A417 Missing Link
TR010056

8.6 Cut and Cover Tunnel Feasibility Study

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A417 Missing Link

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Cut and Cover Tunnel Feasibility Study

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1 Introduction

1.1 Scheme overview

1.1.1 The A417/A419 is a strategic route between Gloucester and Swindon that provides an important link between the Midlands/North and South of England. The route is an alternative to the M5/M4 route via Bristol. The section of the A417 near Birdlip, known as the 'Missing Link', forms the only section of single carriageway along the route and is located in the Cotswolds Area of Outstanding Natural Beauty (AONB).

1.1.2 In 2014, the Department for Transport (DfT) announced its five-year investment programme for making improvements to the strategic road network (SRN) across England. This scheme is one of more than 100 schemes identified as part of the first Road Investment Strategy (RIS1) 2015-2020[1]. Funding for delivery of the scheme has been confirmed within the second Road Investment Strategy (RIS2)[2], which covers the period between 2020 and 2025 and was published on 11 March 2020.

1.1.3 This scheme to upgrade this section of the A417 to dual carriageway, in a way that is sensitive to the surrounding AONB, would help unlock Gloucestershire's potential for growth, support regional plans for more homes and jobs, and improve life in local communities.

1.2 Scheme description

1.2.1 The scheme would provide 3.4 miles (5.5km) of new, rural all-purpose dual carriageway for the A417. The new dual carriageway would connect the existing A417 Brockworth bypass with the existing dual carriageway A417 south of Cowley. The new dual carriageway would be completed in-line with current trunk road design standards. The section to the west of the existing Air Balloon roundabout would follow the existing A417 corridor, but to the south and east of the Air Balloon roundabout, the corridor would be offline, away from the existing road corridor.

1.2.2 The scheme would include a new crossing near Emma's Grove for walkers, cyclists and horse riders including disabled users, which would accommodate the Cotswold Way National Trail. A new junction would be incorporated at Shab Hill, providing a link from the A417 to the A436 (towards the A40 and Oxford), and to the B4070 (for Birdlip and other local destinations).

1.2.3 A new 37m wide multi-purpose crossing would provide essential mitigation for bats and enhancement opportunity of ecology and landscape integration. The public would also further benefit as the crossing would accommodate the Gloucestershire Way and provide an improved visitor experience.

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[1] Department for Transport (March 2015), Road investment strategy: 2015 to 2020, accessed 29 January 2020, https://www.gov.uk/government/publications/road-investment-strategy-for-the-2015-to-2020-road-period

[2] Department for Transport (March 2020), Road investment strategy: 2020 to 2025, accessed 11 March 2020, https://www.gov.uk/government/publications/road-investment-strategy-2-ris2-2020-to-2025

1.2.4 A new junction would be included near Cowley, replacing the existing Cowley roundabout, making use of an existing underbridge to provide access to local destinations. The use of the existing underbridge would allow for all directions of travel to be made.

1.2.5 The current A417 between the existing 'Air Balloon roundabout' and 'Cowley roundabout' would be detrunked for its entire length. Some lengths of the existing road would be converted into a route for walkers, cyclists and horse riders including disabled users. Other sections would be retained as lower-class public roads, maintaining local access for residents. Some of the route would provide Common Land. The scheme is illustrated in Figure 1-1 below.

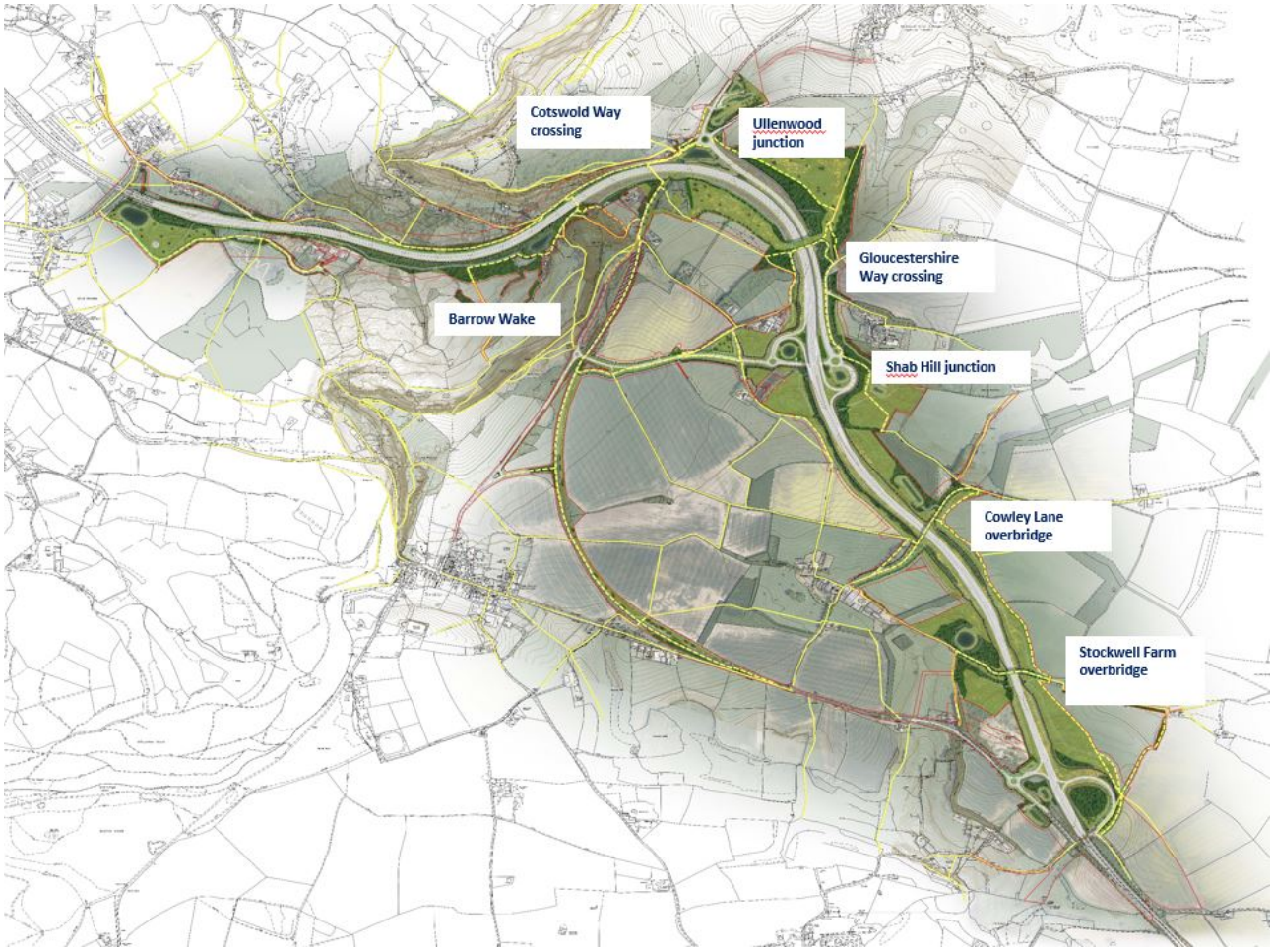

Figure 1-1 The proposed A417 Missing Link scheme

1.3 Purpose of this document

1.3.1 Some stakeholders in response to public consultations have suggested the scheme should not involve a surface route and should instead be delivered as a tunnel, partial tunnel or 'cut and cover' solution.

1.3.2 Those that expressed preference for a tunnel, partial tunnel or 'cut and cover' solution in response to the supplementary statutory public consultation held in Autumn 2020 included the Council for British Archaeology, Gloucestershire Ramblers, and some members of the public.

1.3.3 Those that expressed preference for a tunnel, partial tunnel or 'cut and cover' solution in response to the statutory public consultation held in Autumn 2019 included the Campaign to Protect Rural England (Gloucestershire branch), Cirencester College, Cheltenham Civic Society Planning Forum, Cotswold Conservation Board (CCB) (also known as the Cotswold National Landscape 'CNL'), Cotswold Way Association, Gloucestershire Ramblers, some persons with an interest in land, and some members of the public.

1.3.4 A number of tunnel options and routes were discounted following an options assessment process prior to 2018, largely due to their cost, poor value for money, or likely impacts on the environment. That information was presented at the 2018 non-statutory consultation, as set out in Environmental Statement (ES) Chapter 3 Assessment of Alternatives, Chapter 3 of the Consultation Report, and detailed in the 2018 Technical Appraisal Report (TAR). At the announcement of Option 30 as the preferred (surface) route in March 2019, Highways England concluded its route selection process.

1.3.5 Whilst recognising the conclusions of the route selection process, a number of respondents queried in response to the 2019 statutory consultation whether a partial tunnel design could be incorporated into the Option 30 alignment or through a 'cut and cover' method, for example by utilising the then proposed green bridge on Crickley Hill (which has since been removed from the scheme as set out in section 7.4 of the Consultation Report).

1.3.6 Then in response to the 2020 supplementary statutory consultation, some respondents suggested that a partial tunnel or 'cut and cover' design could be incorporated into the scheme design in the vicinity of the existing Crickley Hill section joining the Air Balloon roundabout, for example through widening the proposed Cotswold Way crossing corridor to create a green bridge or cut and cover solution. It was suggested that this may prevent the Air Balloon Public House from requiring demolition.

1.3.7 This note provides a feasibility study which has looked, at a high level, a new alternative design suggestion provided by stakeholders. It presents a high-level assessment based on a number of assumptions and exclusions as outlined section 4 below. This is being provided to assist stakeholders, as part of ongoing engagement activities including preparation of Statements of Common Ground, in understanding why the present scheme design is considered to be a better solution to the need for the scheme. It is not replicating any specified standard (e.g. ES, TAR) and does not form a Development Consent Order (DCO) application document. It sets out the design process, consultations, technical requirements and potential impacts, including likely programme, cost, and environmental implications.

2 Context

2.1 Background to tunnel and cut and cover options

2.1.1 The A417 Missing Link scheme has been under consideration for more than 20 years. Figure 2-1 shows a high-level overview of the scheme development, highlighting key moments of stakeholder engagement regarding tunnel options.

2.1.2 Highways England has undertaken a staged approach to the design of the A417 Missing Link scheme, engaging with stakeholders and members of the public to seek feedback and inform the design. This has included consideration of tunnel options as illustrated in Figure 2-1.

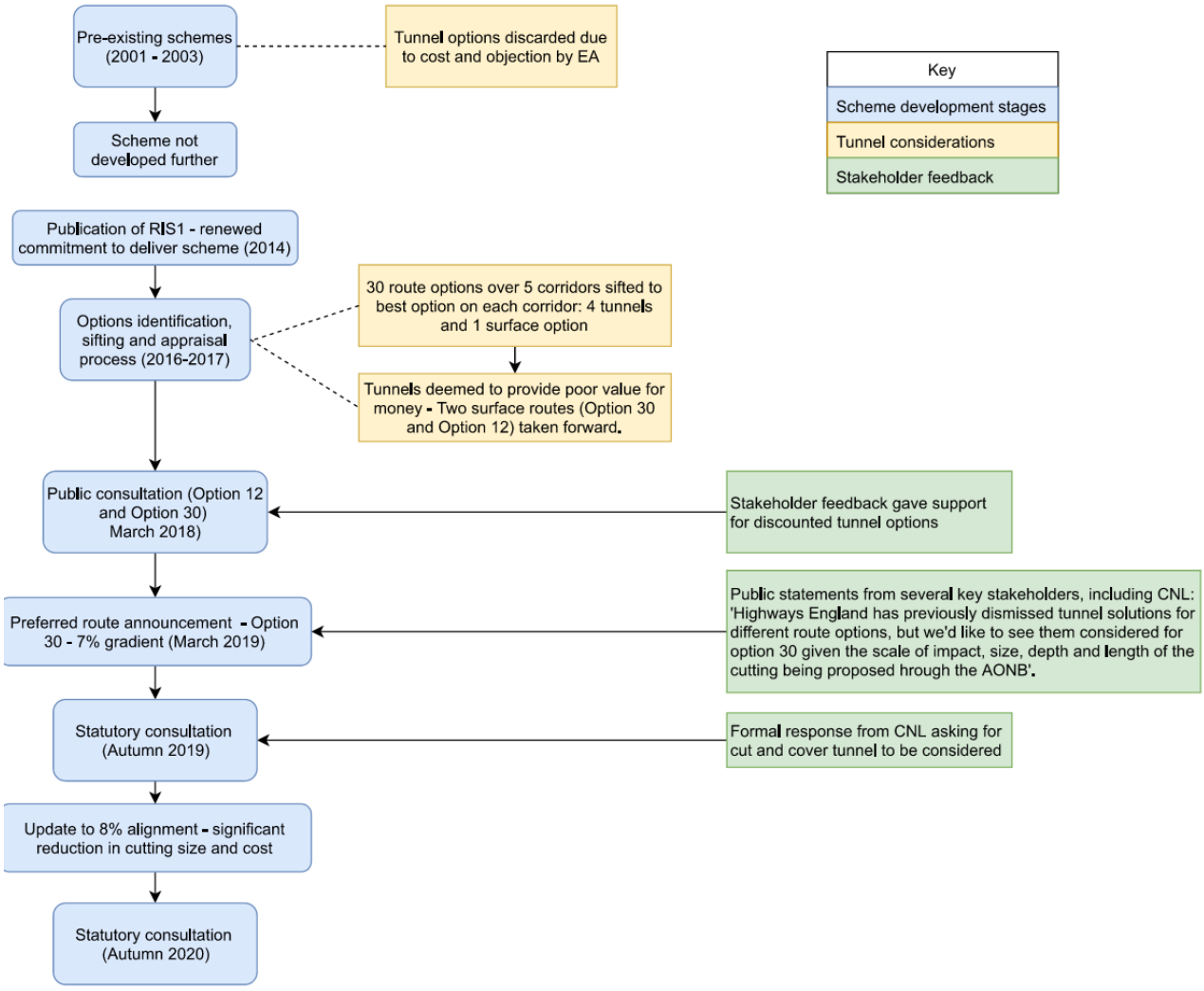

Figure 2-1 Summary of development of the scheme

2.1.3 The publication of the first Road Investment Strategy (RIS1) by the Department for Transport (DfT) in 2014 resulted in a renewed commitment to deliver a scheme between the Brockworth bypass and Cowley junction. Subsequently an options identification, sifting and appraisal process for the current A417 Missing Link scheme was undertaken by Highways England between 2016 and 2017.

2.1.4 Following an initial sift of 30 route options within five route corridors, the best performing option for each corridor was taken forward for further assessment.

2.1.5 This included four tunnel options, and one surface option, as well as one other surface option as a reasonable alternative.

2.1.6 As set out in more detail in the Scheme Assessment Report[3] , the appraisal process concluded that while the tunnel options would potentially deliver some benefits over those provided by the surface routes, they ultimately provided poor value for money for the taxpayer due to their high estimated cost, being significantly higher than the scheme budget of £500m. Subsequently, the two surface options were taken forward for further appraisal and public consultation.

2.1.7 Following public consultation in March 2018, and the preferred route announcement made in March 2019, key stakeholders stated a desire to see tunnel options reconsidered for the chosen route alignment. Several key stakeholders released public statements, asking Highways England to consider possible tunnel solutions for option 30 given the scale of impact, size, depth, and length of the cutting being proposed through the AONB.[4]

2.1.8 It is important to note that the scale of the cutting along Crickley Hill at the earlier stage of appraisal and at the time of stakeholder comments made in 2019, was significantly larger (then it involved a proposed change from its existing 10% to a 7% gradient) when compared to the current 10% to 8% change proposed for the application scheme. The change in gradient for the mainline vertical profile along Crickley Hill has negated the need for large scale retaining walls, and the depth of cutting has been reduced from 26m to 11m. This changes the nature and potential of a tunnel or cut and cover solution, and in response to this change some key stakeholders have revised their position in that a tunnel or cut and cover solution is no longer necessary (for example, see the Statement of Common Ground between CCB (also known as Cotswold National Landscape 'CNL') and Highways England).

2.1.9 However, there is still ongoing interest from the Council for British Archaeology, Gloucestershire Ramblers, and some members of the public about the feasibility of a cut and cover tunnel for part of the proposed scheme route, in the vicinity of the existing Crickley Hill section joining the Air Balloon roundabout. This feedback has mainly focused on the section around the proposed Cotswold Way crossing with stakeholders referencing potential benefits such as retention of the Air Balloon Public House and greater connectivity across the scheme.

3 https://highwaysengland.citizenspace.com/he/a417-missing-link/results/a417_missing_link_scheme_assessment_report.pdf
4 https://www.cotswoldsaonb.org.uk/press-release-board-concerned-over-plans-for-a417-missing-link/

3 Requirements for a cut and cover tunnel

3.1 Highways design

3.1.1 To understand the potential form of a cut and cover tunnel in the vicinity of the existing Crickley Hill section joining the Air Balloon roundabout, an indicative design must respond to the necessary requirements for the structural geometry. This involves assumptions being made about the necessary height and width, the vertical and plan alignment, and its length.

Plan alignment

3.1.2 Given the Preferred Route Announcement made in March 2019, the subsequent design development work along that route and correspondence with stakeholders, it is assumed that a cut and cover tunnel would follow the horizontal alignment of the proposed scheme in the vicinity of the Cotswold Way crossing (see Figure 1-1).

Width

3.1.3 Due to the curvature of the alignment, it is necessary to provide adequate Sight Stopping Distances (SSD), as set out in CD 109[5] of the Design Manual for Roads and Bridges (DMRB).

3.1.4 Figure 3-1 shows the breakdown of the required lane widths and SSDs that makeup the total structure width, assuming a design speed of 120kph is maintained within the tunnel. In both portals the 18.525m wide regions are essentially empty space, to ensure that around the curve in the horizontal alignment there are no obstacles to the forward visibility of the drivers.

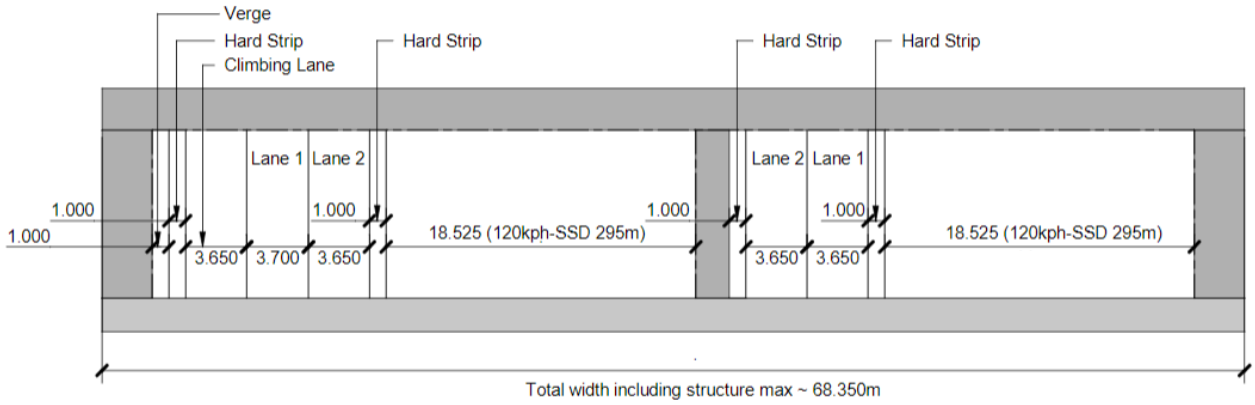

Figure 3-1 Assumed typical carriageway cross section for cut and cover tunnel

[5] Highways England (2020). DMRB, CD 109 Highway Link Design

3.1.5 A key consideration is that the scope for allowable reductions in visibility in tunnels is significantly less than the open road (surface options). Due to the significant span of the structure and weight of soil that will need to be supported, a central supporting wall would be required, and that would further reduce visibility. The total highway width of this option would be over 60m, compared to less than 30m for the current scheme design.

Height

3.1.6 The required headroom clearance will be 5.3m plus addition for structural sag, as set out in CD 127 in the DMRB. In addition to this, for tunnels appropriate allowance must be made for all mechanical systems, in particular ventilation. Appropriate allowance for carriageway surfacing, including future resurfacing, as well as additional clearance to the mechanical equipment results has led to the assumed allowance of 8m for the purpose of this report.

Vertical alignment and length of tunnel

3.1.7 The length of a tunnel will depend on its vertical alignment and how it ties in with the existing ground profile. Following European guidance[6], a 5% gradient has been considered the maximum that will be permissible for the proposed scheme alignment. For that profile, the tunnel would begin at Chainage 1+700 and end at Ch 3+000, giving a total length of 1.3km.

3.1.8 Any steeper gradient would require a Departure from Standard (DfS) from DMRB, which would need to be approved by Safety, Engineering and Standards (SES), which would introduce a risk of failing the approval process.

3.1.9 Further information behind this assumption can be found in Appendix A.

3.1.10 Figure 3-2 shows the necessary 5% profile for a tunnel, as well as the current 8% proposal for the surface route at Crickley Hill, with the existing ground profile shown in green. This illustrates how the difference in profile ultimately affects the depth of the cutting, and the length of the tunnel.

6 European commission (2004). Directive 2004/54/EC of the European Parliament and of the council on minimum safety requirements for tunnels in the Trans-European Road Network (TERN)

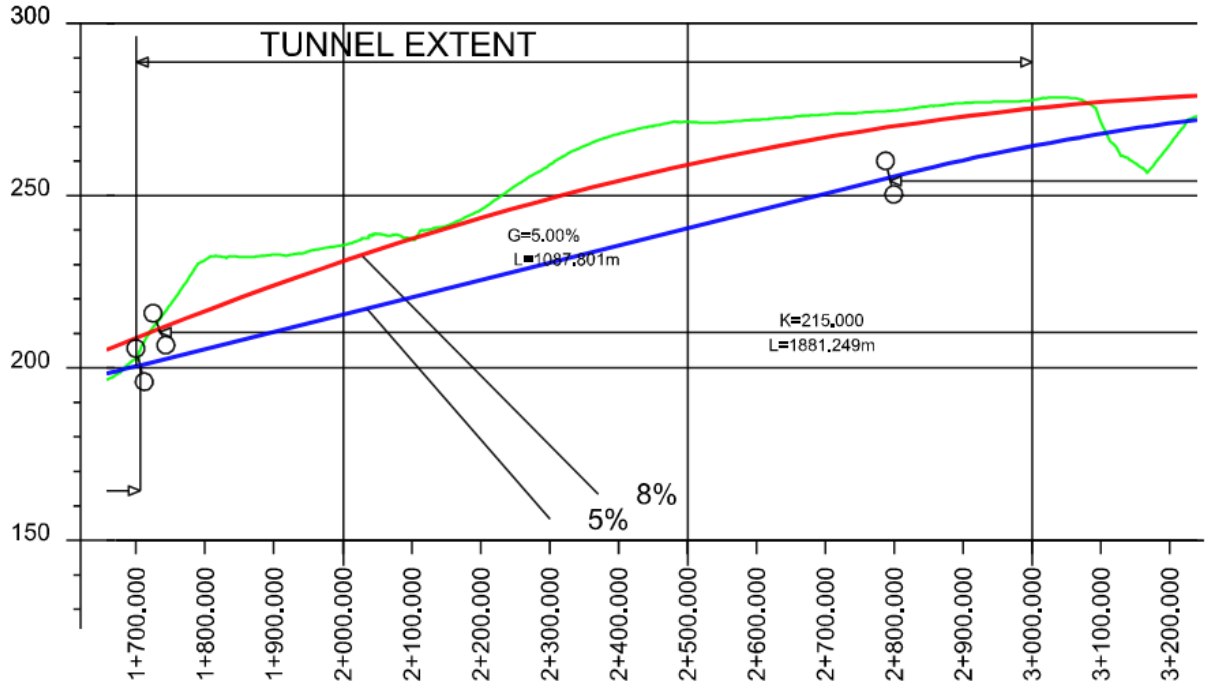

Figure 3-2 Long section comparing 5% alignment, 8% alignment and existing ground profile

3.2 Site constraints

3.2.1 Three key local constraints exist for a cut and cover tunnel in the vicinity of the existing Crickley Hill section joining the Air Balloon roundabout:

a) Traffic must be maintained on Cold Slad Lane (the existing A417) both in the temporary case for construction traffic management, but also in the permanent case to maintain access to properties. This limits the potential cutting width in this location.

b) National Trust inalienable land at Crickley Hill should be avoided. Unless the National Trust were to agree to the use of the land, its objection would trigger special parliamentary procedures (SPP) being required. That constrains the ability to include National Trust land within the scheme.

c) Environmental Designations including the Crickley Hill and Barrow Wake SSSIs, the AONB designation meaning all proposals have regard for the purpose of conserving and enhancing the natural beauty of the AONB, and Ullen Wood. Physical impacts on Ullen Wood ancient woodland should be avoided as it is designated as ancient woodland and considered to be irreplaceable habitat of national importance. That protection appears within the National Policy Statement for National Networks.

3.3 Geotechnical constraints

3.3.1 The inferred ground and groundwater conditions along the scheme are described in the Preliminary Sources Study Report (PSSR) and Preliminary Ground Investigation Report (GIR). A summary of the ground and groundwater conditions between Ch 1+700 and Ch 3+000, corresponding to the extent of a cut and cover tunnel solution is presented in Appendix C.

3.3.2 Based on the required vertical and horizontal alignment described previously, the excavations for the tunnel construction would be predominantly within the Inferior Oolite Group limestone rock. Superficial deposits comprising mass movement (landslip) deposits are anticipated up to around Ch 1+750.

3.3.3 The geotechnical design of any temporary or permanent works for the construction of the cut and cover solution would need to consider the following:

a) Global stability of any temporary cutting slopes and retaining structures.
b) Local stability of any temporary cutting slopes e.g. leading to rockfall from slope surface.
c) Limiting impact on adjacent properties and highways e.g. through limiting deflections of any retaining structures.

3.3.4 Potential geo-hazards for the extents under consideration, representing potential constraints that will need to be considered as part of the design of the structure and temporary works include: potential voids or gulls in the karstic limestone rock; marginally stable ground in the mass movement (landslip) deposits; relatively weaker Lias Group rock towards the base of the excavation; and groundwater inflow into excavations. These have been considered with respect to the illustrative design discussed in Section 4.

4 Form of a cut and cover tunnel

4.1.1 In order to identify and assess the impacts of a cut and cover solution, Highways England has identified an illustrative and appropriate form of a cut and cover tunnel, based on the context set out in Section 2 and the requirements set out in Section 3. This section sets out a reasonable form subject to a series of assumptions listed in 4.2 and exclusions listed in 4.3. This is necessary in order to give sufficient consideration to the comments and suggestions received.

4.2 Assumptions

4.2.1 The following list summarises the assumptions made to define the proposed form of a cut and cover tunnel for the purposes of consideration of likely impacts, as set out in Section 5:

a) The horizontal alignment is based on option 30, the proposed scheme route.
b) The extents of the tunnel would be from Ch 1+700m to Ch 3+000m in the vicinity of the existing Crickley Hill section joining the Air Balloon roundabout, near the Cotswold Way crossing as shown in Figure 1-1.
c) The tunnel design speed would be 120kph, as per a surface route.
d) The minimum width of the tunnel would be 68.5m based on carriageway widths and Stopping Sight Distances (SSD).
e) The allowable vertical gradient would be 5%.
f) The cross section of the structure has been simplified to a box section to allow for approximate construction volumes and cost estimates.

4.3 Exclusions

4.3.1 The following list summarises the exclusions from this study:

a) Study of other types of tunnelling methods: use of a tunnel boring machine, drill and blast techniques or a road header are not considered to be feasible for the horizontal alignment and vertical profile of the proposed scheme route.
b) Entrance portals: where appropriate, as part of this note high level matters associated with entrance portals are considered, for example when considering the likely impacts on structures, land, the environment and cost involved. An illustrative and appropriate form of a cut and cover tunnel is being considered for the purposes of this study, and a more detailed consideration of entrance portals would require further study and design, which would be disproportionate for the purposes of this study.
c) Impact on Shab Hill junction: a cut and cover tunnel would require the proposed Shab Hill junction to be moved east and the underbridge would likely become an overbridge, and thus the approach road gradients and earthworks would need to be redesigned. The impact on Shab Hill would be influenced by the potential design and location of entrance portals, as described above. The redesign of Shab Hill junction would negatively change the cut and fill balance as well as have adverse impacts on cost and programme, when compared to the proposed surface solution. Whilst this note will consider potential impacts on Shab Hill where appropriate at a high level, the full extent of the impacts would require further study and design, which would be disproportionate for the purposes of this study.

d) Realignment of the A436: a cut and cover tunnel would require the A436 to be realigned, with associated adverse cost and programme impacts. Whilst this note will consider a potential solution for a realigned A436 where appropriate at a high level, the full extent of the impacts would require further study and design, which would be disproportionate for the purposes of this study.

4.4 Alignment

4.4.1 Figure 4-1 indicates the most appropriate location of a cut and cover tunnel in the vicinity of the existing Crickley Hill section joining the Air Balloon roundabout. The area shown in red indicates the footprint of the structure, and the grey hatched area shows the approximate extents of the cutting required. The yellow dashed line represents where a retaining wall structure would be needed to maintain the existing A417 during construction.

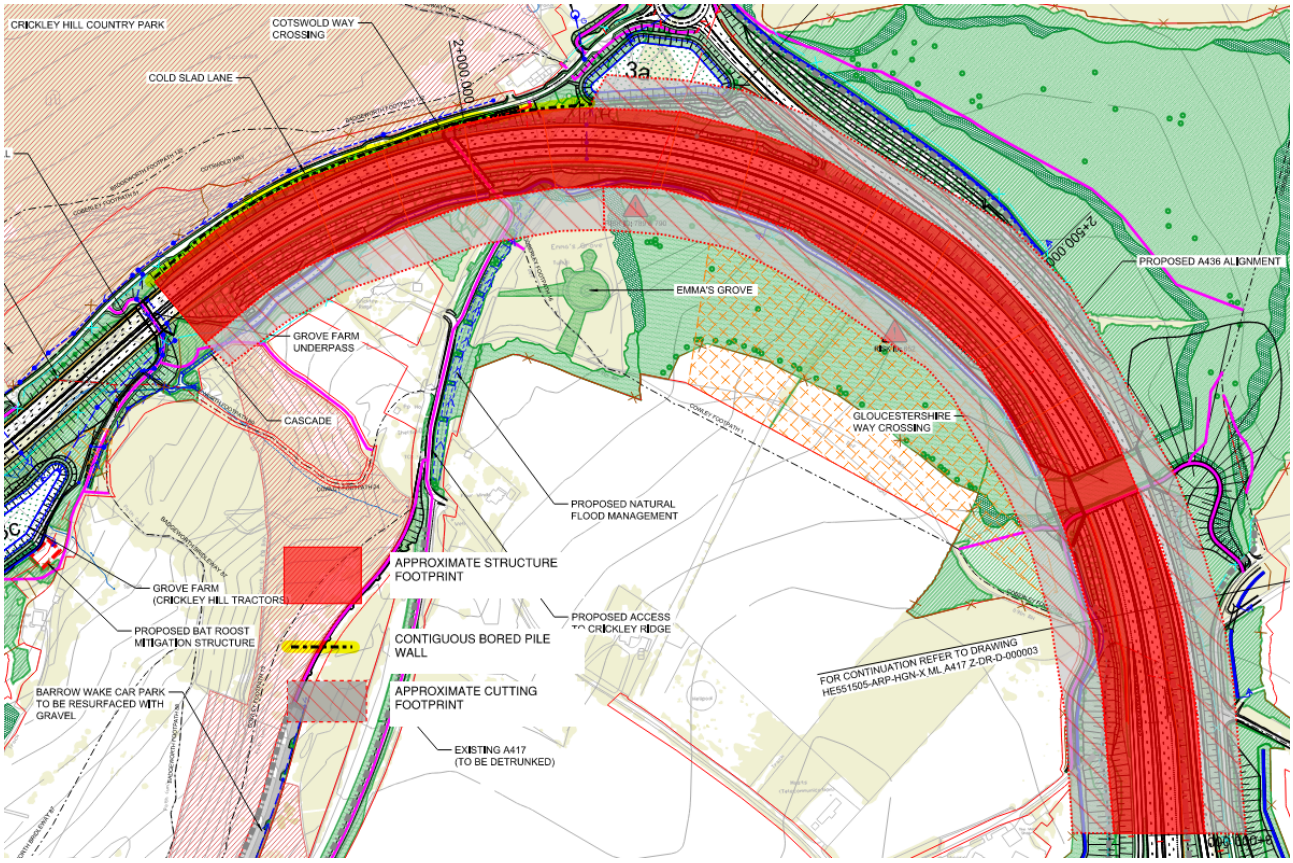

Figure 4-1 Indicative solution layout

4.5 Structure

4.5.1 The main structural form of the cut and cover tunnel structure would be a reinforced concrete box section. The structure would need to be made up of two spans of approximately 28m to 33m, over each carriageway of the A417, with a supporting wall between them. Figure 4-3 demonstrates this suggested cross section. It should be noted that this is a very large span size for a tunnel and this is why a curved alignment would not typically be considered.

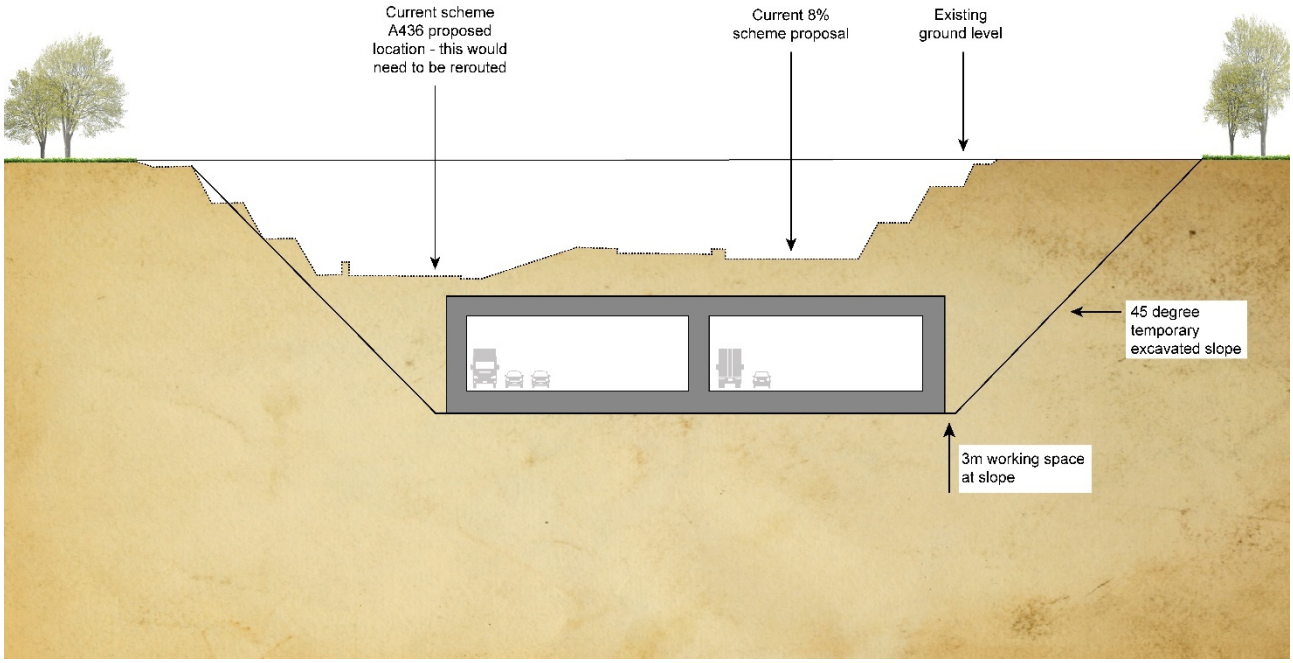

Figure 4-2 Illustration comparing impact of cut and cover tunnel to current scheme

4.5.2 The shallow gradient permissible in tunnels means the required cutting would be over 30m deep in some locations. The size of the cutting is illustrated in Figure 4-2 above. Therefore, the structure could be supporting up to 25m of soil at its greatest depth below ground level, leading to very high flexural demand in the reinforced concrete. At a high-level, it is proposed that the slabs would need be a minimum of 2m thick. For this thickness of concrete and significant loading, multiple layers of heavy reinforcement would be required.

4.5.3 For the required spans and loading, a box section is therefore unlikely to be an acceptable solution. Another possible option would be to create an arch structure for the roof to more effectively support the permanent load case, especially where the cut is at its deepest and the soil loading is maximised. This would allow for the volume of concrete to be reduced, although would lead to more complex construction sequencing and cost.

4.5.4 For the purpose of this note, the structure has been simplified to be a box structure in the interests of presenting the information in an accessible format. In doing so the conclusions of this study underestimate the likely cost and construction sequencing impacts of any cut and cover tunnel solution.

4.5.5 Further considerations such as buoyancy and uplift would need to be considered in the design. Cross passages would also need to be provided, or alternatively exits to the surface.

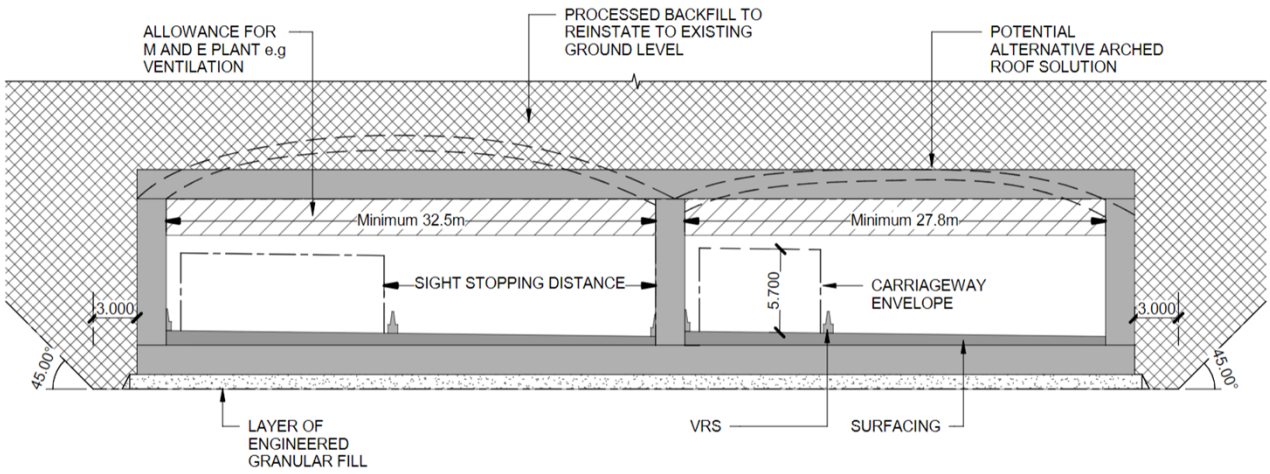

Figure 4-3 Possible cross section

4.6 Temporary excavations

Temporary retaining walls

4.6.1 As outlined in Section 3.2, for the section of the route where the existing A417 would need to be retained during construction, and to avoid encroachment of any temporary works into Ullen Wood or National Trust inalienable land, a temporary retaining wall would be required.

4.6.2 Emma's Grove should not be adversely affected given safe proximity from the necessary excavation area, subject to appropriate construction working areas.

4.6.3 Based on the 5% gradient vertical alignment, a retained height of up to approximately 16m would be required. This would represent a substantial retaining structure that would be required to resist significant earth and groundwater pressures.

4.6.4 The most feasible solution would be an embedded wall solution, comprising of diaphragm walls or contiguous bored piles with multiple rows of ground anchors, the latter installed as the excavation in front of the wall is progressed. A possible cross section is shown in Figure 4-4. Once the excavation reaches the final formation level, corresponding to the base of the proposed cut and cover tunnel structure, the base and roof slabs could also act as props, providing additional lateral support to the wall once the cut and cover tunnel structure has been constructed. For the purpose of this note, a minimum diameter of 1.5m has been assumed for the contiguous bored piles.

4.6.5 In addition to accommodating earth and groundwater pressures, the retaining wall design would need to mitigate the potential geo-hazards identified as part of the site investigation works, including:

a) Existing, marginally stable slopes to the north of the route along Crickley Hill.
b) Potential presence of gulls and dissolution void features within the Inferior Oolite Group bedrock.
c) Potential for voids within the Lias Group (Bridport Sand Formation) bedrock.
d) Groundwater infiltration where the excavation extends into the water bearing Lias Group bedrock between Ch 1+750 and Ch 1+850.

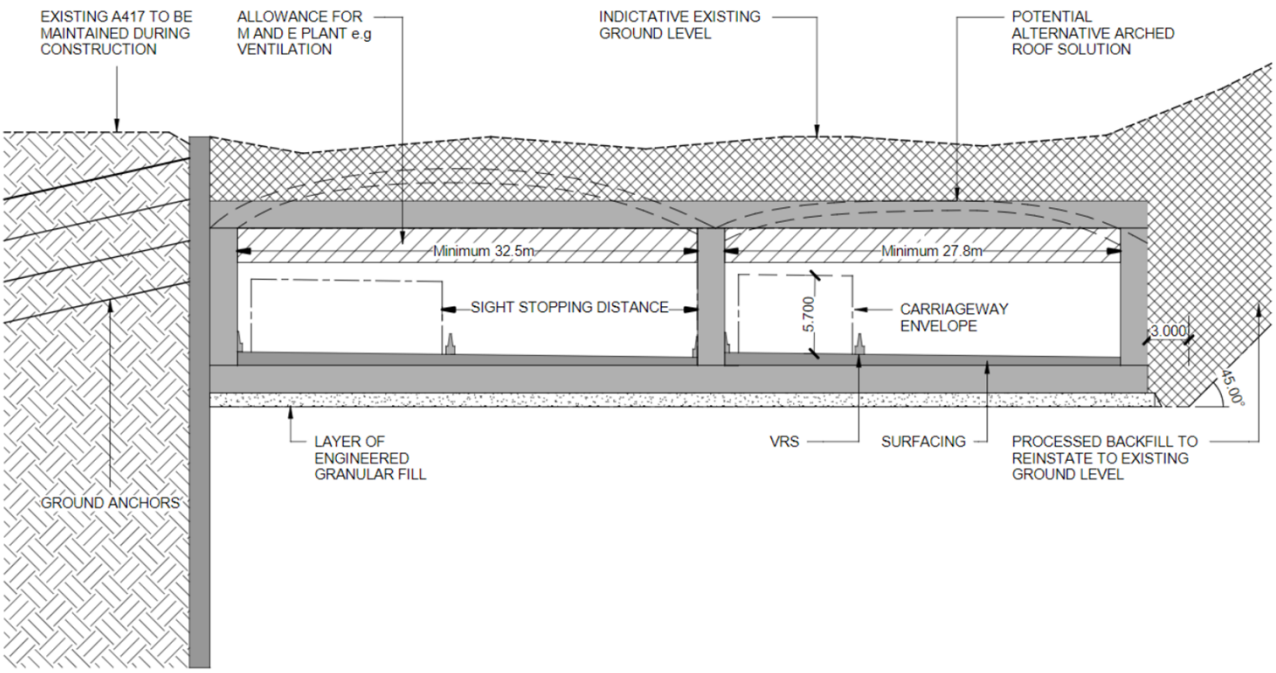

Figure 4-4 Possible cross section through retained section of tunnel

4.6.6 Figure 4-4 demonstrates the scale of this wall – it is bigger than those that would have been required for the 7% option – emphasising that the impact of a cut and cover tunnel is bigger than this previous scheme, rather than minimising the impact on the landscape. The volume of concrete required would be in the region of 20,000m^3.

Temporary open excavations

4.6.7 Table 4-1 presents the anticipated temporary cut geometries, the strata comprising the temporary cut slopes and considerations for these strata.

Table 4-1 Summary of considerations for proposed temporary cuts

Cut material and proposed temporary cut geometry (Cut chainage extent in brackets)	Considerations
Mass Movement Deposits over Lias Group bedrock (Ch1+700 to Ch1+750) 45^o cut slope	The extent of the Mass Movement Deposits within the cut slope is unknown and stabilisation measures such as soil nails may be required. The existing cut slope in this area is a 35^o slope with no stabilisation measures.
Inferior Oolite Group bedrock (Ch1+750 to Ch 2+910) Lias Group bedrock above base of cutting (Ch 1+750 to Ch 1+850) 45^o cut slope	Within the Inferior Oolite Group bedrock, variable rock mass quality, with rock mass quality reducing approaching the Shab Hill Fault – potential that stabilisation measures may be required. Rock fall likely to occur, therefore rock fall protection measures (netting or rock catch fence at the base of the cutting slopes likely to be required. Potential for gulls to be encountered, affecting overall slope stability. Consideration on gull infill treatment would be required in the form of granular fill with a mass concrete or grout plug. Mitigation measures should be in accordance with the karst protocol for the scheme. Gulls have not been explicitly identified in the ground investigation but have been encountered historically in the Birdlip bypass scheme at Barrow Wake.

Cut material and proposed temporary cut geometry (Cut chainage extent in brackets)	Considerations
	The potential for dissolution voids has been identified and there may be a risk that larger dissolution features are present. Void treatment measures within the cut face such as dentition and within the cut floor (i.e. infill and geogrids) would need to be considered. Between Ch 1+750 and 1+850, the cut is likely to be located below the base of the Inferior Oolite and within the Lias Group (Bridport Sand Formation) that is water bearing and potentially has voids. Control of groundwater from the cut face and the cut base is therefore likely to be required. In addition to drainage measures, consideration for the treatment of voids in the form of backfill and spanning with geogrids would need to be considered. The Bridport Sand Formation is also relatively weaker in terms of rock mass properties, particularly within 200m of the edge of the escarpment. Stabilisation measures therefore likely to be required.
Great Oolite Group (Various from Ch 2+910 to Ch 3+000) 45^{o} cut slope	Combination of rock (limestone / mudstone) and weathered rock to soil likely to be encountered in cut face. Localised stabilisation measures would need to be adopted. The presence of low strength zones may occur. The risk of any instability from these zones would need to be addressed in the form of slackening the slope further or slope stabilisation.

4.7 Buildability

4.7.1 The following outlines a high-level construction sequence to facilitate an estimated programme length and cost. It is based on the assumptions and exclusions outlined above.

a) Install required traffic management on the existing A417, which would be similar to that required for the proposed scheme;
b) Ensure any services and utilities in the area have been safely re-routed. This would involve long temporary diversions to ensure they would not be impacted by the cut and fill operations;
c) Establish process plant and material storage area;
d) Establish batching plant facilities;
e) Excavate the new mainline to coincide with the existing A417 between Ch 1,700 and Ch 2,100;
f) Install contiguous bored piles adjacent to existing A417 between Ch 1,700 and Ch 2,100, to maintain the integrity of the existing road during excavations;
g) Prepare storage area for excavated material as well as temporary haul roads, including temporary Bailey Bridge over existing A417;
h) Due to the volume of material arising from excavations, the tunnel will need to be constructed in 100m long segments, while maintaining the length between Ch 2,000 and Ch 2,200 until traffic can be diverted off the existing A417 onto the new A436;
i) Over each 100m length, excavate to new main line formation level, exposing the face of the contiguous bored piles, and maintaining a safe gradient on the open cutting side, with appropriate rock fall protection such as netting;
j) Excavated material will be transported to the process area, where it will be graded and stored ready for backfill operations;
k) Clean off the face of the contiguous bored piles and apply sprayed concrete finish;

l) Prepare foundation and cast walls of tunnel over the 100m length;
m) Cast roof of tunnel;
n) Prepare and install entrance portals;
o) Backfill cutting over the completed 100m of tunnel and excavate for the next 100m of tunnel;
p) Continue repeating the operation until all 1.3km of tunnel is completed. The two segments between Ch 2,000 and Ch 2,200 can only be completed once traffic has been diverted from the existing A417;
q) Install mechanical fittings such as lighting, ventilation etc;
r) Replace topsoil and complete landscaping.

4.7.2 The following list highlights some of the key risks specifically associated with the cut and cover tunnel and associated works. Although these risks could have mitigation put in place to reduce the severity and/or likelihood of occurrence, following the guidance set out by the Construction (Design and Management) (CDM) Regulations, it is pertinent for designers to try and avoid risks in design. Therefore, if many of these risks could be avoided by having a surface route in place of a cut and cover solution, this would be relevant. The key risks are:

a) Working at height at top of cutting. Risk of workers falling into cutting and becoming injured.
b) Working at the base of cuttings that could be liable to rock falls/landslips. Risk of rocks/soil/plant falling onto workers and causing harm.
c) Working in enclosed spaces during installation of road and associated systems within the tunnel.
d) Risk of traffic collision or accident leading to injury or death due to increased vehicle movements to move large volumes of material.
e) Operation risk to tunnel users becoming trapped in the event of an emergency.
f) Risk to maintenance workers due to restricted access.

4.8 Maintenance

4.8.1 A specific tunnel maintenance strategy would need to be developed by the Tunnel Operating Authority (TOA), assumed to be Highways England, to meet the requirements in DMRB CM 430 Maintenance of road tunnels.

4.8.2 The strategy should aim to avoid unplanned tunnel closures, and should incorporate the need for equipment replacement by considering the equipment and component service life expectancy of all mechanical equipment, including but not limited to: ventilation, lighting, drainage equipment, fire safety, evacuation and emergency response systems, firefighting systems, communication systems, traffic control and monitoring systems, power supply and distribution systems.

4.8.3 Typically, maintenance strategies should be considered on a three-year rolling basis for Principal Inspections, with yearly General Inspections.

4.8.4 In addition to the considerations above, any tunnel solution would have to be compliant with the fire safety minimum requirements, of which some requirements are described below:

a) Cross-passages or exits to the ground surface (only for the cut and cover solution) every 500m;
b) Mechanical ventilation;
c) A drainage system;

d) A fire suppression system;
e) A water tank outside the tunnel to supply the fire suppression system (if no direct water supply can be guaranteed); and
f) A tank outside the tunnel to collect flammable fluids potentially spilled inside the tunnel.

5 Likely impacts of a cut and cover tunnel

5.1.1 A high-level understanding of potential impacts of a cut and cover tunnel as described in Section 4 is provided in this Section 5. The cut and cover tunnel is compared with the proposed scheme.

5.2 Programme

5.2.1 The progression of a cut and cover solution would require preliminary design, statutory consultation(s) and preparation of a different DCO application. The process involved would result in significant delay, whereas Highways England intends for the proposed scheme to be subject to a DCO application in the first half of 2021. It is likely that the preliminary design and revised DCO application programme required for a cut and cover solution would delay the project between 2 and 3 years.

5.2.2 Based on the high-level construction sequence provided at Section 4.7, the construction programme for a cut and cover tunnel would be significantly longer than for a surface solution as is proposed for the scheme. It is likely that the construction programme would be between 2 and 3 years longer.

5.2.3 The programme implication would be that the design, construction and opening year would be delayed by up to 6 years, leading to ongoing problems associated with the existing situation continuing for a much longer period. This is likely to be unacceptable to key stakeholders and the public in light of the underlying need for the scheme.

5.3 Cost and Economic Impact

5.3.1 The A417 Missing Link is part of the Government's Road Investment Strategy 2 (RIS2), which identifies parts of the strategic road network which need upgrading to improve safety, connectivity, and reliability for its users. The government has set a cost allocation for this scheme of £250 to £500 million in the context of competing demands for investment in other transport schemes and public services. As such, Highways England is aware that the scheme needs to represent value for money to taxpayers and deliver a return on investment.

5.3.2 Notwithstanding the significant additional cost involved in a new preliminary design, statutory consultation(s) and preparation of a different Development Consent Order (DCO) application, there would also be significant additional cost involved the construction of a cut and cover tunnel when compared to the proposed scheme.

5.3.3 The benefits of a cut and cover tunnel are set out in the remaining sections below, when considering potential impacts on the environment, traffic, land and property.

5.3.4 A high-level cost exercise has been completed based on the information in this note. It is likely that the total cost of a cut and cover scheme would be in excess of £1.3Bn, more than three times the cost of the proposed scheme. This is consistent with the findings at route options stage.

5.3.5 That cost far exceeds the government cost allocation for the scheme, with no clear route to additional funding at this stage.

5.3.6 Further, it is very likely that the costs would significantly outweigh the benefits, offering poor value for money.

5.4 Likely environmental impacts

5.4.1 Table 5-1 summarises a high level qualitative comparison of the potential impacts of the proposed scheme, and the cut and cover tunnel solution outlined in section 4. Further detail regarding potential impacts for each environmental aspect considered is provided in Appendix C.

Table 5-1 Summary of potential environmental impacts

Topic	Likely impacts of the tunnel option when compared to the proposed scheme
Air quality	• Local air quality would be improved at receptors close to the proposed alignment such as at the Birdlip AQMA and at Ullen Wood where impacts are predicted for the ecological receptors. • Impacts could be significant at the tunnel portals close to existing human and ecological receptors (Crickley Hill SSSI) due to the increase in emissions at this point. • Emissions from the tunnel vents would need to be considered via detailed dispersion modelling.
Cultural heritage	• Larger construction footprint puts local protected monuments and archaeological remains at risk of being damaged. • The Air Balloon Pub would still be demolished as part of the necessary construction works, including those involved in the cut and cover solution. • Traffic noise and visual impacts at Emma's Grove removed.
Landscape and Visual	• Greater visual impact during construction due to deeper cutting and temporary spoil storage pile. • Visual and landscape impact of uncharacteristic portal structures. • Greater impact on landscape character during construction. • Reduced impact on landscape character during operation, subject to careful restoration. • Permanent landscape and visual impacts as a result of the realigned A436 and amended Shab Hill junction. Visual effect would be experienced by users of the minor road, residents of properties at Shab Hill, including Cuckoopen Farm and Rushwood Kennels, and users of the Gloucestershire Way long distance footpath.
Biodiversity	• Ecological connectivity can be reinstated following construction, whereas it cannot be to a similar extent by the proposed scheme. • Larger construction footprint resulting in greater temporary habitat loss and fragmentation, including a small portion of Barrow Wake SSSI, during extended construction programme. • Additional habitat loss and fragmentation required due to realignment of the A436 and necessary spoil pile. • Longer construction period leading to increased levels of visual disturbance and disturbance from lighting, noise, vibration. • Higher volume of construction traffic and movement of materials leading to detrimental impacts on air quality through dust deposition and NOx, which in turn have the potential to negatively impact sensitive habitats and plant communities. • Increased risk of species injury and mortality associated with longer construction period and larger construction footprint.
Geology and soils	• Larger temporary loss of ALC Grade 3a and 3b agricultural land. • Reduced loss of ALC Grade 3a and 3b agricultural land once reinstated post construction (assuming soil above structure is returned to productive agriculture and not needed for ecological mitigation for example).

Topic	Likely impacts of the tunnel option when compared to the proposed scheme
Material assets and waste	• Additional 500,000m^3 of concrete for tunnel structure. This would require two on-site batching plants. • Surplus cut material of over 1,500,000m^3 over the 1.3km length of tunnel. • Increased vehicle movements required for movement of fill which will increase pollution.
Noise and Vibration	• Parts of Public Rights of Way (PRoW) close to tunnelled section would be less affected by scheme traffic noise than proposed surface solution. • Area immediately around the tunnelled scheme would still be affected by surface sections to the west and south of the tunnel. • The few significant adverse effects around Shab Hill junction would likely remain significant adverse effects with the tunnelled solution.
Population and human health	• Landscape integration can be reinstated following construction, whereas it cannot be to a similar extent by the proposed scheme. • Increased impact and likely closures of PRoW during construction. • Extended construction period of noise, vibration, and dust impacts on communities and users of PRoW. • Extended construction period of disruption to communities, businesses, and tourists. • Demolition of Air Balloon pub unavoidable. • Cotswold Way National Trail and other rights of way could be re-provided and maintained along existing routes post construction. • Land take and loss of agricultural land would increase during construction. However, there is then the potential to revert to use subject to suitability post construction with reinstatement of land at surface level.
Water environment	• Increased drawdown of groundwater levels into the Bridport Sand Formation near the Cotswold escarpment crest. • Larger reduction or loss of baseflow to springs and seepages feeding the tributary of Norman's Brook. • Loss of the dry valley at Shab Hill junction. • Reduced baseflow in springs and seepages that feed the River Churn headwaters. • Potential deterioration of water framework directive groundwater status. • Potential impact upon groundwater divide and groundwater source protection zone (SPZ).
Climate	• Increase in concrete and steel volumes will have a significant effect on construction and maintenance related emissions. • Surplus materials with increased cutting and associated increased carbon during construction activities such as soils extraction. • Increased emissions from vehicle movements to transport materials to and from site, and increased vehicle movements required for movement of fill and offsite disposal of surplus material.

5.5 Impact on traffic and local roads

5.5.1 The implementation of a cut and cover tunnel in this area would have consequences on the connectivity to the existing Air Balloon roundabout during construction. The scheme proposes that the existing A417 on the approaches to Air Balloon roundabout would be used throughout construction as part of the temporary traffic management strategy. The existing approach would also be partially retained as Cold Slad Lane upon completion of the scheme to maintain local access. Therefore, to maintain this route whilst the cut and cover tunnel is being constructed, a retaining wall would be required.

5.5.2 The proposed scheme proposes that the A436 would connect to the A417 using the proposed Shab Hill junction via a link running broadly parallel with the mainline A417. This would no longer be feasible due to the difference in levels between the two roads, as well as the location of Shab Hill junction.

5.5.3 Due to its proximity to the indicative tunnel portals, the layout of the Shab Hill junction would need to be drastically amended. This note therefore assumes that the A436 link would need to be fully reviewed. A possible solution is shown in Figure 5-1Map showing proposed changes to local roads.

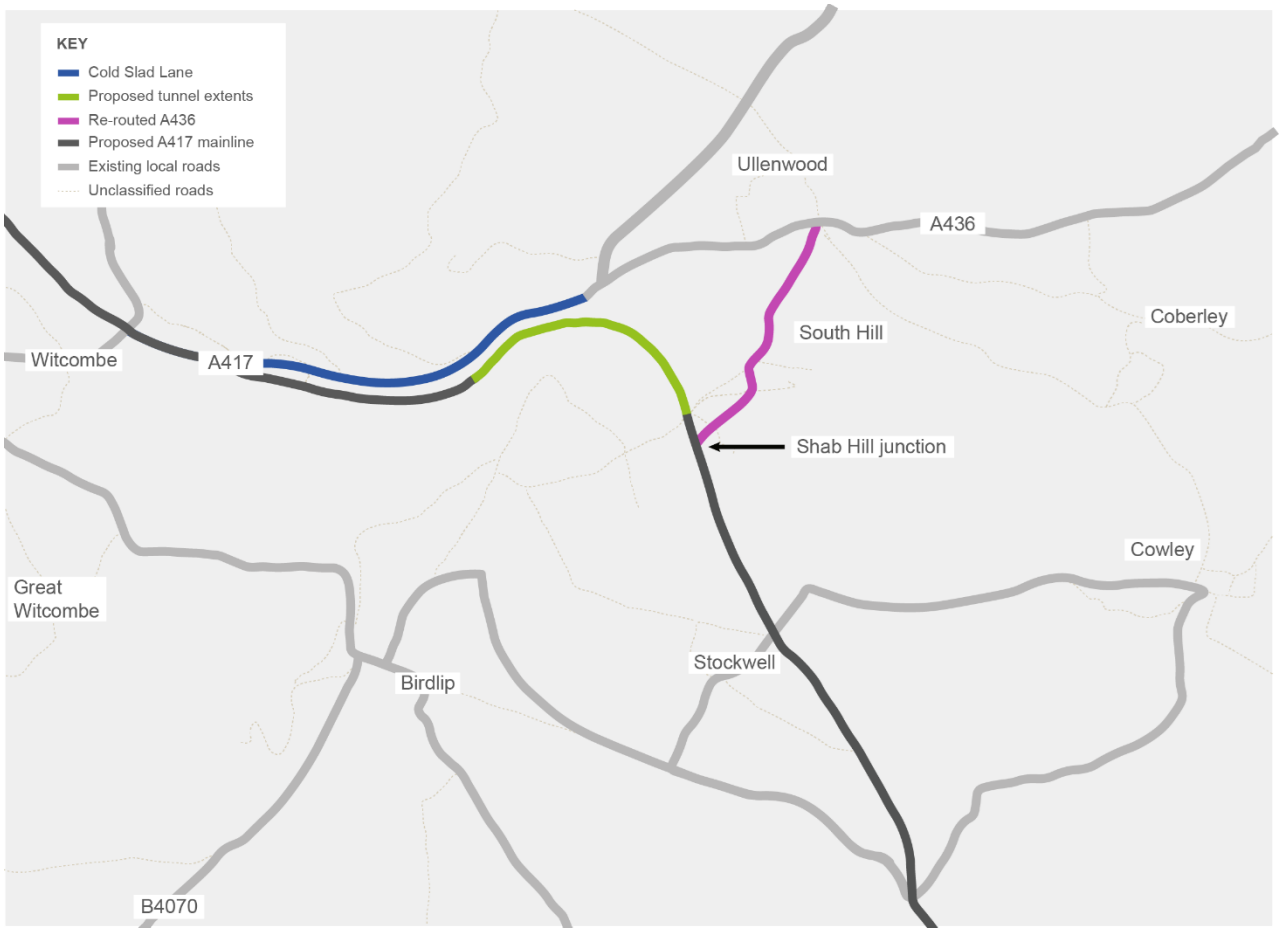

Figure 5-1 Map showing proposed changes to local roads

5.5.4 Further local roads that would be adversely impacted would be:

- Local access to Grove Farm, during construction and operation.
- The existing A417 as it travels south from Air Balloon roundabout, during construction activities.

5.5.5 The impact on through traffic would be similar to the proposed scheme during operation.

5.6 Land and property

5.6.1 With a cut and cover solution there would be increased land required for the scheme. This would occur from the changes needed to accommodate an increased footprint for a tunnelled solution, and to provide the link road for the A436. A new link connecting the A436 to Shab Hill would need to be created leading from the area around Seven Springs south to Shab Hill via an existing PRoW.

5.6.2 The increase in land take would be significantly more than that currently required for the scheme, and the carriageway and verges would be acquired on a permanent basis.

5.6.3 The route would also impact upon Ullen Wood and lead to more tree loss. The new A436 link would also require land to be acquired from the Woodland Trust on a permanent basis. This would lead to potential loss or deterioration of Ancient Woodland / irreplaceable habitat which is a key test within the NPSNN (see 5.7 below).

5.6.4 Subject to further study, there would also be a likely adverse significant effect with additional land take at Grove Farm and nearby land and properties, with scale of impact likely to result in the viability of agricultural holdings being significantly compromised, and with amenity effects being significant to the community during construction, which could result in significant adverse human health effects.

5.6.5 BT Openreach, Gigaclear, STW and WPD services would be impacted by the construction of a cut and fill tunnel. Although these are the same services impacted by the construction of the proposed scheme, additional costs will be incurred as a result of the lengthy temporary diversions required to allow construction of the cut and cover tunnel.

5.7 Policy tests

5.7.1 The A417 Missing Link scheme is situated entirely within the Cotswolds AONB. As such, it is subject to the policies in paragraphs 5.150 to 5.153 of the NPSNN under the generic impact 'landscape and visual impacts' which apply to development proposed within nationally designated areas, such as AONBs.

5.7.2 It is considered that, given the national significance and environmental sensitivity of the Cotswolds AONB landscape, the case for developing the scheme within the AONB requires detailed assessment and forms a key consideration in the determination of the scheme.

5.7.3 Chapter 7 of the Case for the Scheme (Document Reference 7.1) considers in detail the compliance of the proposed scheme with the NPSNN paragraphs 5.150 to 5.153 in relation to its development within the Cotswolds AONB.

5.7.4 Paragraphs 5.150 to 5.153 of the NPSNN set out the policy for development proposed within nationally designated areas.

5.7.5 Any suggested alternative including a tunnel or cut and cover solution must also be considered against the same policy tests.

5.7.6 Paragraph 5.150 of the NPSNN sets out that great weight should be given to conserving landscape and scenic beauty in nationally designated areas. It identifies that such areas have the highest status of protection relating to landscape and scenic beauty and directs that, in making decisions, the Secretary of State (SoS) has a duty to have regard to the statutory purposes of designated areas such as AONBs.

5.7.7 The key policy tests for development located in nationally designated areas, such as AONBs, are set out within paragraphs 5.151 to 5.153 of the NPSNN.

5.7.8 In summary, there are four key NPSNN policy tests relating to development in an AONB:

1. Whether there are exceptional circumstances for the grant of consent of a highways NSIP in the Cotswolds AONB?
2. Whether there are compelling reasons for new or road enhanced capacity?
3. Whether the benefits of the scheme significantly outweigh its costs?
4. Whether the scheme will be carried out to high environmental standards, including, where possible, measures to enhance other aspects of the environment?

5.7.9 Whilst the Case for the Scheme (Document Reference 7.1) concludes the proposed scheme would comply with the policy tests set out above, it is unlikely that the cut and cover solution would do so for the following reasons:

a) the benefits of the scheme would not significantly outweigh its costs; and
b) the ability to achieve high environmental standards would be challenging given adverse impacts listed in Table 5-1.

6 Summary

6.1.1 This note provides a feasibility study which has looked, at a high level, a new alternative design suggestion provided by stakeholders for a cut and cover solution. It has also summarised earlier consideration of other tunnel options and sets out why the proposed scheme is the preferred solution. The key reasons why this alternative cannot be delivered include:

1. **Cost:** The total cost of a cut and cover scheme would be in excess of £1.3Bn, more than three times the cost of the proposed scheme. This is consistent with the findings at route options stage. That cost far exceeds the government cost allocation for the scheme in RIS2, with no clear route to additional funding at this stage.
2. **Value for Money:** It is very likely that the costs would significantly outweigh the benefits, offering poor value for money.
3. **Environmental impacts:** The impacts during construction would be large, with adverse impacts on people, landscape and wildlife. For example, there would be a surplus of cut material of over 1,500,000m^3. The impacts during operation would also results in adverse effects on most environmental topics as set out in Table 5-1.
4. **Programme:** The construction programme would also be much longer, resulting in increased disruption to communities, businesses and visitors.
5. **Policy:** It is unlikely that the cut and cover solution would achieve at least two of the four key NPSNN policy tests relating to development in an AONB, relating to whether the benefits of the scheme significantly outweigh its costs, and whether the scheme will be carried out to high environmental standards, including, where possible, measures to enhance other aspects of the environment. This is because the benefits of the scheme would not significantly outweigh its costs, and the ability to achieve high environmental standards would be challenging given the adverse impacts listed in Table 5-1.

Appendix A Highways alignment calculation information

A.1.1.1 In order to determine the requirements for the structure and cutting, it is first imperative to understand the highway requirements. In this section of the mainline the design speed is 120kph, and the proposed scheme's vertical alignment includes an 8% vertical gradient on Crickley Hill. This gradient falls at the upper end of acceptability in highways terms.

A.1.1.2 Providing an 8% gradient enables the cutting on Crickley Hill to be minimised and by re-using as much of the excavated material as possible on-site, a near balance of material can now be achieved.

A.1.1.3 According to code guidance, the desirable maximum vertical gradient recommended in CD 109 of DMRB is 4% for a dual all-purpose carriageway. Features such as climbing lanes can be appropriate for gradients above 3% and above on dual carriageways. Due to the length of the gradient a climbing lane has been proposed in the current design; the Road Tunnel Safety Regulations 2007 (as amended), which refers back to EU Directive 2004/54 states that longitudinal gradients above 5% shall not be permitted in new tunnels, unless no other solution is geographically possible. CD 352 notes that for tunnels the penalties of steep gradients are more severe than on open roads, and will include higher ventilation costs due to increased vehicle emissions, worsening safety and challenges for means of escape.

A.1.1.4 For comparison a range of gradients were investigated to understand the implications on the design. Based on the EU Directive stating 5% gradients – this was used as a base solution to determine the most appropriate start and end chainages for the tunnel, which were selected as CH 1+700 and CH 3+000.

A.1.1.5 It should be noted that as the gradient of the road decreases, the required cutting depth increases and therefore it would consequentially become significantly wider and more expensive to construct. This would also adversely impact more of the landscape and ecology and become technically more challenging.

Table 6-1 Comparison of scheme options

Option gradient	Maximum cut depth (m)		Maximum width of cutting (m)	Volume of spoil (m^3)
	Ch 1+800	Ch 2+500		
4%	27.4	39.8	175m approx	4.1 million total 1 million surplus
5%	**26.4**	**32.3**	**160m approx**	**3.5 million total** **0.9 million surplus**
7%	27.9	22.6	N/A	N/A
8%	15.2	13.7	N/A	N/A

Appendix B Geotechnical conditions

B.1 Landscape and topography

B.1.1.1 The ground level rises from ~210m AOD to ~280m AOD between Ch 1+700 and Ch 3+070. From Ch 1+700 to Ch 2+000 the alignment is located within an existing cut approximately 20m deep with side slopes of around 35 degrees. At roughly Ch 2+000 the alignment stops following the north-east south-west trending valley/existing cut and climbs to the southeast.

B.2 Ground conditions

B.2.1.1 The following is a brief summary of the bedrock and superficial stratigraphy relevant to the extent of cut and cover structure considered as part of this assessment. A detailed discussion of the published geology of the site based on geological mapping, memoirs and relevant publications is presented in the Preliminary Sources Study Report (PSSR)[7] prepared during PCF Stage 2. A detailed summary and initial interpretation of the available site investigation information gathered in relation to the ground and groundwater conditions along the scheme is presented in the Preliminary Ground Investigation Report (GIR)[8], which is appended to the Environmental Statement.

B.2.1.2 The Jurassic rocks underlying the scheme comprise the Lias Group, the Inferior Oolite group and the Great Oolite Group. Superficial deposits comprising Mass Movement Deposits overlie the area underlain by the Lias Group to the west of Ch 1+750.

B.2.1.3 Figure 6-1 presents a geological plan for the assessment area based on available published information. Figure 6-2 and Figure 6-3 present geological long sections for the assessment area, which include the existing ground surface profile, proposed alignment (8% scheme) profile, cut and cover structure alignment profile, and available exploratory hole information.

[7] Mott Macdonald Sweco Joint Venture (May 2018), "A417 Missing Link. Preliminary sources study report. PCF Stage 2. HA GDMS 30509".

[8] Highways England, "A417 Missing Link. Environmental Statement, Volume 6, Document Reference 6.4 Environmental Statement – appendices, Appendix 9.1, Preliminary Sources Study Report.

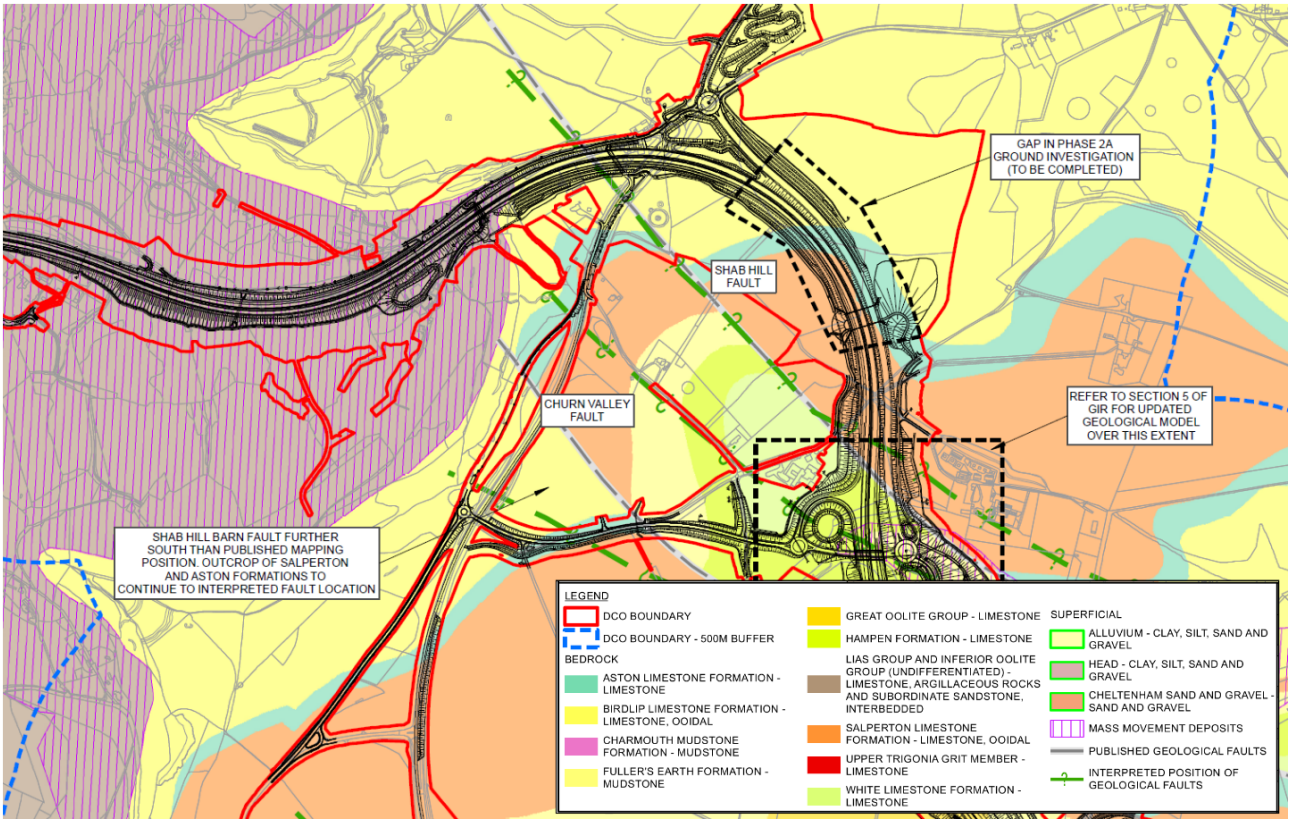

Figure 6-1 Geological plan extracts

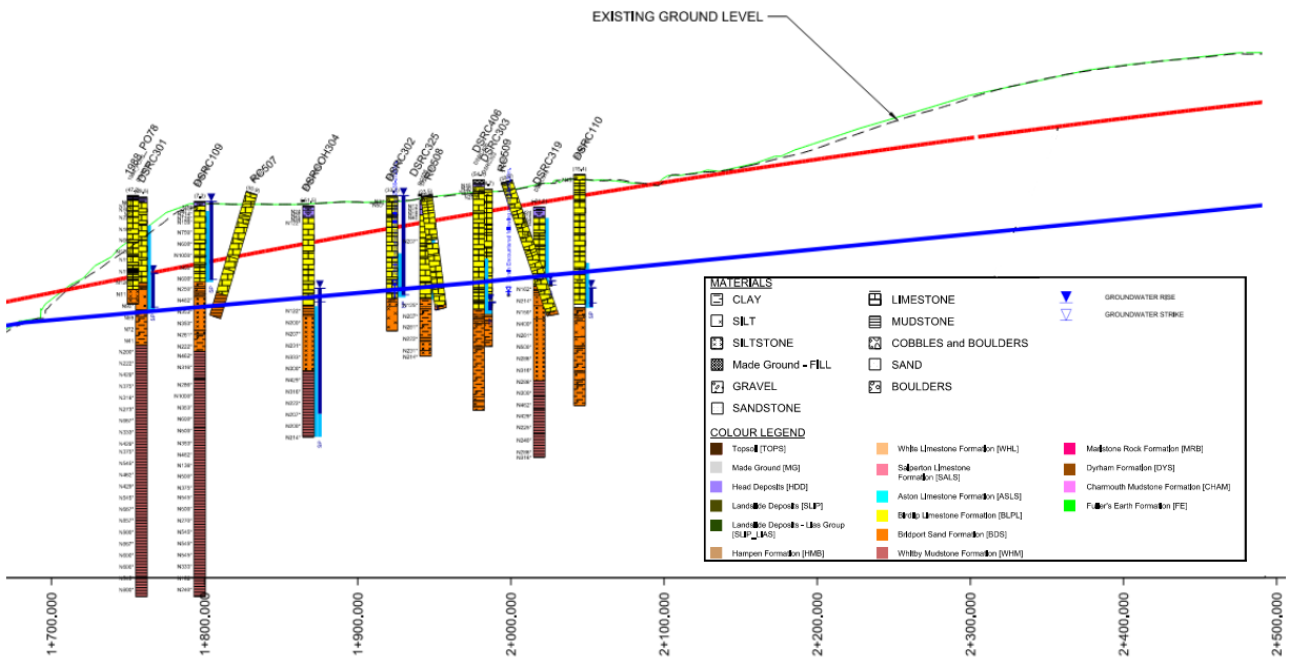

Figure 6-2 Geological longsection, Ch 1+700 to Ch 2+500m

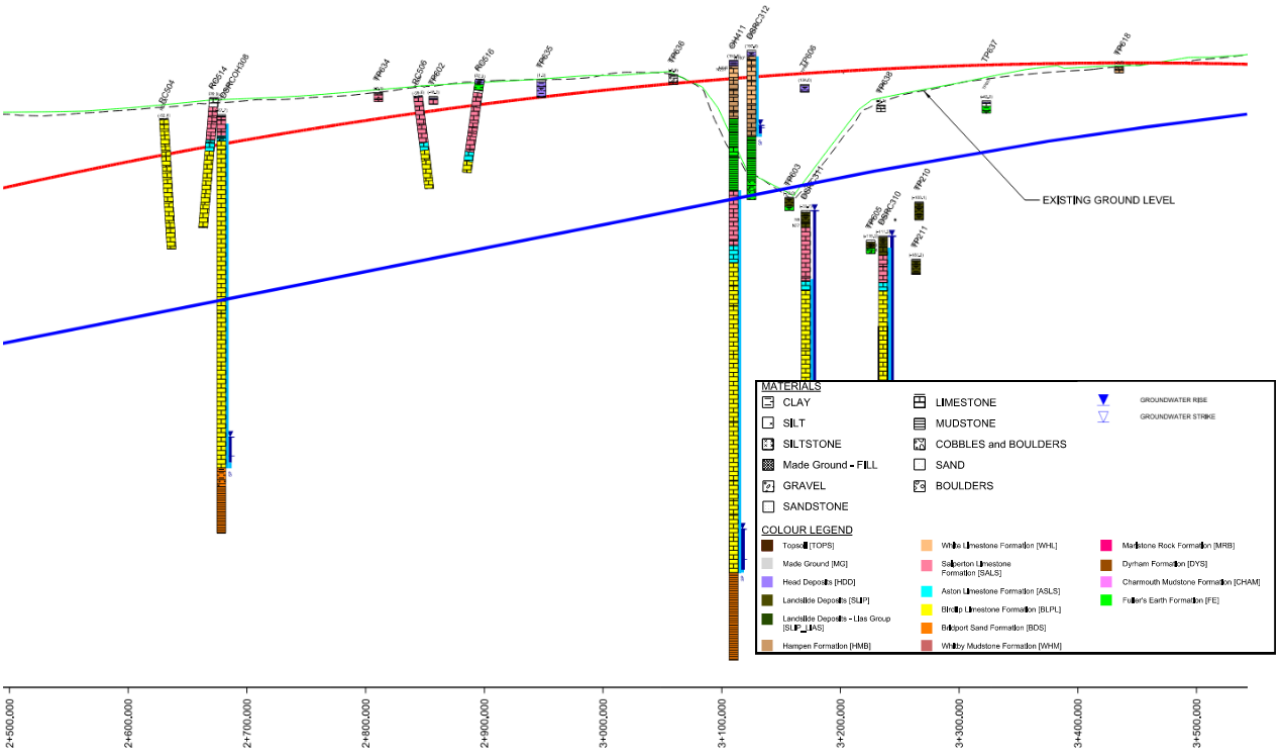

Figure 6-3 Geological longsection, Ch 2+500 to Ch 3+500

B.2.1.4 Based on the geological plan and long sections presented above, it is anticipated that any temporary excavations for the construction of a cut and cover solution would be within the following stratigraphy.

Anticipated chainage extent	Stratigraphy	Superficial deposit type / Bedrock Formation	Typical description
Ch 1+700 to Ch 1+750	Superficial deposit	Mass Movement Deposits	Predominantly cohesive material with variable constancy.
	Bedrock: Lias Group	Bridport Sand Formation	Micaceous silt, silty/sandy clays, and silty sand or micaceous siltstones and mudstones
Ch 1+750 to Ch 1+850	Bedrock: Inferior Oolite Group	Birdlip Limestone Formation	Very weak to strong light yellowish brown bioclastic limestone. Fractures are typically sub horizontal that are considered to represent bedding discontinuities (but were encountered up to sub vertical), undulating, rough and close to medium spaced. Voids of up to 1m in size have been identified, both open voids and voids infilled with clay are described in the logs and televiewer.
	Bedrock: Lias Group	Bridport Sand Formation	See Ch 1+700 to 1+750.

Anticipated chainage extent	Stratigraphy	Superficial deposit type / Bedrock Formation	Typical description
Ch 1+850 to Ch 2+950	Bedrock: Inferior Oolite Group	Salperton Limestone Formation	Very weak to strong yellowish brown/grey oolitic, bioclastic and sometimes crystalline limestone. Fractures are typically sub horizontal that are considered to represent bedding discontinuities (but were encountered up to 50°), undulating, rough and close to medium spaced. Voids of up to 80mm, often infilled with clay, were described in a few of the cores.
		Aston Limestone Formation	Weak to strong light brown/grey bioclastic limestone. Fractures are typically sub horizontal that are considered to represent bedding discontinuities (but were encountered up to 50°), undulating, rough and close to medium spaced. Voids of up to 30mm were described in a few of the cores.
		Birdlip Limestone Formation	See Ch 1+750 to 1+850.
Ch 2+950 to Ch 3+000	Bedrock: Great Oolite Group	White Limestone Formation and Hampen Formation	Light yellowish to greyish brown very weak to weak (occasionally medium strong) thinly bedded bioclastic and ooidal limestone, with rare interlaminations of orangish brown sandy silt/clay
		Fuller's Earth Formation	Extremely weak to weak grey mudstone, with occasional grey bioclastic limestone beds that become more frequent towards the top of the formation. Fractures are variously recorded as both undulating and planar, rough and smooth and occasionally infilled with dark grey clay.
	Bedrock: Inferior Oolite Group	Salperton Limestone Formation	See Ch 1+850 to 2+950.

B.3 Hydrogeological conditions

B.3.1.1 The following is a brief summary of the hydrogeological conditions relevant to the extent of cut and cover structure considered as part of this assessment. A detailed summary and initial interpretation of the available site investigation information gathered in relation to the hydrogeological conditions along the scheme is presented in the Hydrogeological Impact Assessment (HIA)[9], which is appended to the Environmental Statement.

[9] Highways England, "A417 Missing Link. Environmental Statement, Volume 6, Document Reference 6.4 Environmental Statement – appendices, Appendix 13.7, Hydrogeological Impact Assessment.

B.3.1.2 The hydrogeological units underlying the scheme include the superficial deposits minor aquifer, the Great Oolite Group limestone aquifer and the Inferior Oolite Group aquifer and.

B.3.1.3 The Fuller's Earth Formation is the basal mudstone of the Great Oolite Group, which is a groundwater flow barrier that separates the Great Oolite Group limestone aquifer from the underlying Inferior Oolite Group aquifer. The Lias Group comprises the Bridport Sand Formation, minor aquifer which is underlain by mudstone formations that form a groundwater flow barrier. The Bridport Sand Formation is hydraulically connected to the overlying Inferior Oolite Group aquifer. Lias Group mudstones underlie the Bridport Sand Formation across the scheme area and the superficial deposit west of Ch. 1+750.

B.3.1.4 The maximum seasonal groundwater levels in the Inferior Oolite Group are presented in Figure 6-4 and the minimum seasonal groundwater levels are presented in Figure 6-5. Within the Great Oolite Group limestones at Shab Hill Junction the groundwater level is approximately 270mAOD at the crest of the dry valley and 216mAOD at the base of the dry valley.

B.3.1.5 The hydrogeological features near the proposed cut and cover tunnel alignment are presented in Figure 6-6 and Figure 6-7. At the crest of the Cotswold escarpment there are number springs from the Inferior Oolite Group and superficial deposits which form the headwaters of the tributary of Norman's Brook. At Shab Hill junction there is a dry valley that runs to the east and forms the head of the Churn Valley. The dry valley and Churn Valley include springs and seepages from the superficial deposits and limestone aquifers. A groundwater SPZ 3, associated with an abstraction from the Inferior Oolite Group is located around 150m east of Shab Hill junction.

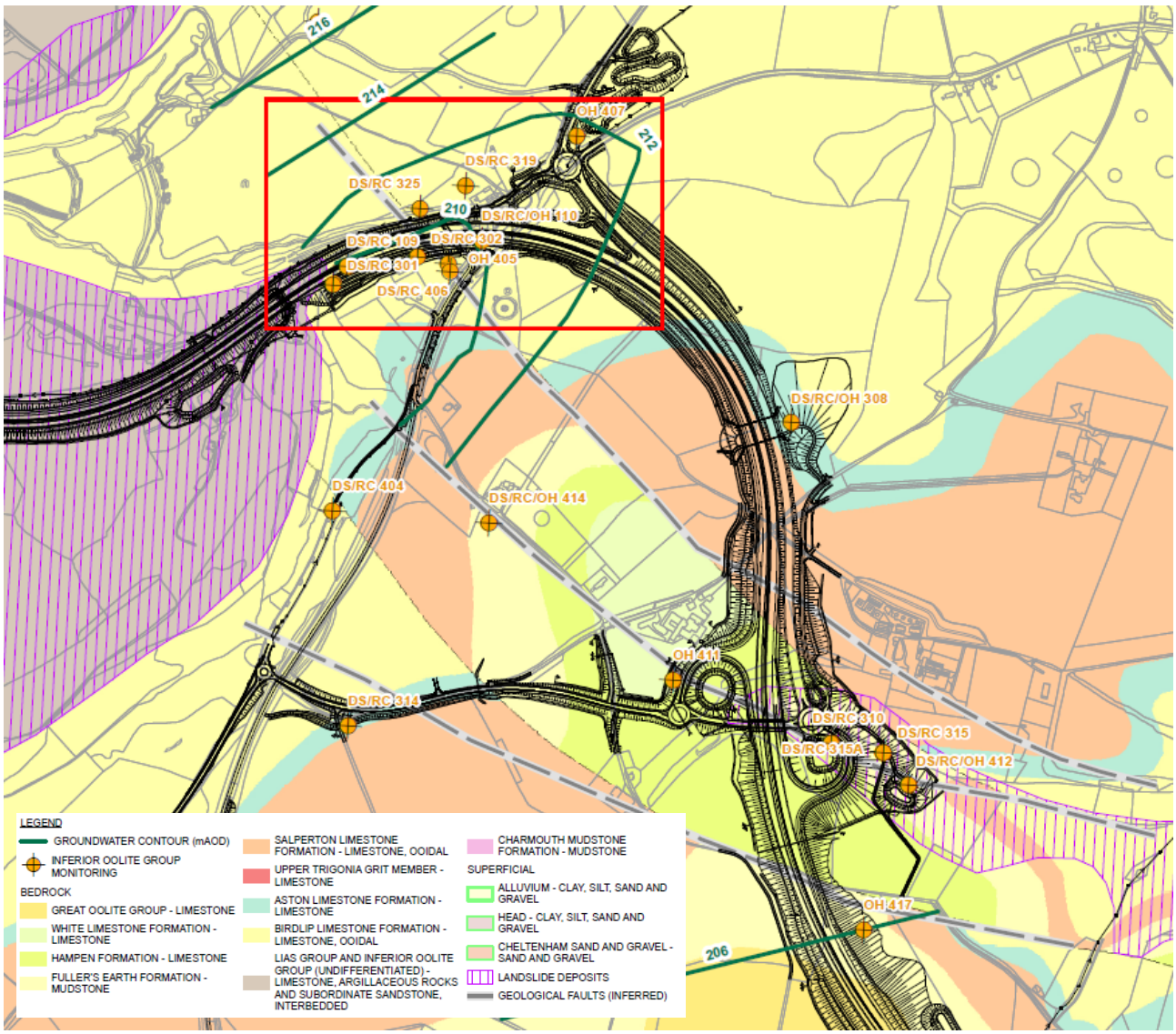

Figure 6-4 Inferior Oolite Group aquifer, maximum seasonal groundwater levels

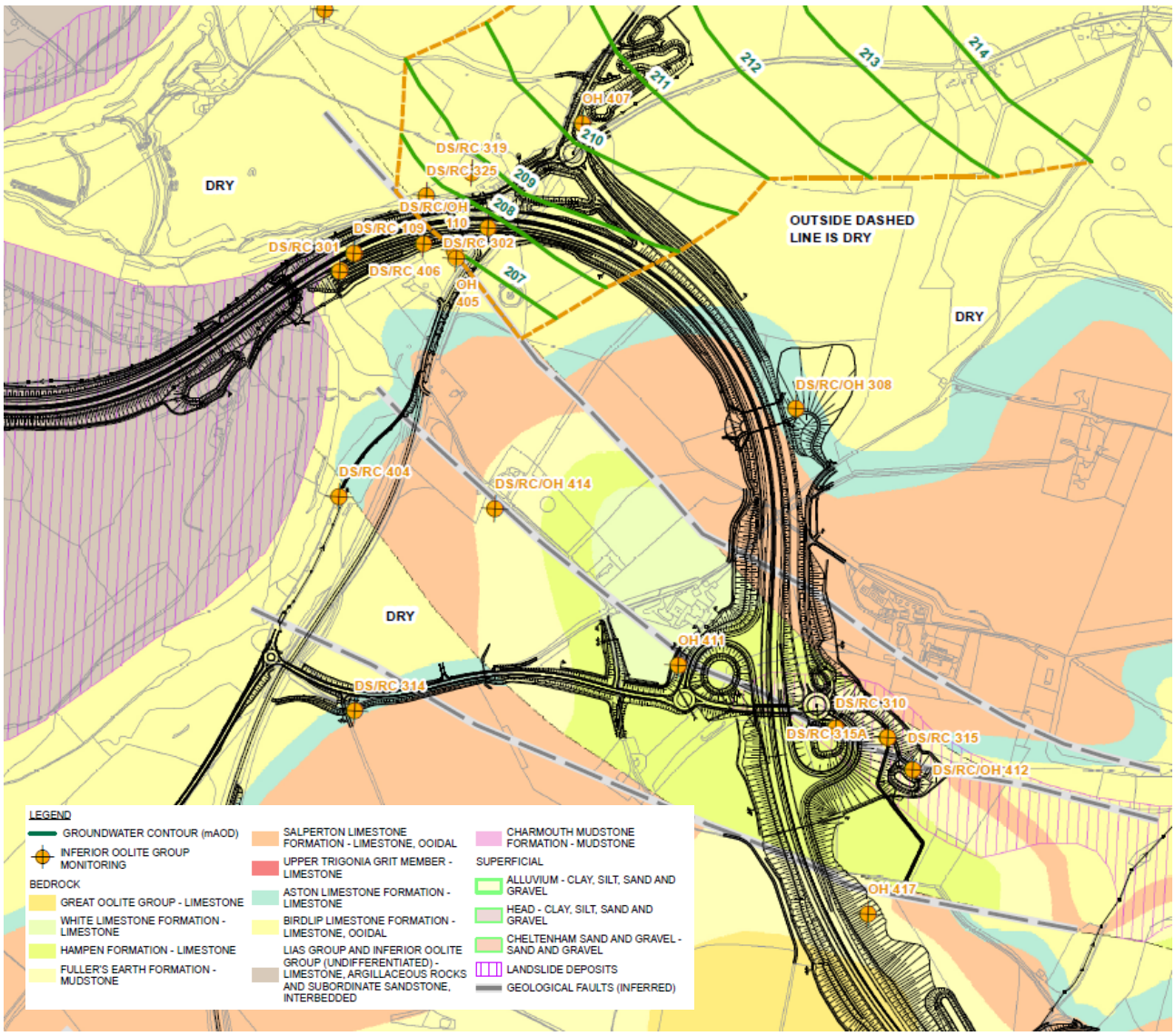

Figure 6-5 Inferior Oolite Group aquifer, minimum seasonal groundwater levels

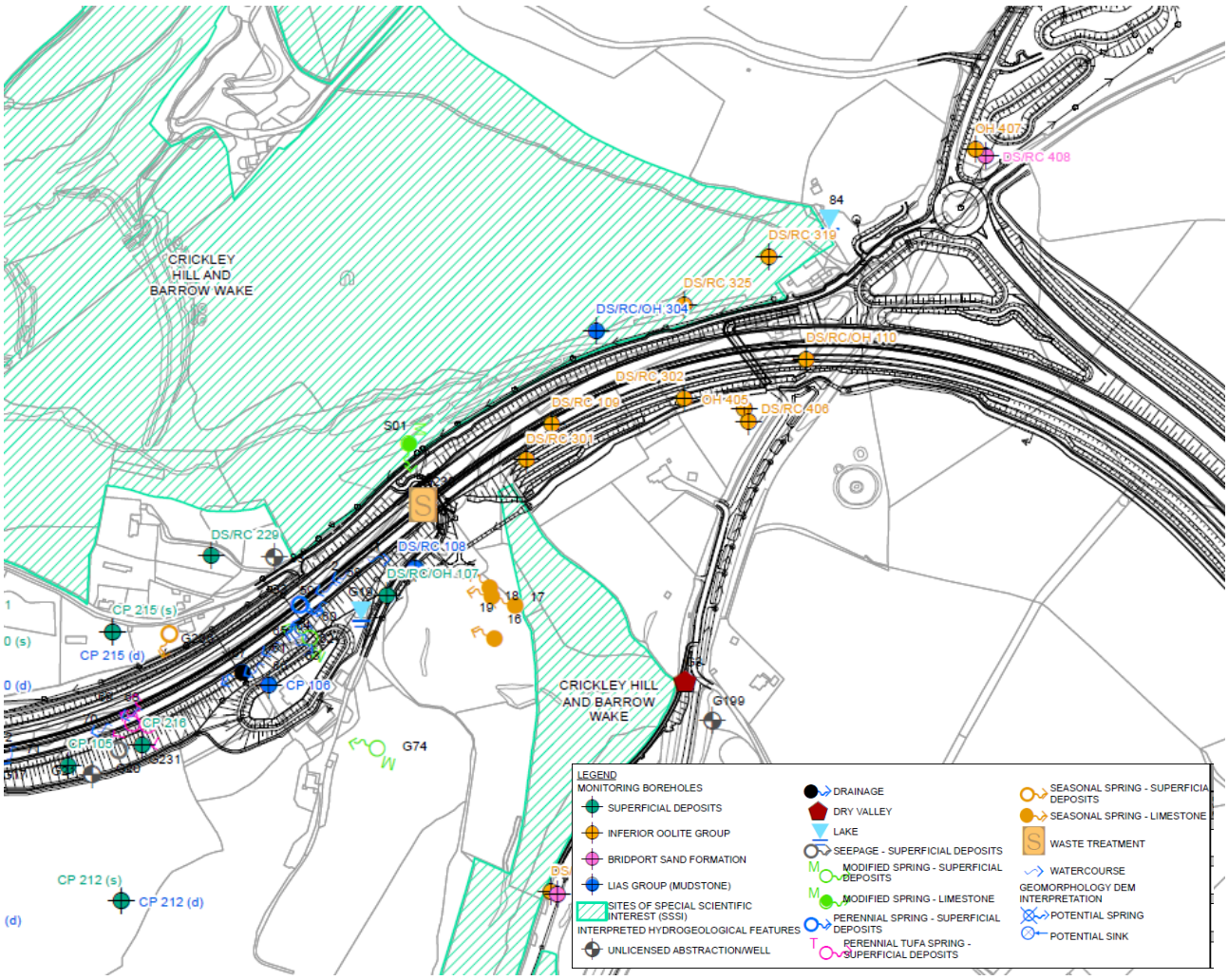

Figure 6-6 Hydrogeological features, Ch. 1+200 to Ch. 2+200

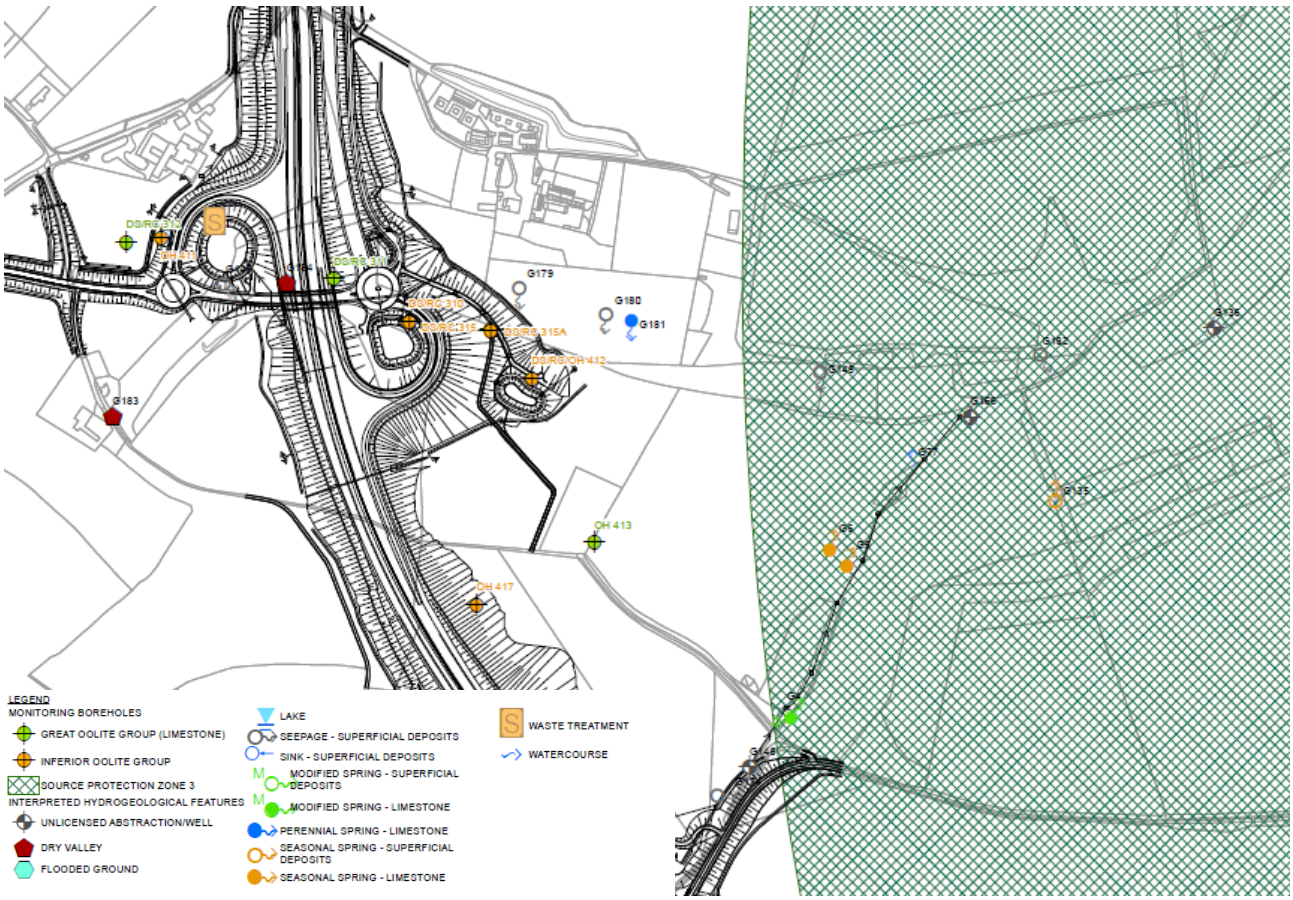

Figure 6-7 Hydrogeological features, Ch. 2+800 to Ch. 4+000

Appendix C Environmental impacts – further information

C.1 Air quality

C.1.1.1 Putting the A417 into a tunnel would improve local air quality in the area immediately adjacent to the road alignment. This would further improve local air quality at the Birdlip AQMA and would have a beneficial impact at Ullen Wood where significant adverse impacts from air quality are predicted to the ancient woodland.

C.1.1.2 There would be a worsening in air quality expected (compared to the existing and assessed case for the ES) at the tunnel portal locations, due to the increased emissions in this area. The tunnel portal impacts and potential impacts from any vents would need to be modelled as there is a risk of resulting in new significant impacts at existing receptors such as the Crickley Hill SSSI.

C.2 Cultural heritage

C.2.1.1 The area of the scheme is rich in history, from the prehistoric settlements on Crickley Hill, through the Roman period right up to the nearby structures associated with World War II communications masts. Much of this evidence survives as buried archaeological remains, and these would be removed within the footprint of the cut and cover tunnel.

C.2.1.2 The Emma's Grove Barrows are legally protected as a scheduled monument and would require an engineering solution that retained them in situ, and which would not cause damage as a result of vibration.

C.2.1.3 The Cotswold Way is a National Trail that follows an ancient routeway that would have been used by the local inhabitants of the area since prehistoric times. The Emma's Grove barrows would have been a landmark for these travellers, and the cut and cover tunnel would act to reinstate this route.

C.2.1.4 The cut and cover tunnel would also remove traffic noise and visual impacts at Emmas Grove, and somewhat restore its setting to a state more similar to that which existed before the construction of the existing A417. This change would likely result in a significant beneficial effect on this monument. The setting of the prehistoric defended settlement at Crickley Hill would also experience beneficial effects from the removal of traffic in views to the south, and through the re-establishment of the physical link between it and Emmas Grove. This is likely to result in a significant beneficial effect.

C.3 Landscape and Visual

C.3.1.1 Construction effects on landscape character and visual amenity would be greater with a cut and cover solution compared to the proposed surface solution. Construction impacts would be considerable with the need to deeply excavate the tunnel through the escarpment and across a short section of the high wold landscape. The excavation activity would require around 250,000m^3 of additional material to be temporarily stored onsite at any one time.

C.3.1.2 The impact on landscape character with the additional loss of agricultural land and locally important landscape features, including Cotswold stone walls, hedgerows and woodland at Emma's Grove and Ullen Wood during construction and operation, would be different with a cut and cover solution compared to the proposed surface solution. The impact on landscape character during construction would be much greater, but the impact during operation would likely be less significant, subject to the sensitive restoration of the land above the tunnel and how this integrates into the existing landscape.

C.3.1.3 The cut and cover design retains Cold Slad lane on the current alignment of the existing A417, meaning there would be limited opportunity to restore the existing cutting, in addition to the area above the cut and cover tunnel. It would also not be possible to provide a continuous landscape connection between Barrow Wake and Crickley Hill. To resolve this, a possible option could be to connect Cold Slad lane to the main carriageway before the tunnel portal, which would allow a greater depth of fill above the tunnel, creating a continuous landscape connection between Barrow Wake and Crickley Hill. The extent and quality of the land cover created would need careful consideration to maximise the landscape benefits. However, the detail of this option has not been fully considered as part of this study.

C.3.1.4 The required tunnel portals would add a new uncharacteristic and permanent feature to both the escarpment and the high wold landscape character types, which are both highly sensitive to the introduction of highways infrastructure.

C.3.1.5 Construction activity would likely bring increased and potentially significant effects on recreational users of the Cotswolds AONB and local communities, with potentially significant visual effects related to the presence and movement of construction vehicles at close proximity and the extent to which people would be able to see the exposed rock and works related to the required retaining walls. There would also be increased construction traffic impacts on sensitive receptor groups with the required movement of significant levels of material.

C.3.1.6 The extent of visual effects for recreational users of Public Rights of Way, including the Cotswold Way National Trail and Gloucestershire Way long distance footpath, would vary depending on the users' location on the footpath and the level of intervisibility from the path to the construction area. Views from communities within the vale and from visitor sites, such as the Great Witcombe Roman Villa would experience greater effects compared to the proposed surface solution. Views from Crickley Hill Country Park would also experience a greater effect during the construction phase.

C.3.1.7 The long-term visual effects during the operational phase of the cut and cover tunnel would be reduced compared to the existing A417 and the current proposals from specific locations where the tunnel portal is not visible, e.g. the entrance to Crickley Hill country park. The cutting would remain, due to the presence of Cold Slad lane, although its width and visibility would be reduced. The western tunnel portal would add a permanent visual feature in local views, effecting the special quality of the Cotswolds AONB – views to and from the escarpment, with the eastern portal giving rise to visual effects from Shab Hill and the high wold, effecting the community of Shab Hill and recreational users of the Gloucestershire Way long distance footpath.

C.4 Biodiversity

C.4.1.1 Due to the construction methods associated with a cut and cover tunnel, a much larger construction footprint is to be expected, as shown on Figure 4-1. This would lead to further permanent loss of Emma's Grove and other areas of semi-natural broadleaved woodland.

C.4.1.2 During the construction phase, there would be an increased severance between Barrow Wake and Crickley Hill SSSI components, further fragmenting the habitats and greater loss of habitat.

C.4.1.3 Higher volume of vehicles required for material movement during the construction phase, could result is a detrimental impact on the concentration oxides of nitrogen (NOx) and nitrogen deposition at some locations.

C.4.1.4 Dust deposition associated with the construction phase has the potential to affect sensitive habitats and plant communities such as ancient woodland at Ullen Wood and calcareous grassland at the Barrow Wake unit of Barrow Wake and Crickley Hill SSSI. This impact is expected to be higher compared with Option 30 due to the high volume of material being excavated, and associated vehicles required for material movement. Dust can directly affect vegetation by smothering, reducing ability to photosynthesise and respire. Dust deposition could have an indirect on fauna, as the quality or suitability of foraging habitat is reduced.

C.4.1.5 A longer construction period would be expected, therefore leading to longer periods of disturbance compared to Option 30.

C.4.1.6 Impacts from visual disturbance (including human activity and artificial lighting) and noise disturbance could have significant effects on sensitive species. This could lead to abandonment of territory or of young, increased predation risk and use of critical energy reserves.

C.4.1.7 Disturbance resulting from lighting can also lead to significant effects on nocturnal species such as bats. The effect of road lighting is complex and varies for different species, but includes roost disturbance and abandonment, severance and loss of foraging and commuting habitats, and a decline in airborne invertebrate prey.

C.4.1.8 Disturbance from noise or vibration during construction, especially over a more prolonged period, may also lead to species abandoning roosting or nesting habitat.

C.4.1.9 It is estimated that during the construction of the tunnel, around 250,000m³ of excavated material would need to be temporarily stored at any one time. Since this would need to be adjacent to the process area, as it is anticipated that the excavated limestone would require processing to ensure it is acceptable for use as structural fill, this would result in the requirement of additional land area and therefore further habitat loss and degradation.

C.4.1.10 A cut and cover tunnel would have one significant benefit compared with Option 30: once the tunnel has been covered, habitats can be reconnected, removing the fragmentation and severance impacts that would otherwise be caused by a new road.

C.4.1.11 A cut and cover tunnel would deliver the additional benefit of providing a new section of approximately 375m of land connection between Crickley Hill and Barrow Wake SSSI components, which are currently severed by the existing A417.

C.5 Geology and soils

C.5.1.1 As with the current scheme, the cut and cover tunnel would not impact the geologically designated Crickley Hill and Barrow Wake SSSI site and particularly the notable exposures of the Leckhampton Member.

C.5.1.2 The construction of the “cut and cover" tunnel would require only temporary use of land, which would take soil out of agricultural use for the period of construction rather than resulting in a permanent loss. Following completion of construction, all temporary facilities would be removed, and the soil reinstated and returned to agricultural use. The agricultural soil temporarily displaced by the scheme would, after land restoration, generally be able to fulfil its primary soil functions on-site i.e. the soil is returned to its current ALC grade (BMV agricultural ALC grade 3a and 3b land).

C.5.1.3 Both options would require similar level of management of risks associated with land contamination. Potential sources of contamination have been identified within the footprint of the tunnel or the temporary works. These include made ground associated with the existing A417 road, and the Air Balloon Public House and the sewage soakaway. These are unlikely to result in significant contamination and could be managed during construction as part of health and safety and materials management in accordance with good practice.

C.5.1.4 Construction of the cut and cover tunnel would require reuse of a significantly greater volume of materials. However, implementation of an appropriate materials management plan would be sufficient to ensure that only materials not posing an unacceptable risk to human health or water environment would have been used within the scheme construction. Any unexpectedly encountered contamination would have been removed.

C.6 Material assets and waste

C.6.1.1 A review of the scheme cut and fill volumes shows a requirement for 3.5 million m^3 of cut and 2.6 million m^3 of fill, a surplus of 900,000 m^3, which would have to be disposed of off-site. If a bulking figure of 25% is applied this would require 112,500 loads of 20 tonne to be removed from site over the construction period.

C.6.1.2 It is estimated that a total of 300,000 m^3 of concrete would be required for the construction of the tunnel, together with 45,000 tonnes of reinforcement. This would require 795,000 tonnes of material to be delivered to site, nearly 40,000 20 tonne loads, over the construction period. Due to the extremely high volume of concrete required and the location of the site, two batching plants would need to be established for on-site production. This would require the area of the main compound to be increased by around 10,000 m^2 to facilitate the batching plant. In addition, a further 5,000 m^2 of land would be required for the storage and sorting of the reinforcement required.

C.6.1.3 There would be a total of just over 150,000 vehicle movements full of material, which doubles to 300,000 when taking into account the movement of the empty vehicle. This equates to one 20 tonne truck movement every 2 minutes, 10 hours per day over 4 years.

C.6.1.4 It is estimated that during the construction of the tunnel, around 250,000 m³ of excavated material would need to be temporarily stored at any one time. This would need to be adjacent to the process area, as it is anticipated that the excavated limestone would require processing to ensure it is acceptable for use as structural fill. Depending on how high it would be acceptable to store this material would define the additional land area required.

C.7 Noise and Vibration

C.7.1.1 The cut and cover solution would result in more intensive works with additional material movement and concrete requirements. Combined with an extended construction period when compared to the proposed surface solution, the construction noise and vibration impacts would be increased. Increased construction traffic movements to move additional materials associated with this option would also contribute to construction noise. Overall, the intensified works would likely result in more properties being subject to significant construction noise effects.

C.7.1.2 Operationally, the section of road that would be in tunnel would reduce traffic noise emission in that immediate area as there would be no noise contribution from the road itself. The noise reductions in the tunnelled area would likely result in smaller noise impacts to parts of the Gloucestershire Way and other PRoWs near to the tunnelled section, relative to the proposed surface solution.

C.7.1.3 However, the area immediately around the tunnelled scheme would still be affected by noise from the route to the west and the new alignment to the south at Shab Hill junction and beyond. It is likely that the significant adverse effects at the few properties associated with the proposed surface solution in the area around Shab Hill would remain significant effects with the tunnelled solution. There would be no benefit to properties or PRoWs further south of Shab Hill junction where noise levels would be dominated by the surface section south of the tunnelled scheme.

C.8 Population and human health

C.8.1.1 The impact of construction on local amenity would be greater with a cut and cover solution and with an extended construction period when compared to the proposed surface solution. This would likely bring increased and potentially significant impacts on local property and with health implications, for example with potentially significant noise and dust impacts during construction. There would also be increased construction traffic impacts on local people and businesses, with the required movement of significant levels of material.

C.8.1.2 The impact on land take including loss of agricultural land during construction and operation would be different with a cut and cover solution compared to the proposed surface solution. The impact on land during construction would be much greater, but the impact during operation would be less, subject to engagement with agricultural holdings and properties who may or may not consider the replacement land suitable for farming.

C.8.1.3 There would be a requirement for a much greater level of land with permanent rights of access required with a cut and cover solution.

C.8.1.4 Public Rights of Way potentially including the Cotswold Way National Trail would require closure during construction with a cut and cover solution, whereas with the proposed surface solution the phasing of provision of the crossings could be achieved in advance or during construction to help maintain the routes, with appropriate diversions of PRoW including the National Trail.

C.8.1.5 The consideration of the Air Balloon public house and its demolition is considered in Environmental Statement Chapter 6 Cultural Heritage and Chapter 12 Population and Health. A cut and cover solution would still require the loss of the building given construction works would impact the land above and adjacent to the solution. Whilst it is recognised that the Air Balloon public house is not a Listed Building, detailed historic building recording will be undertaken as part of the mitigation of the scheme. The need to demolish the Air Balloon pub is unavoidable.

C.8.1.6 The delay to the scheme required with a cut and cover tunnel solution would result in a longer period of potential personal injury accidents, potential fatalities, and adverse impact on businesses, tourism and local communities who would experience the existing and forecast problems for longer.

C.8.1.7 The increased land required shown in Figure 4-1 does show a significant increase in land affected. Whilst the landowners will not permanently lose the use of that land, a permanent right to maintain the structure would inevitably be required and restrictions on future development would also have to be considered. A low risk approach would be to acquire the land permanently for the entirety of the area shown in Figure 4-1.

C.8.1.8 The land shown as being required in Figure 4-1 also requires inalienable land from the National Trust, which if they objected to the use of the land will lead to the need for Special Parliamentary Procedure to be followed and the justification of the use of the land to be debated in parliament.

C.8.1.9 The land required (as shown in Figure 4-1) would involve land take impacting Emma’s Grove, which is a heritage asset.

C.8.1.10 The main issue identified with a cut and cover solution would be to increase the land required for the scheme. This would occur from the changes needed to the link road for the A436. A new link connecting the A436 to Shab Hill would be created leading from the area around Seven Springs south to Shab Hill via an existing PRoW. The increase in land take would be significantly more than that currently required for the scheme, and the carriageway and verges would be acquired on a permanent basis. The route would also impact upon Ullen Wood and lead to more tree loss.

C.8.1.11 The new A436 link would also require land to be acquired from the Woodland Trust on a permanent basis.

C.9 Road drainage and water environment

C.9.1.1 A cut and cover tunnel would increase the amount of groundwater drawdown within the Inferior Oolite Group and into Bridport Sand Formation near the Cotswold escarpment crest. This is likely to permanently drain this part of the aquifer which may cause a deterioration in the Water Framework Directive status for the groundwater body. Springs and seepages located on the Cotswold escarpment which feed the tributary of Norman's Brook are likely to have a large reduction or loss of baseflow. There may also be potential impacts upon the groundwater divide, which could migrate to the east.

C.9.1.2 At Shab Hill junction, a cut and cover tunnel would require excavation into the Great Oolite Group resulting in the loss of the dry valley and reduced baseflow in springs and seepages that feed the River Churn. Migration of the groundwater divide within the Inferior Oolite Group could also impact upon the catchment of the groundwater SPZ, east of Shab Hill junction.

C.9.1.3 The reduction in baseflow to the springs feeding the surface watercourses of the tributary of Norman's Brook and the tributaries to the River Churn is likely to adversely impact the flow regimes of these headwater watercourses. A reduction in flows would adversely impact the hydromorphology of the watercourses and species and habitats within the channels.

C.10 Climate

C.10.1.1 From an embodied carbon perspective, the increase in concrete and steel use for the cut and cover solution would result in a significant increase in greenhouse gas emissions associated with the scheme. Making the case that this scheme is aligned with UK Government legislation on net zero emissions would become more difficult.

C.10.1.2 In terms of the construction phase of the scheme, there will be a considerable increase in emissions from fuel consumed on site by plant and machinery as well as a significant increase in traffic movements to and from site, which will increase direct emissions. This would also put pressure on local road networks, increasing congestion and likely associated emissions throughout the duration of scheme delivery.

C.10.1.3 From a climate resilience perspective, depending on the gradient of the tunnel and the implemented drainage mitigations, there may be an increase in flood risk, which would need to be mitigated through design.