the significant effects associated with the scheme (as reported in Volumes 2 and 5 of CFA 23: Balsall Common and Hampton-in-Arden Environmental Statement (ES)).
- 4.2.2 A petition has also been received from Solihull Metropolitan Borough Council (481) which requests that an assessment of options for a tunnel extending from north of Balsall Common to south of Burton Green be undertaken, including cost benefit analysis and a full consideration of the environmental impacts. This review is intended to address that request. Cost comparison for each option against the relevant section of the Bill Scheme is provided in Appendix E. Given the level of design of each tunnel option, it is not possible to undertake an environmental impact assessment (EIA) of each tunnel option to the same level of detail as the Bill Scheme; instead an evaluation of the environmental and engineering benefits and disbenefits of each option has been undertaken and is reported by option below.

4.3 Tunnel options

- 4.3.1 Petitions received in relation to a request for a tunnel were reviewed and four tunnel options (three bored tunnels and one cut and cover tunnel), were developed as detailed below.

- Option A

- Option A1: 2.5km long twin bored tunnel from south of Berkswell to north of Balsall Common; and
- Option A2: 2.5km long twin bored tunnel and 0.5km long cut and cover tunnel (3km long tunnel in total) from south of Berkswell to north of Balsall Common.
- Option B: 4.8km long twin bored tunnel from south of Burton Green to north of Balsall Common;
- Option C: 6.3km long twin bored tunnel and 0.4km long cut and cover tunnel (6.7km long tunnel in total) from south of Burton Green to north of Sixteen Acre Wood; and
- Option D
 - Option D1: 1.6km long cut and cover tunnel from Lavender Hall Lane through Park Lane cutting; and
 - Option D2: 2km long cut and cover tunnel from Lavender Hall Lane to Sixteen Acre Wood.

4.3.2 Drawings for each tunnel option are provided in Appendix F.

4.3.3 The level of design for each tunnel option was such that it could be evaluated alongside the Bill Scheme and engineering and environmental benefits and disbenefits during construction and operation of the scheme could be identified.

4.3.4 In developing each tunnel option a number of general assumptions were made and limitations identified, as detailed below. Notwithstanding these assumptions and limitations it is considered that an appropriate level of evaluation has been undertaken and the conclusions drawn are valid.

Assumptions

- there would be no change to operational highway traffic flows compared with the Bill Scheme;
- the area of land between the tunnel construction compounds is not required for construction with the exception of defined construction routes and tunnel intervention shafts;
- the limit of land to be acquired beyond the tunnel construction compound areas (i.e. south of the southern portal and north of the northern portal) is assumed as being the same as the Bill Scheme;
- at each portal there would be a construction compound. At the northern portal there would be temporary workers' accommodation, a roadhead, a materials processing centre, a concrete batching plant, a logistics centre and an area for the temporary storage of stockpile material;
- all bored tunnel construction and excavated material disposal would be from

the northern portal;

- bored tunnel and cut and cover tunnel would be constructed using the methods described in Volume 1, Section 6.11 and 6.12 and Section 5.5 and 6.12.13 of the ES respectively;
- the diameter of the tunnel bore used in the evaluation is as other tunnels used on Phase 1 (8.8m). Therefore it is assumed that the maximum operating speed is 320 km/h;
- the geology maps, associated explanatory notes and borehole records published by the British Geological Survey (BGS) are representative of the solid geology, position and nature of geological faults and superficial geology and groundwater levels. Professional judgement has been used to interpret borehole data and generate geological long- and cross-sections to understand the geological and hydrogeological conditions; and
- Berkswell Marsh SSSI is a partially groundwater dependent terrestrial ecosystem.

Limitations

- the level of design has been limited to that required for an evaluation against the Bill Scheme to be undertaken. It is limited to defining the vertical alignment, areas required for construction (including compounds) and construction traffic routes;
- consideration of HGV construction traffic is limited to the main construction routes. In general, changes in HGV construction traffic flows have not been considered beyond the limit of each tunnel option. No account has been taken of the change in impact of worker trips or light goods vehicle (LGV) movements at this stage;
- consideration of changes to the environmental effects reported in the ES is limited to the information collated during the assessment of the Bill Scheme. In locations where the tunnel option extends outside of previous survey areas (including noise monitoring locations) available desk-based information and professional judgment has been applied;
- an assessment of ground movements has not been undertaken for the tunnel options and therefore the impact of tunnelling on existing buildings and structures along the alignment of the tunnel cannot be appraised at this stage;
- costs exclude risk and optimisation bias, demolition works, disruption and possessions, fencing and environmental mitigation;
- no site investigation or monitoring of levels, flows or quality for groundwater or surface water has been undertaken;
- the contribution of groundwater to Berkswell Marsh SSSI has not been quantified, however a qualitative appraisal has been undertaken; and
- there is no local or regional scale published hydrogeological mapping or

groundwater level contour data for strata for the area of the tunnel option.

- 4.3.5 Bored tunnel options (Option A, B and C) would result in a number of environmental and community benefits when compared to the Bill Scheme with benefits generally increasing with the length of the tunnel. However, tunnel options present greater adverse impacts associated with the complexity of tunnelling activities, such as increased HGV movements and the concentration of activities at tunnel portals and intervention shafts. The common environmental and engineering benefits and disbenefits associated with Options A, B and C is detailed below. Where there are additional benefits and disbenefits associated with a specific tunnel option these are detailed separately under that option.
- 4.3.6 The benefits and disbenefits associated with a cut and cover tunnel (Option D) are different to those associated with bored tunnel options because the construction methodology is different. As such, the benefits and disbenefits associated with Option D are reported separately below.

Common bored tunnel engineering and environmental benefits

- 4.3.7 Bored tunnel options would avoid disruption of existing infrastructure such as the crossing of the Rugby to Birmingham rail line and the realignment of Bayleys Brook in the vicinity of Balsall Common. A number of footways and PRow would no longer require temporary or permanent diversion and Truggist Lane and Lavender Hall Lane would no longer need to be temporarily closed. This would reduce delays to road users, including users of public transport, and non-motorised users.
- 4.3.8 There would be a reduced impact on landscape character and a reduction of visual effects on local residents and users of the PRow and highway network as a result of the reduction of infrastructure and construction compounds. The loss of non-designated heritage assets would be reduced as would the impact on the setting of listed buildings and the Berkswell Conservation Area. A number of residential properties, community facilities and business would experience a reduction in noise, with a reduced number of properties qualifying for noise insulation, and amenity and isolation effects.
- 4.3.9 The reduced land required for bored tunnels would reduce the loss and fragmentation of ecological habitats and impacts on protected/notable species and reduce the loss of BMV agricultural land and have a reduced impact on land holdings and agricultural buildings.
- 4.3.10 A single-storey building at a property accessed off Truggist Lane, adjacent to the Rugby to Birmingham rail line, demolished under the Bill Scheme, would be retained.

Common bored tunnel engineering and environmental disbenefits

- 4.3.11 Bored tunnel options are likely to result in increased greenhouse gas emissions and energy use as a higher quantity of earthworks movements and waste would be required during construction. In addition, greater acceleration and deceleration of the trains each side of the tunnel and the operation of the tunnel systems (such as

ventilation) would increase greenhouse gas emissions and energy use during operation.

- 4.3.12 There would be a significant increase in HGV movements on the local highway network during the peak construction period, as a result of the increase in transportation of material. The increased HGV movements would result in congestion and traffic delays as well as impacts on severance for non-motorised users. Increase in HGV movements for each bored tunnel option is detailed separately under each option. An increase in construction traffic, in addition to construction activity, could reduce tranquillity and air quality and result in an increase in noise, vibration, visual and amenity impacts on residential properties and users of the PRoW and highway network in the vicinity of portal locations and intervention shaft(s) (for Options B and C).
- 4.3.13 The bored tunnel and tunnel portals could result in changes to groundwater flows and mounding and diversion of shallow groundwater behind tunnel portals. Construction of the tunnels is likely to require dewatering. There is the potential for diversion of groundwater flow from Bayleys Brook and the Berkswell Marsh SSSI, although this is not considered to impact on the integrity of the SSSI. The southern end of the tunnels would cross a geological fault line close to potential water-bearing sandstone bands.
- 4.3.14 The area of land required for the northern compound would increase the severance and sterilisation of the coal, sand and gravel Mineral Safeguarding Area (MSA) and the Marsh Farm preferred area for mineral extraction.
- 4.3.15 There is a potential requirement for mitigation measures (e.g. grouting or underpinning) to limit ground settlement induced damage to third party assets (e.g. railway, utility lines and buildings) subject to an assessment of ground movements. The outputs of the assessment may identify additional works to the area above the tunnel.
- 4.3.16 Additional emergency and maintenance access arrangements would be more complex as trackside vehicle access cannot be provided through the tunnel bore and therefore access would be via stair access at the tunnel portals.
- 4.3.17 Mechanical, electrical, and power (MEP) systems, for example ventilation and drainage pumping systems, would be required within the tunnel adding to the maintenance required.
- 4.3.18 The need for tunnelling equipment would increase the time to establish construction compounds due to the equipment required and tunnel working introduces construction and maintenance risks due to working in confined spaces.

Option A

Option A1

Description

- 4.3.19 This proposed tunnel option is a 2.5km long twin bored tunnel which would replace the Bill Scheme between a location approximately 100m north-west of the Footpath

W168 underpass and Marsh Farm viaduct⁴. The southern portal would be located in close proximity to Beechwood Farm, with a deep retained cutting linking it with the proposed cut and cover tunnel at Burton Green. The tunnel would pass underneath the Rugby to Birmingham rail line, Truggist Lane, Bayleys Brook, Lavender Hall Lane, Park Lane, and a number of PRow. The northern portal would be located at the southern edge of Marlowes Wood. The tunnel would broadly follow the same horizontal alignment as the Bill Scheme.

4.3.20 The scope for portal locations with this option is limited to the south at the location of Burton Green cut and cover tunnel and to the north at Marsh Farm viaduct where the route crosses over Bayleys Brook and near to Berkswell Marsh SSSI.

4.3.21 The following Bill structures would be amended with this tunnel option:

- Footpath M186 overbridge – the structure would be longer as the clearance between the tracks widens on the approach to the tunnel;
- B4101 Waste Lane overbridge – the overbridge would span across the retained cutting and the finished road level would be similar to its existing ground level;
- Beechwood Farm accommodation underpass – this would be an overbridge and would span across the retained cutting; and
- Beechwood culvert – the culvert would either be diverted over the southern tunnel portal or span across the retained cutting.

4.3.22 The following Bill structures would be removed with this tunnel option:

- Truggist Hill culvert;
- Footpath M191 underpass;
- Carol Green Rail underbridge;
- Lanscombe culvert;
- Balsall Common viaduct;
- Footpath M191 accommodation underpass;
- Lavender Hall Lane overbridge; and
- Footpath M214 overbridge.

4.3.23 Construction of the tunnel will have a broadly similar impact on Kenilworth Greenway as the Bill Scheme, with the Greenway being temporarily diverted during construction to allow for the railway to be built. During operation the Greenway would be reinstated, possibly offline, though precise details of this are unavailable at this stage of design.

⁴ For a more detailed description of the Bill Scheme at the location which the tunnel option has been considered refer to of the area reports CFA 18: Kenilworth, Stoneleigh and Burton Green, and CFA 23: Balsall Common and Hampton-in-Arden, in Volume 2 of the Environmental Statement.

4.3.24 As is the case with all tunnel options, tunnelling and directly associated activities (such as the removal of excavated material, supply of materials and maintenance of tunnelling equipment) would be carried out on a 24-hours-a-day, seven-days-a-week basis. Where reasonably practicable, material would be stockpiled within the worksite for removal during core working hours.

4.3.25 The northern tunnel portal main construction compound would be used to manage the construction of the tunnel. A concrete batching plant to supply concrete, a concrete pre-casting facility to manufacture concrete elements such as tunnel segments, a temporary materials stockpile, and temporary workers' accommodation would also be located at this compound.

Material excavated from the southern portal and southern section of retained cutting would be hauled along the B4101 Waste Lane and then towards the north along the A452 Kenilworth Road. The location of where this material would be used or disposed of has not yet been determined. Material from the northern portal and tunnel would be processed and hauled via the site access off the roundabout at Bradnock's Marsh and then north along the A452 Kenilworth Road. There would also be an access off Park Lane.

4.3.26 A pumping station would be required in a tunnel cross passage with storage tanks required at the tunnel portal.

4.3.27 A drawing illustrating Option A1 is provided in Appendix F.

Engineering and environmental benefits

4.3.28 The Berkswell Clay Pigeon Shooting Club site would be retained and there would be no requirement to take part of the Lavender Hall Fisheries site.

Engineering and environmental disbenefits

4.3.29 There would be a significant increase in daily HGV movements on the local highway network during the construction peak period, as a result of the increase in transportation of material, including on the A452 Kenilworth Road south of Stonebridge Island (110% increase on the Bill Scheme), A452 Kenilworth Road through Balsall Common (363% increase on the Bill Scheme), B4101 Kelsey Lane (363% increase on the Bill Scheme), B4101 Waste Lane (600% increase on the Bill Scheme) and Park Lane (60% increase on the Bill Scheme). The increased HGV movements would result in congestion and traffic delays as well as impacts on severance for non-motorised users.

Option A2

Description

4.3.30 This tunnel option is the same as Option A1, but with an additional 485m of cut and cover tunnel to the south end of the tunnel⁵. The overall length of this tunnel option would be 3km. The tunnel portal in the south would be located approximately 300m north of the B4101 Waste Lane.

⁵ For a more detailed description of the Bill Scheme at the location which the tunnel option has been considered refer to of the area reports CFA 18: Kenilworth, Stoneleigh and Burton Green, and CFA 23: Balsall Common and Hampton-in-Arden, in Volume 2 of the Environmental Statement.

4.3.31 The following Bill structures would be additionally removed with this tunnel option:

- Beechwood Farm accommodation underpass; and
- Beechwood culvert.

4.3.32 As with Option A1 the Kenilworth Greenway would be temporarily diverted during construction and reinstated.

4.3.33 A drawing illustrating Option A2 is provided in Appendix F.

Engineering and environmental benefits

4.3.34 The engineering and environmental benefits are as those described in Option A1.

Engineering and environmental disbenefits

4.3.35 This option would further increase in daily HGV movements on the highway network during the construction peak period, including on the A452 Kenilworth Road south of Stonebridge Island (9 % increase on the Bill Scheme), A452 Kenilworth Road through Balsall Common (363% increase on the Bill Scheme), B4101 Kelsey Lane (363% increase on the Bill Scheme), B4101 Waste Lane (600% increase on the Bill Scheme) and Park Lane (9% increase on the Bill Scheme).

4.3.36 The cut and cover section of this option also increases complexity due to the construction of the roof slab.

Option B

Description

4.3.37 This proposed tunnel option is a 4.8km long twin bored tunnel which would replace the Bill Scheme between a location 300m south-east of Broadwells Wood and Marsh Farm viaduct⁶.

4.3.38 The southern portal would be located in close proximity to Black Waste Wood and the northern portal would be located at the southern edge of Marlowes Wood. The tunnel would pass underneath Cromwell Lane, B4101 Waste Lane, the existing Beechwood Farm underpass, the Rugby to Birmingham rail line, Truggist Lane, Bayleys Brook, Lavender Hall Lane, Park Lane, and a number of PRoW. This option would replace the cut and cover tunnel proposed at Burton Green. The tunnel would broadly follow the same horizontal alignment as the Bill Scheme.

4.3.39 The scope for portal locations with this option is limited to the south by replicating the approximate position of the southern portal of the Burton Green cut and cover tunnel (as in the Bill scheme) so as to tie in to the existing route alignment and to the north at Marsh Farm viaduct where the route crosses over Bayleys Brook and is located in close proximity to Berkswell Marsh SSSI.

⁶ For a more detailed description of the Bill Scheme at the location which the tunnel option has been considered refer to of the area reports CFA 18: Kenilworth, Stoneleigh and Burton Green, and CFA 23: Balsall Common and Hampton-in-Arden, in Volume 2 of the Environmental Statement.

- 4.3.40 A tunnel intervention shaft would be required as the tunnel is longer than 3km and would be located south of Beechwood Farm adjacent to Kenilworth Greenway. A tunnel headhouse building would be located at each tunnel portal and these would contain the control equipment for the tunnel and ventilation fans. An area of hard-standing next to the headhouse building would allow for maintenance and emergency access and egress from the tunnel.
- 4.3.41 The following Bill structures would be removed with this tunnel option. None of the Bill structures would need amending with this option.
- Burton Green tunnel and tunnel portals;
 - Footpath M186 overbridge;
 - B4101 Waste Lane overbridge;
 - Beechwood Farm Accommodation underbridge;
 - Beechwood culvert;
 - Truggist Hill culvert;
 - Footpath M191 underpass;
 - Carol Green Rail underbridge;
 - Lanscombe culvert;
 - Balsall Common viaduct;
 - Footpath M191 Accommodation underpass;
 - Lavender Hall Lane overbridge; and
 - Footpath M214 overbridge.
- 4.3.42 The Auto-transformer Feeder Station currently proposed at Burton Green would be relocated to a tunnel portal or intervention shaft headhouse.
- 4.3.43 Construction of the southern tunnel portal would minimise disruption to users of the Kenilworth Greenway by removing works through and north of Burton Green. Some minor diversions of the Greenway during construction would likely to be required around the new portal construction site with the Greenway being reinstated upon completion of the works. Access to the new portal from Red Lane would likely cross the Greenway at grade.
- 4.3.44 The northern tunnel portal main construction compound would be used to manage the construction of the tunnel. A concrete batching plant to supply concrete, a concrete pre-casting facility to manufacture concrete elements such as tunnel segments, a temporary materials stockpile, and temporary workers' accommodation would also be located at this compound.
- 4.3.45 Materials would be brought into and out of the northern site compound from an access/egress formed off an existing roundabout on the A452 Kenilworth Road at Bradnock's Marsh. The construction haul route for the southern tunnel portal would

be along the A452 Kenilworth Road, then B4101 Kelsey Lane, Windmill Lane, Hob Lane, then onto Cromwell Lane and Red Lane to the southern tunnel portal. There would also be an access off Park Lane. The construction haul route for the tunnel intervention shaft would be along the A452 Kenilworth Road, then along the B4101 Kelsey Lane and the B4101 Waste Lane. A construction compound would be required at the intervention shaft. The location of where excavated material would be used or disposed of has not yet been determined.

4.3.46 A pumping station would be required at the intervention shaft with storage tanks located at surface level.

4.3.47 A drawing illustrating Option B is provided in Appendix F.

Engineering and environmental benefits

4.3.48 The Berkswell Clay Pigeon Shooting Club site, No's 303, 305 and 404 Cromwell Lane, Burton Green village hall and Odnauil End Farm would be retained and there would be no requirement to take part of the Lavender Hall Fisheries site.

Engineering and environmental disbenefits

4.3.49 There would be a significant increase in daily HGV movements on the highway network during the construction peak period, as a result of the increase in transportation of material, including on the A452 Kenilworth Road south of Stonebridge Island (73% increase on the Bill Scheme), A452 Kenilworth Road through Balsall Common (175% increase on the Bill Scheme), B4101 Kelsey Lane (175% increase on the Bill Scheme), Hobb Lane (597% increase on the Bill Scheme) and Park Lane (100% increase on the Bill Scheme). The increased HGV movements would result in congestion and traffic delays as well as impacts on severance for non-motorised users.

4.3.50 Supplying power to the railway would be more challenging as the tunnel prohibits direct access to the existing substation at Burton Green. Power supply routes are therefore likely to have to be diverted into an intermediate tunnel intervention shaft to supply power to HS2.

4.3.51 A tributary of Canley Brook at Burton Green/Black Waste Wood would need to be realigned to cross the retained cutting and there would be the potential to impact on local shallow groundwater levels, several ponds, and a spring. There would be an increased impact on listed buildings and the setting of Black Waste Wood, an ancient woodland, which would be in close proximity to the southern portal.

Option C

Description

- 4.3.52 This proposed tunnel option is a 6.3km long twin bored tunnel and 0.4km long cut and cover tunnel which would replace the Bill Scheme between a location 300m south-east of Broadwells Wood and the River Blythe viaduct⁷.
- 4.3.53 The southern portal would be located in close proximity to Black Waste Wood and the northern portal would be located at Mercote Hall Lane (Bridleway M218) where the road would be reinstated over the tunnel. The tunnel would pass underneath Cromwell Lane, the B4101 Waste Lane, the existing Beechwood Farm underpass, the Rugby to Birmingham rail line, Truggist Lane, Bayleys Brook, Lavender Hall Lane, Park Lane, Mercote Hall Lane, a number of PRow. This option would replace the green tunnel proposed at Burton Green. The tunnel would broadly follow the same horizontal alignment as the Bill Scheme.
- 4.3.54 The scope for portal locations with this option is limited to the south by replicating the approximate position of the southern portal of the Burton Green cut and cover tunnel (Bill scheme) so as to tie in to the existing route alignment, and to the north at the B4101 Meriden Road underbridge and the River Blythe viaduct where the route alignment crosses over the River Blythe.
- 4.3.55 Two tunnel intervention shafts would be required as the tunnel is longer than 6km, and these would be located south of Beechwood Farm, adjacent to Kenilworth Greenway, and at Park Lane. A tunnel headhouse building would be located at each tunnel portal and these would contain the control equipment for the tunnel and ventilation fans. An area of hard-standing next to the headhouse building would allow for maintenance and emergency access and egress from the tunnel.
- 4.3.56 Bayleys Brook would be temporarily diverted during construction and reinstated over the cut and cover tunnel upon completion. In addition a permanent alternative diversion of the River Blythe Bypass culvert would be required.
- 4.3.57 The following Bill structures would be removed with this tunnel option. None of the Bill Scheme structures would need amending with this option.
- Burton Green cut and cover tunnel and tunnel portals;
 - Footpath M186 overbridge;
 - B4101 Waste Lane overbridge;
 - Beechwood Farm Accommodation underbridge;
 - Beechwood culvert;
 - Truggist Hill culvert;
 - Footpath M191 underpass;

⁷ For a more detailed description of the Bill Scheme at the location which the tunnel option has been considered refer to of the area reports CFA 18: Kenilworth, Stoneleigh and Burton Green, and CFA 23: Balsall Common and Hampton-in-Arden, in Volume 2 of the Environmental Statement.

- Carol Green Rail underbridge;
- Lanscombe culvert;
- Balsall Common viaduct;
- Footpath M191 Accommodation underpass;
- Lavender Hall Lane overbridge;
- Footpath M214 overbridge;
- Footpath M215 overbridge;
- Marsh Farm Viaduct; and
- Mercote Hall Lane (Bridleway M218) Accommodation overbridge.

4.3.58 The Auto-transformer Feeder Station currently proposed at Burton Green would be relocated to a tunnel portal or intervention shaft headhouse.

4.3.59 Construction of the southern tunnel portal would minimise disruption to users of the Kenilworth Greenway by removing works through and north of Burton Green. Some minor diversions of the Greenway during construction would be likely to be required around the new portal construction site with the Greenway being reinstated upon completion of the works. Access to the new portal from Red Lane would likely cross the Greenway at grade.

4.3.60 The northern tunnel portal main construction compound would be used to manage the construction of the tunnel. A concrete batching plant to supply concrete, a concrete pre-casting facility to manufacture concrete elements such as tunnel segments, a temporary material stockpile, and temporary workers' accommodation would also be located at this compound.

4.3.61 Materials would be brought into and out of the northern site compound from an access/egress formed off an existing roundabout on the A452 Kenilworth Road at Bradnock's Marsh. The construction haul route for the southern tunnel portal would be along the A452 Kenilworth Road, then B4101 Kelsey Lane, Windmill Lane, Hob Lane, then onto Cromwell Lane and Red Lane to the southern tunnel portal. There would also be an access off Park Lane. The construction haul route for the first tunnel intervention shaft would be along the A452 Kenilworth Road, then along the B4101 Kelsey Lane and the B4101 Waste Lane. The construction haul route for the second tunnel intervention shaft would be from the A452 Kenilworth Road, and then along Park Lane. Construction compounds would be required at both tunnel shafts. The location of where excavated material would be used or disposed of has not yet been determined.

4.3.62 A pumping station would be required at the intervention shaft with storage tanks located at surface level.

4.3.63 A drawing illustrating Option C is provided in Appendix F.

Engineering and environmental benefits

- 4.3.64 The Berkswell Clay Pigeon Shooting Club site, No's 303, 305 and 404 Cromwell Lane, Burton Green village hall and Odnauil End Farm would be retained and there would be no requirement to take part of the Lavender Hall Fisheries site.
- 4.3.65 There would be a reduction in the loss of commercial forestry.

Engineering and environmental disbenefits

- 4.3.66 There would be a significant increase in daily HGV movements on the highway network during the construction peak period, as a result of the increase in transportation of material, including on the A452 Kenilworth Road south of Stonebridge Island (68% increase on the Bill Scheme), A452 Kenilworth Road through Balsall Common (134% increase on the Bill Scheme), B4101 Kelsey Lane (134% increase on the Bill Scheme), Windmill Lane (494% increase on the Bill Scheme), Hobb Lane (494% increase on the Bill Scheme), Cromwell Lane at the junction of Red Lane (494% increase on the Bill Scheme), and Red Lane (494% increase on the Bill Scheme). The increased HGV movements would result in congestion and traffic delays as well as impacts on severance for non-motorised users.
- 4.3.67 The cut and cover section of this option increases complexity in constructing the tunnel and retaining walls, due to the proximity of Berkswell Marsh SSSI and Bayleys Brook floodplain, and the construction of the roof slab.
- 4.3.68 Supplying power to the railway would be more challenging as the tunnel prohibits direct access to the existing substation at Burton Green. Power supply routes are therefore likely to have to be diverted into an intermediate tunnel intervention shaft to supply power to HS2.
- 4.3.69 A tributary of Canley Brook at Burton Green/Black Waste Wood would need to be realigned to cross the retained cutting and there would be the potential to impact on local shallow groundwater levels, several ponds, and a spring. There would be an increased impact on listed buildings and the setting of Black Waste Wood, an ancient woodland, which would be in close proximity to the southern portal.

Option D

Option D1

Description

- 4.3.70 This proposed tunnel option is a 1.6km long cut and cover tunnel with the southern portal at Lavender Hall Lane and the northern portal just south of Sixteen Acre Wood. This option would replace a section of Park Lane cutting, with the cutting being modified so it can be covered⁸.
- 4.3.71 The southern tunnel portal would be located at Lavender Hall Lane. Lavender Hall Lane would be diverted broadly as per the Bill Scheme and incorporated into the southern tunnel portal with local traffic management used during construction. Park

⁸ For a more detailed description of the Bill Scheme at the location which the tunnel option has been considered refer to of the area report CFA 23: Balsall Common and Hampton-in-Arden, in Volume 2 of the Environmental Statement.

Lane would be reinstated on its current alignment over the tunnel and would be temporarily diverted during construction. The tunnel would pass underneath Lavender Hall Lane, Park Lane, Footpath M214 and Footpath M215. The tunnel would broadly follow the same horizontal and vertical alignment as the Bill Scheme.

- 4.3.72 A tunnel headhouse building would be located at each tunnel portal and these would contain the control equipment for the tunnel and ventilation fans. An area of hard-standing next to the headhouse building would allow for maintenance and emergency access and egress from the tunnel.
- 4.3.73 The following Bill structures would be removed with this tunnel option.
- Footpath M214 overbridge; and
 - Footpath M215 overbridge.
- 4.3.74 The northern tunnel portal main construction compound would be used to manage the construction of the tunnel. A concrete batching plant to supply concrete, a concrete pre-casting facility to manufacture concrete elements such as tunnel segments, a temporary material stockpile, and temporary workers' accommodation would also be located at this compound.
- 4.3.75 A construction haul route would be provided alongside the works. Access would be provided to the southern portal from Lavender Hall Lane and to the northern portal via the site access off the roundabout at Bradnock's Marsh. There would also be an access off Park Lane. Materials would be generally brought into and out of the northern site compound. This option would require an import of fill material and this is assumed to be hauled via the A452 Kenilworth Road from a location south of the tunnel option.
- 4.3.76 A drawing illustrating Option D1 is provided in Appendix F.

Engineering and environmental benefits

- 4.3.77 There would be a reduced impact on landscape character and a reduction of visual effects on local residents and users of the PRoW and highway network as a result of the reduction of infrastructure and construction compounds. The impact on the setting of Berkswell Conservation Area would be reduced. A number of residential properties, community facilities and businesses would experience a reduction in noise, with a reduced number of properties qualifying for noise insulation.
- 4.3.78 Assuming that habitats could be reinstated above the cut and cover tunnel there would be a reduced loss and fragmentation of ecological habitats and impacts on protected/notable species.

Engineering and environmental disbenefits

- 4.3.79 Cut and cover tunnel options are likely to result in increased greenhouse gas emissions and energy use as a higher quantity of earthworks movements and waste would be required during construction and running of the tunnel systems during operation.

- 4.3.80 There would be a significant increase in daily HGV movements on the highway network during the construction peak period, as a result of the increase in transportation of material, including on the A452 Kenilworth Road south of Stonebridge Island (29% increase on the Bill Scheme). The increased HGV movements would result in congestion and traffic delays as well as impacts on severance for non-motorised users. Increase in construction traffic, in addition to construction activity, could reduce tranquillity and air quality and result in an increase in noise, vibration, visual and amenity impacts on residential properties and users of the PRow and highway network.
- 4.3.81 The cut and cover tunnel portals could result in changes to groundwater flows and mounding and diversion of shallow groundwater flows behind the portals. Construction of the cut and cover tunnel is likely to require dewatering. There is the potential for diversion of groundwater flow from Bayleys Brook and the Berkswell Marsh SSSI, although this is not considered to impact on the integrity of the SSSI, and tunnel portals would require protection from flooding from the Bayleys Brook.
- 4.3.82 The area of land required for the northern compound would increase the severance and sterilisation of the coal and sand and gravel MSA and the Marsh Farm preferred area for mineral extraction.
- 4.3.83 MEP systems would be required within the tunnel adding to the maintenance required and operational costs.
- 4.3.84 Additional emergency and maintenance access arrangements would be more complex as trackside vehicle access cannot be provided through the tunnel box and therefore access would be via stair access at the tunnel portals.
- 4.3.85 The construction of a roof slab increases the complexity of construction with this option.

Option D2

Description

- 4.3.86 This tunnel option is the same as Option D1, but with a change to the vertical alignment at the northern end of the tunnel which would be lowered by up to 2.5m to extend Park Lane cutting and the cut and cover tunnel by approximately 500m⁹. The extent of this lowering is constrained to the north by Bayleys Brook and Marsh Farm viaduct. This would increase the overall length of the tunnel to 3km. The southern tunnel portal would be located at Lavender Hall Lane and the northern portal would be located north of Sixteen Acre Wood in shallow cutting.
- 4.3.87 The Bill structures to be removed with this option are as those described in Option D1.
- 4.3.88 A drawing illustrating Option D2 is provided in Appendix F.

⁹ For a more detailed description of the Bill Scheme at the location which the tunnel option has been considered refer to of the area report CFA 23: Balsall Common and Hampton-in-Arden, in Volume 2 of the Environmental Statement.

Engineering and environmental benefits

- 4.3.89 In addition to the engineering and environmental benefits described in Option D1, this option would also reduce the impact on the setting of listed buildings.

Engineering and environmental disbenefits

- 4.3.90 This option would result in a significant increase in daily HGV movements on the highway network during the construction peak period, including on the A452 Kenilworth Road south of Stonebridge Island (29% increase on the Bill Scheme).

4.4 Summary

- 4.4.1 The evaluation of the four tunnel options against the Bill Scheme has been undertaken and it has been determined that the Bill Scheme remains as the option to be taken forward through the parliamentary process for Royal Assent.
- 4.4.2 As was the conclusion drawn in 2012, all four proposed alternative tunnel options would have environmental and community benefits in comparison to the Bill Scheme, with the magnitude of benefits increasing with the tunnel length. Environmental and community benefits include; reduced impact on landscape character and a reduction of visual effects, reduced impact on the setting of listed buildings and the Berkswell Conservation Area, and reduced impact on residential and non-residential properties experiencing noise, amenity and isolation effects. In addition, the land required for Option A, B and C would reduce the loss and fragmentation of ecological habitats and impacts on protected/notable species and reduce the loss of BMV agricultural land and reduce impacts on land holdings and agricultural buildings.
- 4.4.3 However, the tunnel options are more complex than the Bill Scheme and the need for tunnelling equipment would increase the time to establish construction compounds and tunnel working would introduce construction and maintenance risks. The tunnel options are likely to result in increased greenhouse gas emissions and energy during construction and operation. In addition, with all options there would be a substantial increase in excavated materials and HGV movements on the highway network during the peak period. Combined with increased construction activity in the vicinity of portal locations and intervention shaft(s) (for Options B and C) this could reduce tranquillity and air quality and result in an increase in noise, vibration, visual and amenity impacts on residential properties and users of the PRoW and highway network close to these works.
- 4.4.4 Bored and cut and cover tunnel and tunnel portals could result in changes to groundwater flows and mounding and diversion of shallow groundwater flows behind tunnel portals. It is now considered unlikely that there would be greater adverse impacts on groundwater and indirectly on Berkswell Marsh SSSI as reported in of the area report CFA 23: Balsall Common and Hampton-in-Arden, in Volume 2 of the ES. A desk-based study, which included obtaining BGS Survey data from boreholes in close proximity to the tunnel options, and a site walkover has determined that whilst there is likely to be hydraulic continuity between the superficial deposits and Bayleys Brook along the stretch between Berkswell Marsh SSSI and the Berkswell Estate fishing lake

area, the contributing catchment intersected by the tunnel options is very small and potential for groundwater flows to be intercepted is limited. Bayleys Brook and the fishing lake are also expected to receive the majority of their flow contributions from the Bromsgrove Sandstone Formation, sandstone horizons within Tile Hill Mudstone Formation and the significantly larger catchment area to the east and south north-east which includes mapped drainage features. These are situated away from the location of tunnel portals and intervention shafts. Therefore any reduction of groundwater flow in the superficial deposits to Bayleys Brook is assessed to be low and unlikely to be significant. Permanent pumping facilities might need to be constructed where passive drainage of water was not possible.

- 4.4.5 The four tunnel options would be substantially more expensive than the Bill Scheme and whilst the environmental and community benefits of tunnel options are evident these are still not considered to be substantial enough to justify the increased cost.

5 List of acronyms and abbreviations

BGS	British Geological Society
BMV	Best and most versatile
CFA	Community forum area
EIA	Environmental impact assessment
ES	Environmental Statement
LGV	Light goods vehicle
HGV	Heavy goods vehicle
MEP	Mechanical, electrical, power
MSA	Mineral Safeguarding Area
PRoW	Public Rights of Way
SSSI	Site of Special Scientific Interest

Appendix A: 2010 Consultation Route Drawing

Appendix B: 2012 Post Consultation Route Drawing

Appendix C: 2012 Tunnel Options Drawings

Appendix D: Bill Scheme Residual Significant Effects Drawings

Appendix E: 2014 Cost Comparison Tables

Appendix F: 2014 Tunnel Options Drawings