A417 Missing Link
TR010056

6.4 Environmental Statement
Appendix 13.5 Hydromorphology Assessment

Planning Act 2008

APFP Regulation 5(2)(a)
Infrastructure Planning (Applications: Prescribed Forms and Procedure) Regulations 2009

Volume 6

May 2021

Infrastructure Planning

Planning Act 2008

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A417 Missing Link

Development Consent Order 202[x]

6.4 Environmental Statement
Appendix 13.5 Hydromorphology Assessment

Regulation Number:	5(2)(a)
Planning Inspectorate Scheme Reference	TR010056
Application Document Reference	6.4
Author:	A417 Missing Link

Version	Date	Status of Version
C01	May 2021	Application Submission

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1 Introduction

1.1 Purpose

1.1.1 This document describes the hydromorphological baseline for the proposed scheme and outlines the likely potential impacts upon hydromorphology. This informs ES Chapter 13 Road drainage and water environment (Document Reference 6.2) and ES Appendix 13.2 WFD compliance (Document Reference 6.4).

2 Methodology

2.1 Study area

2.1.1 For direct effects on surface waters, the study area includes the geographical extent of the full scope of the works and all surface water features within 1km, where features have hydrological connectivity to the scheme.

2.1.2 For groundwater, the study area includes the geographical extent of the full scope of the works and groundwater features within the schemes study area (defined in ES Chapter 13 Road drainage and the water environment (Document Reference 6.2).

2.1.3 The following surface watercourses, shown on ES Figure 13.1 (Document Reference 6.3), have been deemed to be within the study area of the assessment:

- Norman's Brook– source to confluence Hatherley Brook (No. GB109054032780) waterbody. A tracer test was undertaken in March 2019 finding that the watercourse flowing alongside the A417 at Crickley Hill was a tributary of Norman's Brook, rather than Horsbere Brook;
- River Churn – source to Perrots Brook (No. GB106039029810) waterbody (Unnamed tributaries of River Churn 1 and 2); and
- River Frome – source to Ebley Mill (No. GB109054032470) waterbody.

2.2 Desk study

2.2.1 A desk study to collate and review available hydromorphology information has been conducted for watercourses that may be impacted by the scheme.

2.2.2 The desktop assessment has collated and reviewed the status and objectives information for hydromorphological quality elements of the relevant Water Framework Directive (WFD) waterbodies based on Environment Agency (EA) data (2016 Cycle 2 Waterbody Status Classification data).

2.2.3 The following sources have also been used to further establish the existing conditions of the hydromorphology of watercourses within the study area:

- EA Catchment Data Explorer, including relevant information from the Severn and Thames River Basin Management Plans 2015[1]
- Ordnance Survey (OS) mapping (including topography)
- Preliminary Groundwater Report 2019[2]
- ES Appendix 13.7 Hydrogeological Impact Assessment (Document Reference 6.4)
- ES Appendix 13.11 Water Features Survey (Document Reference 6.4)

- ES Appendix 13.12 Water Environment Monitoring Data (Document Reference 6.4)

2.3 Site survey

2.3.1 A walkover survey of the watercourses potentially impacted by the scheme was undertaken by a geomorphologist on the 28 and 29 October 2019. The survey collected information on the form of the channels, the flow types and the characteristics of the riparian zone for up to 1km from the scheme boundary. The surveys were undertaken following a weekend of heavy rainfall and flows were high.

2.3.2 Spot flow gauging was undertaken at 47 locations during four monitoring periods between April 2018 and March 2019. This has provided an initial characterisation of the range of flows within the watercourses of interest. This data is presented in ES Appendix 13.11 Water Features Survey (Document Reference 6.4).

2.3.3 Additional flow gauging was undertaken at six surface water and seven spring locations between July 2020 and December 2020. For surface waters, these were a mixture of continuous (gauged) sites and spot (monthly) measurements. All spring locations were spot measurements. Details on this are presented in ES Chapter 13 Road drainage and the water environment (Document Reference 6.2) and results presented in ES Appendix 13.12 Water Environment Monitoring Data (Document Reference 6.4).

2.4 Impact Assessment

2.4.1 Potential impacts upon hydromorphology have been assessed at a catchment level. The assessment has considered potential impacts upon the following:

- flow processes
- sediment movement
- boundary conditions (channel bed and banks)
- riparian zones
- floodplains
- downstream and catchment-channel connectivity
- the general form and function of the channel and near-channel zones
- the setting of the watercourse within the wider catchment

2.4.2 Where significant potential impacts have been identified, mitigation measures are proposed. Mitigation takes the form of requirements in the ES Appendix 2.1 Environmental Management Plan (EMP) (Document Reference 6.4) to minimise the effect of the construction activities or requirements to incorporate into the detailed design of the scheme.

Construction impacts

2.4.3 LA 113 Road drainage and the water environment (LA 113) recommends that construction impacts are considered using the source – pathway – receptor approach and defers specific guidance of highway construction impacts to CIRIA 648 Control of Water Pollution from Linear Construction Projects.

2.4.4 The potential impacts of construction on hydromorphology have been assessed based on the planned construction methods and sequencing. Where construction methods are not available, standard construction practices have been assumed.

2.4.5 Where measures to reduce construction impacts are considered standard practice they have been included in ES Appendix 2.1 EMP (Document Reference 6.4). It has been assumed that they will be carried out in respect of the impact assessment presented in this chapter. Measures beyond standard practice are typically considered to be mitigation and have been identified as such in this assessment.

Operational impacts

2.4.6 A qualitative assessment of possible impacts on the hydromorphology of watercourses has been undertaken based on a geomorphologist's understanding of the potential for impacts to the flow dynamics and sediment transport processes and the subsequent effects that this might have on the ecological potential of the water feature (where relevant).

2.4.7 The assessment has been made using professional judgement and experience and is focussed on locations where the route physically interacts with watercourses (for example proposed culverts or realignments) or where discharges from the road drainage system may occur.

3 Baseline hydromorphology

3.1 Introduction

3.1.1 The Cotswold escarpment forms a surface water divide between the River Severn catchment and the River Thames catchment (to the east and south-east of the divide). To the west of the divide, the land drains to the River Severn and its tributaries, including Norman's Brook, Horsbere Brook and the River Frome. To the east and south-east, the land drains to the River Churn, a tributary of the Thames.

3.1.2 Norman's Brook, the River Frome and the River Churn are classed by the EA as ordinary watercourses within the study area.

3.2 Tributary of Norman's Brook

3.2.1 The tributary of Norman's Brook flows westwards along the southern edge of the existing A417 embankment at Crickley Hill. The watercourse emerges from a pipe to the north of Crickley Hill Tractors, at approximately National Grid Reference (NGR) SO 93057 15871, and flows down the relatively steep, wooded valley.

3.2.2 The watercourse is fed by several springs that emerge at various elevations from the complex geology in this area. Many of these features are ephemeral.

3.2.3 Spot flow gauging undertaken between April 2018 and March 2019 along the watercourse recorded flows up to 0.013m^3/s, with evidence of flow losses (assumed to the underlying aquifer), principally around Ch 0+900m (ES Appendix 13.11 Water Features Survey (Document Reference 6.4).

3.2.4 Spot gauging has also been undertaken between July – December 2020, with flows ranging from 0.001 to 0.062m^3/s (Location SW2 in ES Appendix 13.12 Water Environment Monitoring Data (Document Reference 6.4)).

3.2.5 The watercourse is approximately 1m wide and is characterised by run and cascade flow types. The dominant bed material is fine gravel, with coarse gravel, cobbles, sand and clay also present. The banks are densely wooded and composed of cohesive material with limited evidence of erosion, principally by geotechnical failure.

3.2.6 A representative photo of the watercourse is shown in Photograph 3-1.

Photograph 3-1 Representative photo of characteristics of tributary of Norman's Brook

3.2.7 The watercourse enters a buried culvert via a 2.5m high concrete weir at Ch 1+200m, before re-emerging 50m downstream.

3.2.8 Tufa deposits have been identified in this section of the tributary of Norman's Brook in ES Appendix 8.24 Assessment of tufaceous material (Document Reference 6.4). Tufa is formed when carbonate is precipitated out of alkaline water. Carbonate deposits are apparent over existing concrete weir structures at this location (Photograph 3-2), where precipitation is induced by the increased air-water interaction created by the turbulent flow. There are seven cascades in total, each around 2.5m wide.

Photograph 3-2 Tufa cascades along the tributary of Norman's Brook

3.2.9 Further information on the hydrogeological setting for the carbonate deposits is presented in ES Appendix 13.7 Hydrogeological Impact Assessment (Document 6.4).

3.2.10 The watercourse is culverted from Ch 0+700m to 0+800m.

3.2.11 The watercourse enters existing Crickley Hill stream culvert beneath the A417 at Ch 0+600m (Photograph 3-3). Due to uncertainties about the flow direction of the culvert, a tracer test has been carried out to establish where the watercourse emerges[3]. This has found that it emerges along Bentham Lane (NGR: SO 91337 16344) and flows north-westwards into Norman's Brook, rather than Horsbere Brook as shown on WFD mapping.

Photograph 3-3 Existing culvert entrance under A417 - tributary of Norman's Brook

3.2.12 The watercourse is therefore assumed to be part of the Norman's Brook - source to confluence Hatherley Brook (GB109054032780) waterbody. The waterbody has an overall status of 'Moderate' and a hydromorphological supporting elements status of 'Supports Good'.

3.3 Tributary of River Churn 1

3.3.1 The unnamed tributary of the River Churn 1 flows eastwards away from the scheme. The watercourse is first recorded where it crosses beneath the A436 to the south-east of Ullenwood Manor Golf Course.

3.3.2 The road drainage discharged into this catchment would only flow directly into the watercourse during periods when the catchment was saturated and overland flow processes were active.

3.3.3 The watercourse has been straightened and flows through rough pasture and woodland, with some evidence of poaching (Photograph 3-4). The watercourse if approximately 2m wide with flow types of runs and glides and a gravel bed.

Photograph 3-4 Representative photo of characteristics of tributary of River Churn 1

3.3.4 Spot flow gauging of the watercourse was undertaken four times from April 2018 to March 2019 at NGR SO 94711 16460. Flows were too low to be recorded in April 2018, July 2018 and February 2018 but were recorded as 0.04m^3/s in March 2019[3]. Spot gauging was also undertaken between August – December 2020, with flows ranging from 0.005 to 0.054m3/s (Location SW5 in ES Appendix 13.12 Water Environment Monitoring Data (Document Reference 6.4)).

3.3.5 The watercourse is within the River Churn - source to Perrots Brook (GB106039029810) waterbody. It has an overall status of ‘Moderate’ and a hydromorphological supporting elements status of ‘Supports Good’.

3.4 Tributary of River Churn 2

3.4.1 The unnamed tributary of the River Churn 2 is a dry valley feature which is crossed by the scheme at the head of the valley between Ch 3+100m and 3+300m. A watercourse is not present in the valley bottom until approximately 1.2km downstream of the scheme at NGR SO 95380 15473.

3.4.2 The dry valley may experience episodical surface water flows during periods of high groundwater levels but is otherwise a relict landscape feature formed by past periglacial processes.

3.4.3 The watercourse is ponded and flows eastwards through along a dense wooded field boundary towards the River Churn (Photograph 3-5).

Photograph 3-5 Representative photo of characteristics of tributary of River Churn 2

3.4.4 Spot flow gauging of the watercourse was undertaken four times from April 2018 to March 2019 at NGR SO964155. Flows ranged from dry (July 2018) to 0.07m^3/s (April 2018)[3]. Spot gauging was also undertaken between October – December 2020, with flows ranging from 0.002 to 0.018m^3/s (Location SW6 in ES Appendix 13.12 Water Environment Monitoring Data (Document Reference 6.4)).

3.4.5 The watercourse is within the River Churn - source to Perrots Brook (GB106039029810) waterbody. It has an overall status of ‘Moderate’ and a hydromorphological supporting elements status of ‘Supports Good’.

3.5 River Frome

3.5.1 The River Frome and its unnamed tributaries emerge to the south of the eastern end of the scheme, near Nettleton. The catchment is fed by a series of springs that emerge at the boundary of the Great Oolite limestones over Fuller's Earth mudstone.

3.5.2 The watercourses in this catchment are not directly modified by the scheme but would receive discharges from the road drainage network.

3.5.3 Spot gauging has been undertaken between July – December 2020, with flows ranging from 0.001 to 0.166m^3/s (Locations SW3 & SW4 in ES Appendix 13.12 Water Environment Monitoring Data (Document Reference 6.4)).

3.5.4 The tributary which flows southwards from Nettleton is within a piped culvert from the existing A417 until it emerges, as shown on OS mapping. The watercourse has been overdeepened and has approximately 1.5m high banks (Photograph 3-6).

Photograph 3-6 Representative photo of characteristics of tributary of River Frome at Nettleton

3.5.5 The Nettleton tributary joins the main arm of the River Frome at the southern end of Bushley Muzzard SSSI. A 1m high concrete weir forms a densely vegetated ponded area at this location.

3.5.6 Downstream of this the watercourse flows through woodland and has a relatively natural form, made up of runs with small cascade sections, typically formed by

outcrops of clay hardpan material. The riverbed level appears to be controlled by the erosion resistant clay with sections dominated by fine gravel.

3.5.7 Another small tributary enters in this section which would receive flow from the road drainage system.

3.5.8 Approximately 700m downstream of the scheme area, the watercourse has been impounded to form a series of ponds through Brimpsfield Park. The impounding structures are large concrete weirs which appear to restrict coarse sediment transport downstream.

4 Impact assessment

4.1 Construction activities

4.1.1 The construction of the scheme requires works in proximity of the watercourses in the study area. These works include:

- Installation of culverts to maintain surface water flow routes.
- Installation of outfalls from the road drainage system.
- General earthworks required to construct the scheme, including the widening of the highway and inclusion of earth bunding from Ch 0+500m to Ch 1+700m, which includes the realignment and partial loss of the tributary of Normans Brook.

4.1.2 The full assessment of likely significant effects is report in ES Chapter 13 Road drainage and the water environment (Document Reference 6.2). The assessment below defines the magnitude of impact for each construction activity.

4.1.3 There is a risk of sediment runoff entering any of the watercourses in the study area during construction, with potential long-term effects upon channel morphology and substrate. This risk would be managed through Annex G Ground and surface water management plan (GSWMP) of ES Appendix 2.1 EMP (Document Reference 6.4).

4.1.4 Following the implementation of the measures outlined in Annex G GSWMP of ES Appendix 2.1 EMP (Document Reference 6.4), the magnitude of impact upon hydromorphology from sediment runoff is negligible.

Culverts

4.1.5 New culverts are proposed within the scheme to enable the highway to cross existing watercourses (Table 4-1). None of these watercourses are designated as main rivers. In addition to these culverts, there will be other smaller culverts conveying flows from the cut-off ditches under tracks, public rights of way and private accesses.

4.1.6 The culverts at Shab Hill and Stockwell are to provide an overland flow pathway beneath the scheme along dry valleys. The potential for impact to hydromorphology is therefore limited and with implementation of the culvert design principles in DMRB CD 529[4], the magnitude of impact upon hydromorphology is negligible.

Table 4-1 New culverts proposed as part of the scheme

Chainage (m) / Name	Watercourse	Size	Potential effect	Embedded design/ mitigation
0+530 Culvert near Crickley Hill Farm (Fly Up Bike Park) – replacement of existing culvert	Tributary of Norman's Brook	0.6m diameter (as existing). 190m length (~55m existing)	Local shading of watercourse. Local conversion of natural channel to culvert. Scour at inlet/outlet if poorly designed. Barrier to sediment transport.	Designed to DMRB CD 529 Design of outfall and culvert details. Designed to CIRIA C786 Culvert, screen and operation manual guidance.
1+450 Grove Farm Culvert	Tributary of Norman's Brook	1.2m diameter. 320m length.		
3+200 Shab Hill Culvert	Dry valley to Tributary of River Churn 2	1.2m to account for dry valley.	Scour at inlet/outlet if poorly designed.	
4+775 Stockwell Culvert	Dry valley to Tributary of River Churn 2	1.2m to account for dry valley.		

Outfalls

4.1.7 New outfalls would be installed or existing outfalls re-used to discharge treated carriageway runoff and cutting drainage to surface watercourses, where infiltration is not possible. Three outfalls would discharge to the tributary of Normans Brook, two to tributary of River Churn 1, five to tributary of River Churn 2 and two to the River Frome. The scheme drainage networks have been designed to maintain flows within their existing catchments where practicable to maintain the current surface water hydrology.

4.1.8 New outfall structures within a watercourse can alter local channel cross section and induce local bank or bed erosion, as well as reduce the available natural bank habitat area.

4.1.9 The potential for outfalls to impact upon hydromorphology is assessed in Table 4-2. This has established that the outfalls are either replacements of existing structures or are located on dry valleys at the head of watercourses and therefore, following the implementation of the standards in DMRB CD 529 Design of outfall and culvert details, the magnitude of impact upon hydromorphology is negligible.

Table 4-2 New outfalls proposed as part of the scheme

Outfall Number	Watercourse	Potential effect	Embedded design/ mitigation
2	Trib of Norman's Brook	New outfall – potential for hydromorphological change	Designed to DMRB CD 529 standards
3c			
3a	Dry valley leading to Trib of River Churn 1		
5a, 5b, 5c (combined)			
6	Dry valley leading to Trib of River Churn 2		
7b			
8			
9			
10	Dry valley leading to Trib of River Frome 1		
11a, 11b, 11c	Dry valley leading to Trib of River From 2	Existing outfall – limited potential for change	

Realignment of tributary of Normans Brook

4.1.10 The widening of the A417 and the provision of earth bunding and planting along the southern side of the alignment (to screen the road from the surrounding area) results in the need to realign the tributary of Norman's Brook. The watercourse would be re-routed between Ch 0+500m and Ch 1+700m.

4.1.11 The scheme involves the:

- Realignment of approximately 850m of the watercourse to accommodate the wider road and subsequent larger embankment.
- Culverting of the top 320m of the watercourse to accommodate highways drainage basin 3c and alleviate ground stability concerns (Grove Farm Culvert in Table 4-1).
- Replacement and lengthening of the existing Crickley Hill stream culvert beneath the A417 (culvert near Crickley Hill Farm (Fly Up Bike Park) in Table 4-1).

4.1.12 Following construction, the watercourse will flow along a new alignment around the southern edge of the earth bunding.

4.1.13 The temporary loss of approximately 1.1km of watercourse would impact upon hydromorphology. However, this impact would be localised to the watercourse upstream of the existing A417 culvert.

4.1.14 Mitigation of this effect is unlikely to be feasible given the constraints on the construction area. Opportunities for enhancement of the realigned channel will be sought to offset the impact and provide net benefit.

4.1.15 As the widened road and earth bunding would take up a greater proportion of the valley, the bed of the realigned watercourse would be perched above the existing riverbed level. ES Appendix 13.10 Drainage Report (Document Reference 6.4) describes this in further detail.

4.1.16 The springs that enter the existing watercourse around Ch 1+000 are below the proposed elevation of the realigned watercourse and would no longer augment flow in the tributary of Norman's Brook at this location. The embankment drainage

design would allow this water to move through the earthworks and likely enter the watercourse at a similar elevation to present.

4.1.17 The spring supplying the head of the tributary of Norman's Brook at Ch 1+600 would be retained, along with supply from the road drainage system (Catchment 3c), which would receive water from a larger catchment area than at present as the top section of the tributary of Norman's Brook, which is currently drained towards the River Churn, would be re-directed to its natural catchment.

4.1.18 The water balance of the tributary of Norman's Brook is therefore anticipated to result in little change in flow in the upper portion of the watercourse, a potential reduction in typical flow downstream of the current spring at Ch 1+000 and no change in flow downstream of the Crickley Hill stream culvert. Further details are provided in ES Appendix 13.10 Drainage Report (Document Reference 6.4).

4.1.19 The realignment of the watercourse and raising of the bed level would impact upon flows within the watercourse by limiting the ability of the realigned watercourse to receive water from existing springs due to its raised bed level.

Essential mitigation

4.1.20 The following design principles are incorporated in Annex G Ground and Surface Water Management Plan of ES Appendix 2.1 EMP (Document Reference 6.4) and reported in ES Chapter 13 Road drainage and water environment. These would be implemented during the detailed design of the scheme to mitigate the effects of the realignment upon hydromorphology:

- The detailed design of the realigned watercourse would provide naturalistic features of an equivalent or greater value to that of the existing watercourse. The scheme would aim to replicate the character and geomorphology of a typical upland stream, and there would be space within the 5m wide platform to accommodate features such as step pools, cascades, informal steps and irregular meanders.
- The realigned stream would minimise the introduction of new culverted sections, wherever possible.
- The flow regime of the realigned watercourse would be as similar as the existing flow regime as practicable.
- The detailed design should be overseen by an experienced fluvial geomorphologist.

4.1.21 Following the implementation of these mitigation measures, the magnitude of impact upon hydromorphology is considered to be negligible.

5 Summary

5.1.1 The assessment has documented the baseline hydromorphology of watercourses within the study area.

5.1.2 Potential effects upon hydromorphology have been identified and assessed. Mitigation measures have been proposed where a potential effect has been identified and an assessment of residual risk undertaken.

5.1.3 Potential adverse effects upon hydromorphology from sediment runoff during construction would be mitigated by the measures included in ES Appendix 2.1 EMP (Document Reference 6.4).

5.1.4 There would be an adverse effect upon hydromorphology as a result of the temporary loss of 1.1km of the tributary of Normans Brook. This impact would be

present during the construction period and would be localised to the section of watercourse from the spring at the head of the watercourse to the Crickley Hill stream culvert beneath the A417 to the (a distance of 1.1km).

5.1.5 Mitigation of this effect is unlikely to be feasible given the constraints on the construction area. Opportunities for enhancement of the realigned channel would be explored at detailed design to offset the impact and provide net benefit.

5.1.6 Potential adverse effects upon hydromorphology from new culverts and outfalls would be suitably mitigated by following the guidance in DMRB CD 529 Design of outfall and culvert details[4] during detailed design.

5.1.7 The potential for adverse effect upon the hydromorphology of the tributary of Normans Brook as a result of the loss of up to 320m of open watercourse and the realignment of a further 850m of watercourse would be mitigated. Following the implementation of mitigation measures, the magnitude of impact upon hydromorphology is negligible.

5.1.8 The full assessment of likely significant effects is report in ES Chapter 13 Road drainage and the water environment (Document Reference 6.2).

References

[1] Environment Agency (2020). Catchment Data Explorer [Online]. Available at: http://environment.data.gov.uk/catchment-planning/ (Accessed 15/01/2021).
[2] Mott MacDonald Sweco JV (2019). Preliminary Groundwater Report, Doc No. HE551505-MMSJV-HGT-000-RP-CE-00004
[3] Mott MacDonald Sweco JV (2019). A417 “Missing Link” Road Scheme, A417 Tracer Test
[4] Highways England (2020). Design Manual for Roads and Bridges, CD 529, Design of outfall and culvert details (Rev 1).