M5 Junction 10 Improvements Scheme

Environmental Statement

Chapter 8: Road Drainage and the Water Environment

TR010063 - APP 6.6

Planning Act 2008

Infrastructure Planning (Applications: Prescribed Forms and Procedure) Regulations 2009

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Infrastructure Planning

Planning Act 2008

The Infrastructure Planning (Applications: Prescribed Forms and Procedure) Regulations 2009

M5 Junction 10 Improvements Scheme

Development Consent Order 202[x]

6.6 Environmental Statement: Chapter 8: Road Drainage and the Water Environment (Tracked Change Version)

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8. Road Drainage and the Water Environment

8.1. Introduction

8.1.1. This chapter presents the findings of the Road ~~drainage~~ Drainage and the ~~water~~ Water ~~environment~~ Environment assessment for the M5 Junction 10 Improvements Scheme ("the Scheme"). The assessment is based on the Scheme as it is described in Chapter 2 – The Scheme (application document TR010063/~~-~~APP/~~-~~6.2) and detailed in the General arrangement plans (application document TR010063/~~-~~APP/~~-~~2.9). The chapter sets out the standards and methodologies that have been used to carry out the assessment for this Environmental Statement (ES). It contains information on regulatory/policy framework that applies to water, defines the study area, and describes baseline conditions, identifying receptors that are potentially affected and their importance. It goes on to suggest potential mitigation and enhancement measures, where relevant, the monitoring requirements and the magnitude of impacts and significance of effects of the Scheme. The potential cumulative effects have also been assessed.

8.1.2. The assessment covers:

- Surface water quality.
- Surface water hydromorphology.
- Groundwater resources (including Groundwater Dependent Terrestrial Ecosystems (GWDTE) and groundwater water quality).
- Flood risk; including a Flood Risk Assessment (FRA) - Appendix 8.1 (application document TR010063/~~-~~APP/~~-~~6.15).
- A Water Framework Directive (WFD) Assessment - Appendix 8.2 (application document TR010063/~~-~~APP/~~-~~6.15).
- Surface water quality assessment - Appendix 8.3 (application document TR010063/~~-~~APP/~~-~~6.15).
- River Chelt Geomorphological assessment.

8.1.3. The assessment has been prepared in accordance with the Design Manual for Roads and Bridges (DMRB) Standards LA 113 and LA 104.

8.2. Competent expertise

8.2.1. The Road Drainage and the Water Environment chapter has been undertaken by the following competent experts who have used their knowledge, professional ~~experience~~experience, and judgement to undertake and report this assessment:

- An Environmental Scientist with over 4 years' experience in EIA and WFD assessments.
- An Environmental Scientist with over 4 years' experience in flood risk modelling.
- A Hydrogeologist with over 4 years' experience in EIA and groundwater management.

8.3. Planning policy and topic legislative context

8.3.1. The relevant National, regional and local policy, legislation and guidance used as the basis for preparation of the ES chapter and Environmental Impact Assessment (EIA) supporting technical assessments (FRA and WFD compliance assessment) are provided in Table 8-1.

8.3.2. It should be noted that the details presented in this section are not intended to provide a full consideration of the relevant documents and their application to the Scheme. This information is provided within the Planning Statement and Schedule of Accordance with National Policy Statement (application document TR010063 – APP 7.1) that accompanies the application for a DCO.

Table 8-1 - National, regional and local policy, legislation and guidance

Legislation/policy/ regulation	Summary of requirements
National	
National Networks National Policy Statement (NN NPS)	The NN NPS sets out the need for, and Government's policies to, deliver development of nationally significant infrastructure projects (NSIPs) on the national road and rail networks in England.
Water Environment (Water Framework Directive) (England and Wales) Regulations 2017	The WFD legislation requires that all inland waters within defined river basin districts must reach at least Good status and defines how this should be achieved through the establishment of environmental objectives and ecological targets for surface waters. Any new project must not cause deterioration of the water environment or prevent the future attainment of Good status. The WFD requires that surface water discharges are managed so that their impact on the receiving environment is mitigated. The objective is to protect the aquatic environment and control pollution from diffuse sources such as urban drainage – a key aspect that effectively precludes use of the traditional approach to drainage.
Groundwater Directive (2006/118/EC)	Complements the WFD. It requires measures to prevent or limit inputs of pollutants into groundwater to be operational so that WFD environmental objectives can be achieved.
Antipollution Works Regulations 1999	Where pollution occurs or is likely to occur the Environment Agency can serve a works notice under Section 161A of the Water Resources Act on any person who has caused or knowingly permitted the pollution (or risk of pollution) to a watercourse, requiring them to carry out anti-pollution/preventative works and operations. The Environment Agency can also recover the costs of any investigation and anti-pollution works carried out. The Anti-Pollution Works Regulations prescribe the content of anti-pollution works notices and the particulars that need to be placed on the pollution control registers maintained by the Environment Agency.
Environment Act 1995	The Act provides for the establishment of the Environment Agency, the Scottish Environmental Protection Agency (SEPA) and the National Parks Authority.
Environmental Damage (Prevention and Remediation) Regulations 2015	The emphasis of these Regulations is proactively putting in place appropriate pollution prevention measures to reduce risks to the environment.
Environmental Protection Act 1990	This Act brings in a system of integrated pollution control for the disposal of wastes to land, water, and air.
Flood Risk Regulations 2009	These Regulations transpose the Floods Directive (2007/60/EC). They aim to provide a consistent approach to managing flood risk. The Environment Agency is responsible for managing flood risk from main rivers, the sea, and reservoirs. LLFAs are responsible for local sources of flood risk, in particular surface water, groundwater, and ordinary watercourses.

Legislation/policy/ regulation	Summary of requirements
Flood and Water Management Act 2010 and Commencement Orders	The key areas covered by this Act are: • Roles and responsibilities for flood and coastal erosion risk management. • Improving reservoir safety.
Highways Act 1980 (HA 1980)	The Act deals with the management and operation of the road network in England and Wales including the drainage of highways into environmental waters and sewers.
National Planning Policy Framework (NPPF) (20231)	The NPPF sets strict tests to protect people and property from flooding which all local planning authorities are expected to follow. It forms the basis of assessment of flood risk for schemes.
National Planning Practice Guidance (NPPG) (2022)	Accompanying the NPPF, the NPPG was first published in 2014, and most recently updated in 2022 when updates were made to the practice guide for flood risk. This advises on how Local Planning Authorities can ensure the protection of water quality, the delivery of adequate water infrastructure and take account of the risks associated with flooding in the planning application process.
The Environmental Permitting (England and Wales) Regulations 2016	These Regulations provide a consolidated system of environmental permitting in England and Wales and transpose provisions of fifteen EU Directives which impose obligations requiring delivery through permits or which are capable of being delivered through permits. It covers Environment Agency permits for flood risk (on Main River), WFD regulations and certain discharges to watercourses.
The Water Resources (Environmental Impact Assessment) (England and Wales) Regulations 2006	These Regulations impose procedural requirements in relation to the consideration of applications or proposals for an abstraction or impounding licence under Chapter II of Part II of the Water Resources Act 1991 and require consent in other cases.
Water Act 2003 and Water Act 2014	These Acts aim to improve water conservation, protect public health and the environment, and improve the service offered to consumers. The basis of the Act is three parts relating to water resources, regulation of the water industry and other provisions.
WFD (Standards and Classification) Directions (England and Wales) 2015	These Directions set out the environmental standards to be used for the second cycle of river basin plans. They transpose Directive 2013/39/EU on environmental quality standards for priority substances. They also cover Specific Pollutants which include certain metals that are associated with road are associated with road drainage.
Water Industry Act 1991 (Amendment) (England and Wales) Regulations 2009	This Act sets out the responsibilities of the Environment Agency of England and Wales in relation to water pollution, resource management, flood defence, fisheries, and in some areas, navigation. The Act regulates discharges to controlled waters, namely rivers, estuaries, coastal waters, lakes and groundwaters.
Water Resources Act 1991	This Act sets out to regulate water resources, water quality and pollution, and flood defence. It sets out standards for Controlled Waters.

Legislation/policy/ regulation	Summary of requirements
The Land Drainage Act 1991 and 1994	This Act requires that a watercourse be maintained by its owner in such a condition that the free flow of water is not impeded. The 1994 Act amends it in relation to the functions of internal drainage boards and local authorities.
The Control of Pollution (Oil Storage) (England) Regulations 2001	Applicable for storage of more than 200 litres of oil above ground at industrial, commercial, or institutional sites. The sites they cover include factories, shops, offices, hotels, schools, churches, public sector buildings and hospitals. The Regulations apply only in England.
The Environment Act (2021)	The Bill makes provisions about targets, plans and policies for improving the natural environment. It outlines how the government will reduce waste, make better use of resources, and improve management of water resources in a changing climate.
Planning Inspectorate (PINS) advice note 18	This advice note supports the application of WFD assessments and clearly outlines the requirements of these assessments for Nationally Significant Infrastructure Projects (NSIP).
Regional and Local	
Severn River Basin Management Plan (RBMP)	This RBMP is designed to protect and improve the quality of the water environment. It includes consideration of the following topics: • Plans for the protection and improvement of the water environment • Future plans that may affect the infrastructure sector and its obligations • Development proposal considerations regarding the requirements of the plan • Environmental permit applications.
The adopted Joint Core Strategy (JCS) (Gloucester City Council, Cheltenham Borough Council, and Tewkesbury Borough Council., 2017)	The JCS provides a co-ordinated strategic plan for this joint administrative area during the period up to 2031. The JCS sets out strategic objectives one of which focuses on conservation and enhancement of the natural environment, including biodiversity, waterways and geological assets. It also has an extensive and up-to-date evidence base, including Strategic FRA which provide a detailed assessment of multiple flood sources for specific broad locations within the JCS area. The JCS is currently undergoing a review process. Whilst the JCS provides the strategic level policies for development in the area, this will be supplemented at individual district level by locally specific plans. In Tewkesbury Borough, the council has adopted the updated Tewkesbury Borough Plan (2022).
The Flood and Water Management Supplementary Planning Document (SPD) (Tewkesbury Borough Council, 2018)	Guidance on the approach that should be taken to manage flood risk and the water environment as part of new development proposals. The SPD highlights the documents which will be required to accompany planning applications including site specific FRAs and drainage strategies (incorporating an appropriate approach to surface water drainage including suitability evidence).

Tewkesbury Borough Plan (2011-2031)	The plan states that, where practical, the Council will 'seek appropriate opportunities offered by new development proposals to recreate more natural conditions and new habitat along watercourses, for example by requiring; the de-culverting, restoration or re-profiling of watercourses; the removal of barriers to fish migration; or the integration of watercourses with wider green/blue infrastructure networks.' This commitment is in support of WFD legislation. In addition to the NPPF and the JCS, the Council will apply the following principles: Proposals (including surface water drainage schemes) should be designed to appropriate, locally specific allowances for climate change for peak river flood flows and rainfall intensity. Opportunities to reduce the existing risk of flooding in the Borough will be sought, including requiring developments to provide flood storage on sites located within the headwaters of the Borough's watercourses. All proposals will be expected to incorporate sustainable drainage systems where appropriate and proportionate to the scale and nature of development proposed. Proposals must demonstrate that development is designed to use and manage water efficiently, including rainwater harvesting and greywater recycling where possible. Surface water drainage proposals should, where appropriate, achieve significant betterment on existing discharge rates for all corresponding storm events. Sustainable drainage systems should be designed to achieve multifunctional benefits. Priority should be given to green/soft solutions and the integration of sustainable drainage systems with green infrastructure and street networks. Arrangements for the long term maintenance of sustainable drainage systems must be in place to the Council's satisfaction
Cheltenham Borough Plan (2011-2031)	The plan has set an objective to manage and reduce the risk of flooding within the borough.

8.4. Methodology

8.4.1. The baseline has been presented in Section 8.6 and the methodology presented in DMRB LA 113 has been applied to assign the importance of the water environment receptors. The potential impacts have been highlighted in Section 8.7. This section also sets out the assessment of impact of the Scheme with embedded mitigation based on the LA 113 methodology. An assessment of the significance of impacts has been undertaken following the methodology set out in DMRB LA 104. The criteria for determining the significance and the significance categories are presented in Table 8-2 and Table 8-3 respectively.

8.4.2. Essential mitigation has been highlighted in Section 8.8 with the residual impact outlined in Section 8.9.

Table 8-2 - Significance matrix

Importance of receptor	Magnitude of impact				
	Major	Moderate	Minor	Negligible	No change
Very high	Very large	Large or very large	Moderate or large	Slight	Neutral
High	Large or very large*	Moderate or large	Slight or moderate	Slight	Neutral
Medium	Moderate or large	Moderate	Slight	Neutral or slight	Neutral
Low	Slight or moderate	Slight	Neutral or slight	Neutral or slight	Neutral
Negligible	Slight	Neutral or slight	Neutral or slight	Neutral	Neutral

Table Source: DMRB LA 104 Environmental assessment and monitoring Table 3.8.1
* Where two significance categories are provided, evidence should be given to support the reporting of a single significance for each impact.

Table 8-3 - Significance categories and typical descriptions

Value	Typical descriptors
Very large	Effects at this level are material in the decision-making process.
Large	Effects at this level are likely to be material in the decision-making process.
Moderate	Effects at this level can be considered to be material decision-making factors.
Slight	Effects at this level are not material in the decision-making process.
Negligible	No effects or those that are beneath levels of perception, within normal bounds of variation or within the margin of forecasting error.

Table Source: DMRB LA 104 Environmental assessment and monitoring Table 3.7

8.4.3. The assessment has used a range of open-source data and information provided by the Environment Agency and Lead Local Flood Authority (LLFA) (Gloucestershire County Council and Tewkesbury Borough Council). This data includes:

- The Environment Agency Catchment Data Explorer (https://environment.data.gov.uk/catchment-planning/).
- Environment Agency Flood Maps for Planning (Flood map for planning - GOV.UK (flood-map-for-planning.service.gov.uk)).
- The Environment Agency Main Rivers Maps (Statutory Main River Map (arcgis.com)).
- British Geological Survey 1:50k bedrock and superficial geology mapping (Geology of Britain viewer | British Geological Survey (BGS)).
- Aquifer designation (Magic Map Application (defra.gov.uk)).
- Base flow index (Search Data | National River Flow Archive (ceh.ac.uk)).
- Traffic modelling data (Atkins 2021).
- Drainage Plans (application document TR010063 - APP 6.15).
- Environmental Design (application document TR010063 – APP 2.13).

- WFD Extended Water Body Summary Reports.
- Abstraction and discharge locations.
- Mitigation strategies in place.

Study area

8.4.4. The scope of the assessment includes as a minimum, features of the water environment within 1 km of the Scheme's Order limits. A 1 km buffer around the Scheme was selected as professional judgement and understanding of the local watercourses' connectivity considers this to be an appropriate distance for any potential impacts to be sufficiently reduced, for example, dilution of pollutants. This study area has been adopted as a minimum for the groundwater assessments as the conceptual understanding indicates any impacts to groundwater flow will also be dissipated within 1 km.

8.4.5. For hydromorphology, the study area consists of any watercourse within the Order limits and those hydrologically connected with the immediate downstream WFD water body catchments:

- Chelt - source to M5.
- Chelt - M5 to conf R Severn[1].
- Leigh Bk - source to conf R Chelt.
- Swilgate - source to conf. R. Avon.
- Hatherley Bk - source to conf R Severn.

8.4.6. During consultation with the Environment Agency (See Section 8.5) it has been suggested that consideration also be given to the potential impacts on the River Severn due to hydrological connectivity to designated sites. Therefore, the Severn – conf R Avon to conf Upper Parting catchment also forms part of the study area for hydromorphology.

8.4.7. The study area for flood risk is defined by the hydraulic zone of influence created by the Scheme and as a minimum considers the 1 km buffer zone. This is influenced by encroachments into the watercourse and floodplain. Further information on the study area for Flood risk can be found in Appendix 8.1.

~~8.4.8.~~ A summary of the study areas has been presented in Table 8-4 ~~Table 8-4~~

~~8.4.9.~~8.4.8. ~~and~~ and Figure 8-1 shows the 1 km study area. The study area for hydromorphology can be seen in Figure 8-2.

~~8.4.10.~~8.4.9. Risks of pollution to the water environment associated with the release of pollutants (e.g., hydrocarbons, cement, fine sediment, mobilised contaminants) due to existing ground contamination are considered within the ES Chapter 10 - Geology and Soils (application document TR010063/~~—~~APP/~~-~~6.8) and will not be considered here.

Table 8-4 - Study areas for each topic

Topic	Study area
Surface water quality	1 km radial buffer from Order limits
Hydromorphology	Any watercourse within the Order limits and hydrologically connected with the immediate downstream WFD water body catchments: • Chelt - source to M5. • Chelt - M5 to conf R Severn.

[1] Refers to the section of the River Chelt, from the M5 downstream to its confluence with the River Severn.

Topic	Study area
	• Leigh Bk - source to conf R Chelt. • Swilgate - source to conf. R. Avon. • Hatherley Bk - source to conf R Severn. • Severn – conf R Avon to conf Upper Parting.
Groundwater	1 km radial buffer from Order limits
Flood Risk	The hydraulic zone of influence created by the Scheme and as a minimum considers the 1 km radial buffer from the Order limits.

Figure 8-1 provided in Appendix 8.4 (application document TR010063-/–APP/-6.15)
Figure 8-1 - General Arrangement and 1 km study area

Surface water methodology

8.4.11.8.4.10. Surface water receptors have been identified within the study area using the environment Agency WFD water body data[2], Main Rivers maps[3], Ordnance survey ordinary watercourse data[4], background mapping and watercourse walkover survey completed in Summer of 2022.

8.4.12.8.4.11. The receptors have been given an importance based on methodology set out in the DMRB LA 113 Table 3.70. The magnitude of impact and significance of effect have been determined using DMRB LA 113 Table 3.71 and the DMRB LA 104 Table 3.8.1.

8.4.13.8.4.12. The methodology for the assessments undertaken as part of this ES includes the following:

- An assessment of the impact of the Scheme on surface water quality through routine runoff and accidental spillages in line with the DMRB LA 113 including the use of the Highways England Water Risk Assessment Tool (HEWRAT). Further details on the methodology used to complete the HEWRAT can be found in the surface Water Quality Assessment (Application document TR010063/APP/6.15 Appendix 8.3).
- An assessment of the hydromorphological impact of the Scheme on surface water features in line with the DMRB LA 113. Analysis of freely available maps, arial photographs and walkover surveys has been undertaken to determine the importance of receptors and impact from the Scheme. A Geomorphological assessment has been undertaken to determine the requirement for bank protection on the River Chelt.

8.4.14.8.4.13. A WFD compliance assessment is a requirement for new developments and schemes to demonstrate that they will not result in a deterioration in status (or potential) of any water body or prevent the water body from meeting good status (or potential) in the future (2021 or 2027). A WFD preliminary assessment was undertaken in December 2019. The assessment has been updated (September 2022) based on the most recent design (Appendix 8.2 – application document TR010063/APP/6.15~~TR010063 - APP 6.15~~).

8.4.15.8.4.14. The WFD legislation applies to all surface watercourses (Main River[5] and ordinary watercourse). The Environment Agency is the overall competent authority, however, the

[2] Environment Agency, 2020. Catchment Data Explorer. [Online] Available at: Environment Agency - Catchment Data Explorer [Accessed 24 March 2022].
[3] Environment Agency, 2022, Main Rivers Map [Online Available at: ArcGIS Web Application [Accessed on 24 March 2022]
[4] Ordnance Survey, 2022. OS Open Rivers [Online] Available at; OS Open Rivers | High Level View of Watercourses| Vector Map Data | Free Download (ordnancesurvey.co.uk) [Accessed on 8 Nov 2022]
[5] Main Rivers are those identified on the Environment Agency's Main Rivers Map: Environment Agency, 2022, Main Rivers Map [Online Available at: ArcGIS Web Application [Accessed on 24 March 2022]

LLFA (Gloucestershire County Council and Tewkesbury Borough Council) should ensure the Scheme complies with WFD legislation regarding ordinary watercourses.

~~8.4.16.~~8.4.15. The approach to the WFD compliance assessment will follow the Planning Inspectorate (PINS) advice note 18[6] on preparation of WFD assessments for a Nationally Significant Infrastructure Project (NSIP). The assessment can be readily updated, creating a clear audit trail of WFD compliance as the Scheme progresses through its lifecycle from options assessment to design and environmental permitting.

Groundwater methodology

~~8.4.17.~~8.4.16. The methodology for the assessments undertaken as part of this ES comprises of an assessment of the impact of the Scheme on the groundwater environment in line with the DMRB LA 113 standard including the identification of the importance of receptors and the magnitude of impact. Groundwater receptors have been identified using the British Geological Survey bedrock and superficial aquifer data[7] and Environment Agency WFD groundwater body data. Groundwater receptors have also been identified through review of the Environment Agency's GWDTE data[8] and data collected from the local authority and Envirocheck reports[9] for licenced and private groundwater abstractions and discharges.

~~8.4.18.~~8.4.17. Site specific intrusive ground investigation (GI) information is available for assessment alongside detailed design data (e.g., piling depth and installation method). Details on the GI can be found in the Ground Investigations Report (GIR) (application document TR010063 - APP 6.15). This data has been used to determine the baseline hydrological conditions within the study area.

~~8.4.19.~~8.4.18. Site visits have been completed where a groundwater receptor has been identified within the study area. A Chartered Geologist visited the Uckington Moat to determine the connectivity to the nearby spring. The survey was completed on the 25 March 2022.

~~8.4.20.~~8.4.19. The importance of each groundwater receptor has been classified using the methodology set out in the DMRB LA 113 Table 3.70. The magnitude of impact and significance of effect have been determined using DMRB LA 113 Table 3.71 and the DMRB LA 104 Table 3.8.1.

~~8.4.21.~~8.4.20. Groundwater assessment has been included as part of the WFD compliance assessment as outlined for surface water above (section 8.4.13).

Flood risk methodology

~~8.4.22.~~8.4.21. Detailed hydraulic modelling has been undertaken to understand the baseline flood risk conditions and evaluate the flood risk both to and from the Scheme.

~~8.4.23.~~8.4.22. Flood risk receptors have been identified through a review of Environment Agency fluvial flood zones and areas at Risk of Surface Water Flooding, the British Geological Survey susceptibility to groundwater flooding maps and detailed hydrological modelling of the study area. Further details of the hydraulic modelling can be found in Appendix 8.1.

~~8.4.24.~~8.4.23. The importance of each receptor within an area at risk of flooding has been determined using the methodology set out in the DMRB LA 113 Table 3.70. The

[6] The Planning Inspectorate, 2017. The Water Framework Directive. Advice Note Eighteen: The Water Framework Directive.
[7] BGS, 2020. Geology of Britain Viewer. [Online] Available at: Geology of Britain viewer | British Geological Survey (BGS) [Accessed on 23 March 2122]
[8] Environment Agency, 2020. Groundwater Dependent Terrestrial Ecosystems (England only) [Online] Available at: Groundwater Dependent Terrestrial Ecosystems (England only) - data.gov.uk [Accessed on 8 Nov 2022]
[9] Landmark, 2019. Envirocheck Reports.

magnitude of impact and significance of effect have been determined using DMRB LA 113 Table 3.71 and the DMRB LA 104 Table 3.8.1 respectively.

8.4.25.8.4.24. In line with the NPPF[10], the design flood for the Scheme is the 1% annual exceedance probability event (1 in 100-year return period) with an allowance for future climate change. The Environment Agency's climate change guidance at the time of writing was the July 2021 update, which was in line with the UKCP18 data. The guidance recommends using the higher central climate change allowance (+53% increase in flow) for a scheme of this type in this location. The Environmental Statement, the flood ~~modelling~~modelling, and the FRA (Appendix 8.1, TR010063 – APP 6.15) include the application of this Environment Agency climate change allowance.

Limits of deviation

8.4.26.8.4.25. The assessment has been conducted within the Limits of Deviation (LoD) outlined within Chapter 2 - The Scheme (application document TR010063/~~—~~APP/~~-~~6.2). The vertical and lateral LoD for the Scheme have been reviewed with respect to sensitive receptors identified within this ES ~~chapter, and~~chapter and would not affect the conclusions of the assessment reported in this chapter.

8.5. Consultation

8.5.1. To date, consultation has been undertaken with the Environment Agency and LLFA with the main points highlighted below. Consultation with regulators, principally the Environment Agency and LLFA, will continue throughout the DCO application process to ensure that the Scheme is designed to be compliant with the objectives of the WFD and flood risk guidance and that opportunities for improvements to the water environment are integrated into the Scheme. This consultation will be secured through the application of relevant permits.

Scoping Opinion

8.5.2. A Scoping Opinion was received from PINS in August 2021. All comments from PINS have been addressed as part of this assessment, including:

- Potential impacts from tidal sources of flooding have been scoped out of this assessment.
- Inclusion of the sequential test in relation to flood risk.
- The inclusion of baseline information in relation to any springs within the study area.
- Inclusion of the most up to date climate change allowances for flood risk modelling.

8.5.3. Further information on the scoping opinion can be found in Appendix 2.1 – Scoping Opinion (application document TR010063/~~—~~APP/~~-~~6.15).

Non-statutory consultation

8.5.4. In November 2020, the Environment Agency commented on the Scheme as part of the non-statutory consultation. The main issues identified were:

- Climate change.
- Fluvial flood risk.
- Ecological protection and enhancement.

[10] Environment Agency, 2020. Flood risk assessments: climate change allowances. [Online] Available at: https://www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances [Accessed 01 March 2021].

- Ground conditions.
- Water quality and pollution prevention.

8.5.5. The Environment Agency has emphasised the importance for early consideration of climate change adaptation and mitigation specifically highlighting drainage, hydrology and flood risk and ecology as key aspects likely to be impacted.

8.5.6. The River Chelt floodplain and M5 crossing were highlighted as key points to be considered as part of the detailed flood modelling. However, the Environment Agency concluded that there were no significant concerns with the Scheme should flood risk be appropriately investigated. Further consultation with the Environment Agency has been undertaken to ensure a suitable baseline flood model, the appropriate flood modelling of the Scheme, and to seek advice on compensatory floodplain and the design of river crossings.

8.5.7. The Environment Agency noted that additional consideration should be made to the impact on the Severn Estuary Site of Special Scientific Interest (SSSI) Special Protection area (SPA) Ramsar and Special Area of Conservation (SAC) to ensure the Scheme does not negatively impact protected species within that ecosystem due to hydrologically connected environments. This has been considered as part of the Biodiversity Chapter and Habitats Regulations Assessment (application document TR010063/~~-~~APP/~~-~~6.5 and TR010063/~~-~~APP/~~-~~6.15 respectively). This feature falls outside of the study area for this chapter. Additionally, further consideration should be given to the impact on the River Chelt due to its significant hydromorphological activity. The Environment Agency stated that further details on compensatory mitigation should be included to ensure biodiversity net gain (application document TR010063/~~-~~APP/~~-~~6.15) across the Scheme including consideration of wetlands, basins, scrapes, reedbeds, floodplain grazing marsh, semi-improved or unimproved grassland (lowland meadows and pastures) and traditional orchard[11].

8.5.8. It was highlighted that the assessment should consider the impact of foundation/piling works which have the potential to increase contamination and migration pathways of pollutants. Surface water drainage should also be considered as part of the detailed impact assessment.

8.5.9. The Environment Agency has advised that road drainage design should include consideration of swales, balancing basins/~~wetlands~~wetlands, and other Sustainable Drainage Systems (SuDS) to improve water quality.

8.5.10. As part of the non-statutory consultation, the LLFA highlighted that the design of drainage systems should be in accordance with the CIRIA SuDS Manual C753. It is confirmed that this will be adopted throughout the Scheme.

Statutory Consultation

8.5.11. In February 2022, statutory consultation was undertaken on the Preliminary Environmental Information Report (PEIR) and accompanying assessments (WFD and FRA).

8.5.12. The response in relation to the FRA was subject to further reviews of the Baseline flood risk model by the Environment Agency and final acceptance by formal sign off which had not been received at the time. However, it was determined that the principles regarding flood risk set out within the PEIR were considered appropriate and correct in relation to current planning guidance. The Environment Agency did indicate that a lower climate change allowance might be acceptable for the Link Road (the Link Road) element of the

[11] BNG is not currently a legal requirement of this Scheme. However, the Scheme has an objective to deliver a net gain in biodiversity.

Scheme: however, for practical purposes the higher +53% allowance has been retained throughout the assessment.

8.5.13. The Environment Agency has since reviewed both the Baseline and Scheme models and deemed them appropriate, such that the results from these models can be used to support the final Flood Risk Assessment (FRA) and this ES.

8.5.14. It was advised by the Environment Agency that the groundwater regime would require further investigation in relation to the flood storage area to ensure capacity during flood events which was deemed a potential significant risk. This has since been completed and is described in the FRA.

8.5.15. In relation to biodiversity, the Environment Agency registered their concern that, based on the stage of the project for the delivery of the PEIR, they did not consider it includes sufficient river and floodplain restoration in order to mitigate the impacts of the proposed development. Since this consultation, further work has been undertaken to incorporate the essential mitigation outlined by the Environment Agency into the design. This includes:

- Floodplain reconnection.
- Improvements to watercourse condition.
- Improvements to riparian condition.

8.5.16. It was also noted by the Environment Agency that bed and bank protection should only be used where a real risk to life or critical infrastructure is apparent.

Targeted consultation

8.5.17. A targeted consultation period extended from the 8 August to the 5 September 2022. Information was submitted to the Environment Agency, and Gloucestershire County Council as the LLFA (Tewkesbury Borough Council (TBC) was also included as it assumes a delegated role for the LLFA). The consultation focused on details of design updates since the statutory consultation in February. There were no responses received from the Environment Agency. However, GCC and TBC provided feedback with no objections to the updates.

8.5.18. A second targeted consultation period took place between the 21 December 2022 and the 18 February 2023, and provided the Environment Agency and LLFA with further design changes since the earlier targeted consultation. There were no further comments from the LLFA. The Environment Agency highlighted the need to ensure adherence with the COMAH (Control of Major Accidents and Hazards) Regulations in relation to the gas pipeline within the change proposed working area.

8.5.19. A third targeted consultation period took place between the 29 May and the 27 June 2023, covering the inclusion of a bus lane eastbound on the A4019 between the West Cheltenham Fire Station and the Gallagher Junction. A response of no comment was received from the Environment Agency. No response was received from the LLFA.

8.6. Baseline conditions

8.6.1. This section sets out the baseline conditions of the water environment. A desk-based assessment has provided most of the baseline information, using publicly available spatial data under the Open Government Licence and from open sources including the Environment Agency. This has been backed up by primary information collected during 2019 and 2022 site visits. The assessment for flood risk is based on a detailed baseline flood model which included gauged flow and rainfall from the Environment Agency, and topographic survey of the watercourses.

Surface water

8.6.2. Surface watercourses within the study area generally flow from east to west and are located within the Severn River Basin District (RBD), as set out in the Severn River Basin Management Plan (RBMP). Figure 8-2 – TR010063 – APP 6.15 shows the location of the Scheme in relation to the surface water bodies.

8.6.3. Table 8-5 provides the current WFD status for the six surface water body catchments within the study area for surface water quality and hydromorphology.

Table 8-5 - Summary of status, Reasons for Not Achieving Good (RNAG), and objectives for WFD surface water bodies within the study area.

Water body name (Water Body ID)	Water-course name	2019 (Cycle 2) overall status	HMWB* or artificial	RNAG	Objective**
Chelt - source to M5 (GB109054032820)	River Chelt	Moderate	HMWB	Mitigation Measures Assessment	Good by 2027 (Disproportionate Burdens)
Chelt - M5 to conf. R. Severn (GB109054032810)	River Chelt	Poor	Not assigned heavily modified or artificial	Phosphate Macrophytes and Phytobenthos	Good by 2027 (Disproportionate Burdens)
Leigh Bk - source to conf. R. Chelt (GB109054039770)	Leigh Brook	Moderate	Not assigned heavily modified or artificial	Phosphate Macrophytes and Phytobenthos	Moderate by 2015 (Unfavourable balance of costs and benefits)
Swilgate - source to conf. R. Avon (GB109054039780)	River Swilgate	Moderate	n/a	Phosphate Invertebrates Macrophytes and Phytobenthos Dissolved Oxygen	Good by 2027 (Ecological Recovery Time)
Hatherley Bk - source to conf R Severn (GB109054032801)	Hatherley Brook	Moderate	HMWB	Phosphate	Good by 2027 (Disproportionate Burdens)
Severn – conf R Avon to conf Upper Parting (GB10905404440)	River Severn	Moderate	HMWB	Local and Central Government and Urban transport, Urban and transport Navigation Water Industry	Moderate by 2015 (Unfavourable balance of costs and benefits)

* Heavily Modified Water Body
** Objectives as published on Catchment Data Explorer[12]

[12] Environment Agency, 2020. Catchment Data Explorer. [Online] Available at: Environment Agency - Catchment Data Explorer [Accessed 24 March 2021].

Figure 8-2 provided in Appendix 8.4
Figure 8-2 - Scheme location in relation to WFD surface water bodies

8.6.4. The River Chelt is a Main River within the study area and is accounted for under two WFD catchments: Chelt - source to M5 (GB109054032820) and Chelt - M5 to conf. R. Severn (GB109054032810) (Table 8-5)). It is currently crossed by the M5 approximately 0.9 km south of Junction 10 (SO 90019 24822).

8.6.5. The Leigh Brook is crossed by the M5 0.4 km north of Junction 10 (SO 89278 26792). At the point of intersection with the M5, the watercourse is an ordinary watercourse, defined as: every river, stream, ditch, drain, cut, dyke, sluice, sewer (other than a public sewer) and passage through which water flows and which does not form part of a Main River. Approximately 2.3 km downstream of the M5 crossing, the watercourse is designated as Main River. The Leigh Brook is designated under the WFD from its source to its confluence with the River Chelt (Leigh Bk - source to conf. R. Chelt, GB109054039770).

8.6.6. The River Swilgate and ~~Hatherly~~Hatherley Brook are Main Rivers and are designated under the WFD (Swilgate - source to conf. R. Avon, GB109054039780 and Hatherley Bk - source to conf R Severn, GB109054032801). Although they lie within the 1 km study area, they are not directly crossed by the M5 within 1 km of Junction 10. Although the River Severn (Severn – conf R Avon to conf Upper Parting, GB10905404440) lies outside the study area, it has been included as part of the assessment following consultation with the regulators. Detailed descriptions of the WFD water bodies, including site photos, and survey information, have been outlined as part of the WFD assessment (Appendix 8.2 - TR010063 – APP 6.15). Table 8-7 along with a number of additional ordinary watercourses within the study area. These watercourses are also shown in Figure 8-3. The ordinary watercourses have been given a unique ID where they do not have a known name which aligns with those presented in Chapter 7 - Biodiversity (application document TR010063 – APP 6.5) and have been identified as drains and minor watercourses. None of these watercourses are classified reaches under the WFD, however, they do fall within a WFD water body catchment.

8.6.7. The current drainage system consists of eight drainage catchments. All drainage catchments discharge to surface water (either the Leigh Brook or River Chelt). Table 8-6 provides details of each drainage catchment. Further information on the drainage catchments can be found in the Surface Water Quality Assessment (Appendix 8.3 – TR0100063 – APP 6.15).

Table 8-6 - Current drainage design

Drainage catchment name	Receiving watercourse	Impermeable area (ha)	Permeable area (ha)	Current mitigation
J1	Leigh Brook	1.106	0.18	Vegetated ditch
A4019 Main Line at Elms Park	River Chelt	2.456	0.286	Vegetated ditch
Combined Basin	Leigh Brook	3.571	0.743	Vegetated ditch
S1	River Chelt	1.618	0.550	Vegetated ditch
M5 South of the River Chelt*	River Chelt	0.480*	0.000	None
S2	Leigh Brook	5.885	1.955	Vegetated ditch
B Road	River Chelt	0.496	0.192	None
Piffs Elm Culvert	Leigh Brook	2.027	0.666	Vegetated ditch

* Area has been estimated using National Highways Drainage Data Management System (HADDMS) and professional judgement.

8.6.8. All watercourses within the study area have been listed in Table 8-7 along with a scoping decision and reasons. Watercourses have been scoped out of the assessment with the assumption that there will be no hydromorphological or water quality impacts.

Table 8-7 - Watercourses within the study area

Watercourse ID	Main River	Scoped in/out	Reason for scoping out where appropriate
		Chelt – source to M5 (GB109054032820)	
River Chelt	Yes	In	N/A
MW5	No	Out	No hydrological connectivity to the Scheme alignment
Drain 21	No	In	N/A
Uckington Moat	No	Out	No hydrological connectivity to the Scheme alignment
		Chelt - M5 to conf. R. Severn (GB109054032810)	
River Chelt	Yes	In	N/A
MW3	No	In	N/A
MW4	No	Out	No hydrological connectivity to the Scheme alignment
Drain 12	No	In	N/A
Drain 13a	No	Out	No hydrological connectivity to the Scheme alignment
Drain 14	No	Out	No pathway of impact from the Scheme.
Drain 15	No	In	N/A
Drain 16	No	In	N/A
Drain 17	No	Out	No hydrological connectivity to the Scheme alignment
Drain 19	No	Out	No hydrological connectivity to the Scheme alignment
Drain 20	No	In	N/A
		Leigh Bk - source to conf. R. Chelt (GB109054039770)	
Leigh Brook	No*	In	N/A
Drain 3	No	Out	No hydrological connectivity to the Scheme alignment
Drain 4	No	Out	No hydrological connectivity to the Scheme alignment
Drain 5	No	Out	No hydrological connectivity to the Scheme alignment
Drain 6	No	In	N/A
Drain 7	No	Out	No hydrological connectivity to the Scheme alignment

Watercourse ID	Main River	Scoped in/out	Reason for scoping out where appropriate
Drain 8	No	In	N/A
Drain 9	No	In	N/A
Drain 10	No	In	N/A
Drain 11	No	In	N/A
Drain 13	No	Out	No hydrological connectivity to the Scheme alignment
Drain 22	No	In	N/A
		Swilgate - source to conf. R. Avon (GB109054039780)	
River Swilgate	Yes	Out	No hydrological connectivity to the Scheme alignment
		Hatherley Bk - source to conf R Severn (GB109054032801)	
Hatherley Brook	Yes	Out	No hydrological connectivity to the Scheme alignment
		Severn – conf R Avon to conf Upper Parting (GB10905404440)	
River Severn	Yes	Out	Impacts are unlikely to propagate the approximate 8 km downstream to this watercourse and no barrier to fish migration is expected.

* The Leigh Brook is an ordinary watercourse where it is crossed by the Scheme. Approximately 2.3 km downstream of its M5 crossing, it is designated Main River.

8.6.9. The DMRB LA 113 uses WFD designation and Q95 flow to determine the importance of a watercourse. Although the high-level nature of these criteria means they are not always representative indicators of importance, in this instance, there is correlation which was determined through site visits and consultation with the regulators. Hence, these criteria have been used to determine the importance of surface water receptors. WFD designated watercourses with a Q95 flow greater than 1.0 m3/s will be assigned Very High importance. WFD designated watercourses with Q95 flow less than 1.0 m3/s will be assigned High importance.

8.6.10. Ordinary watercourses with a Q95 flow greater than 0.001 m3/s will be assigned Medium importance. Ordinary watercourses with a Q95 flow less than 0.001 m3/s will be assigned Low importance. Where the Q95 flow is unknown, a conservative approach using professional judgement has been adopted.

8.6.11. The importance of each surface water receptor for water quality and hydromorphology are listed in Table 8-11.

Figure 8-3 provided in Appendix 8.4
Figure 8-3 - Surface water courses within the study area

Surface water abstractions and discharges

8.6.12. Based on Envirocheck ® data[13], there are two public surface water abstraction licences within the study area operated by Corilla. There are 12 current surface water discharge consents within the study area.

8.6.13. A review of private abstractions has been supplied by Tewkesbury Borough Council, suggesting there are no private abstractions within the study area.

Lakes and other surface water features

8.6.14. There are no WFD designated lakes within the study area, however, there are several ponds which will be assessed as part of Chapter 7 - Biodiversity (application document TR010063 – APP 6.5).

Statutory designated sites

8.6.15. There are no statutory designated sites, including SSSI, RAMSARs, SPA, SAC, Local Nature Reserves (LNR) or National Nature Reserves (NNR) within the study area.

8.6.16. The Coombe Hill Canal is an SSSI which lies approximately 1.7 km to the west of the M5. The canal is down slope of the study area and is not within a downstream catchment as the A38 lies on an elevated ridge which forms a barrier to surface water flow pathways which cross the study area.

8.6.17. The Environment Agency have advised that, at times of high flows, there is a hydrological connection between the River Chelt and the canal when water floods from the River Chelt and into the SSSI approximately 7 km downstream of the study area. However, it is expected that this is driven by flooding from the River Severn rather than the River Chelt. It is unlikely that there will be significant impact which propagate this distance downstream. Additionally, as this connectivity occurs during high flows, any impacts from surface water quality or hydromorphology are likely to be diluted further. Therefore, the Coombe Hill Canal SSSI designated site is not considered further as part of this assessment in relation to surface water quality and hydromorphology.

Groundwater

Both publicly available data and site specific intrusive investigation data are available to establish the baseline conditions in the study area. According to the 1:50,000 mapped geology[14], there is moderate superficial deposit coverage, consisting of Alluvium and Cheltenham Sand and Gravel (river terrace deposits). The eastern portion of the study area is largely underlain by the Charmouth Mudstone Formation bedrock with the western portion underlain by the Rugby Limestone Member. Mapped geology is presented at the 1:50,000 scale in

8.6.18. Figure *8-4*.

8.6.19. Site specific ground investigation was conducted in the study area and is summarised in full in the GIR (application document TR010063 - APP 6.15). Ground investigation data is broadly consistent with the mapped geology. It confirmed the presence of Charmouth Mudstone bedrock throughout the majority of the study area. The Rugby Limestone member was not explicitly confirmed, however in the western most extremity of the study area calcareous/limestone lithologies were identified in borehole logs. Site specific ground investigation data showed the lateral extent of superficial deposits to be slightly greater than the mapped extent. However, due to the position of ground investigations the spatial extent of superficial deposits were not confirmed in eastern and western most extremities of the study area. Borehole logs confirmed the presence of Alluvium on top of the Cheltenham Sands ranging from 0 – 2.7 m, and 0 – 2.4 m, thickness respectively.

[13] Landmark, 2019. Envirocheck Reports.

8.6.20. Lithological descriptions of both superficial and bedrock geology and a generalised geological sequence are provided ~~in~~in Table 8-8.

8.6.21. Further detail particularly regarding made ground, soils and local geology can be found in Chapter 10 - Geology and Soils (application document TR010063/~~-~~APP/6.8).

8.6.22. Figure 8-4 provided in Appendix 8.4 (application document TR010063/~~-~~APP/6.15)

Figure 8-4 - Geology and WFD groundwater bodies

Table 8-8 - Generalised geological sequence for the Scheme

Type	Period	Formation/ sub-unit	Lithological description[14]	Environment Agency Aquifer Designation[15]
Superficial Geology	Quaternary	Cheltenham Sand and Gravel	Fine-medium grained of quartroze sand with seams of poorly sorted limestone gravel.	Secondary A
		Alluvium	Unconsolidated clay, sand, and silt.	Secondary A
Bedrock Geology	Triassic	Charmouth Mudstone Formation	Dark grey laminated shales, blue/grey mudstones with local concretions and argillaceous limestone beds with some sandy layers at the base of the stratigraphy.	Secondary Undifferentiated
		Rugby Limestone Member	Grey argillaceous mudstones and limestones.	Secondary A

8.6.23. The study area is underlain by Secondary A and Secondary (undifferentiated) bedrock aquifers[16]. These bedrock aquifer designations are associated with the Charmouth Mudstone Formation (Secondary Undifferentiated) and the Rugby Limestone Member (Secondary A). The study area is also underlain by discreet areas of Secondary A superficial aquifer associated with the Alluvium and Cheltenham Sand and Gravel[17]. Secondary A aquifers are defined by the Environment Agency as providing "significant quantities of drinking water, and water for business needs. They may also support rivers, lakes and wetlands"[18]. Secondary B aquifers are defined as "predominantly lower permeability layers which may store and yield limited amounts of groundwater due to localised features such as fissures, thin permeable horizons and weathering". Secondary (undifferentiated) aquifers are assigned by the Environment Agency where it has not been possible to attribute either category A or B to a rock type.

[14] BGS, 2020. Geology of Britain Viewer. [Online] Available at: Geology of Britain viewer | British Geological Survey (BGS) [Accessed on 23 March 2021]
[15] Environment Agency, 2017. Protect groundwater and prevent groundwater pollution [Online] Available at: Protect groundwater and prevent groundwater pollution - GOV.UK (www.gov.uk) [Accessed on 23 ~~Marcy~~ March 2021]
[16] Environment Agency, 2017. Protect groundwater and prevent groundwater pollution [Online] Available at: Protect groundwater and prevent groundwater pollution - GOV.UK (www.gov.uk) [Accessed on 23 ~~Marcy~~ March 2021]
[17] Environment Agency, 2017. Groundwater Vulnerability Maps on MAGIC [Online] Available at: Groundwater Vulnerability Maps (2017) on MAGIC - data.gov.uk [Accessed 24 March 2021]
[18] Environment Agency, 2017. Protect groundwater and prevent groundwater pollution [Online] Available at: Protect groundwater and prevent groundwater pollution - GOV.UK (www.gov.uk) [Accessed on 23 ~~Marcy~~ March 2021]

8.6.24. Groundwater level data is available from the site specific ground investigation. Monthly groundwater levels are available for the study area at 14 locations between August 2021 and February 2022 (Table 8-9). Nine were installed in the mudstone, three in the shallow superficials and one paired install (one shallow and one deep) for both shallow superficials and bedrock. Monitoring results from these range between 0.11 and 5.98 mbgl, with an average of 1.59 mbgl. During the monitoring period groundwater levels fluctuated a minimum of 0.11 m, maximum of 5.58 m and average of 1.43 m. Locations of these monitoring points can be found in Appendix 10.8 - Geology and Soils chapter figures (application document TR010063/—APP/-6.15).

8.6.25. Permeability testing of the Charmouth Mudstone indicate a low permeability and low flow occurring within the unit. Field permeability tests were undertaken on superficial deposits at one location (WL_WS003) and yielded results which were 2.1 x 10-7 m/s (0.02 m/d). Literature values suggest that the maximum k value for a superficial deposit between sand and gravel may be up to 8.64 m/d[19]. This suggests flow in the unit, as expected.

8.6.26. Shallow groundwater in the superficial deposits is interpreted to flow broadly east to west, following topography and likely discharges to the River Chelt, again, as expected.

The study area is underlain by two WFD groundwater bodies[20] which are shown in

8.6.27. Figure *8-4*:

- Severn Vale - Secondary Combined (GB40902G204900).
- Warwickshire Avon - Secondary Mudrocks (GB40902G990900).

8.6.28. The status of these groundwater bodies is set out in Table 8-10. For both water bodies, the overall status is Good.

8.6.29. The two bedrock and two superficial aquifers are not principal, based on DMRB LA 113, they will be classified with Medium importance.

[19] Domenico, P.A. and Schwartz, F.W. (1990) Physical and Chemical Hydrogeology. John Wiley and Sons, New York, 824
[20] Environment Agency, 2020. Catchment Data Explorer. [Online] Available at: Environment Agency - Catchment Data Explorer [Accessed 24 March 2021].

Table 8-9 - Groundwater levels within the study area

Borehole	A4019_BH001		A4019_BH002		A4019_BH010		LR_BH002		LR_BH007		LR_BH012		LR_BH018A		LR_BH024		LR_BH026		M5_BH014		M5_BH027		M5_BH032		WL_WS002		WL_WS004	
Monitored formation	**Charmouth Mudstone**		**Cheltenham Sands and Gravels*/ Charmouth Mudstone****		**Cheltenham Sands and Gravels& Upper Charmouth Mudstone**		**Charmouth Mudstone**		**Charmouth Mudstone**		**Charmouth Mudstone**		**Cheltenham Sands and Gravels& Charmouth Mudstone**		**Charmouth Mudstone**		**Charmouth Mudstone**		**Charmouth Mudstone**		**Charmouth Mudstone**		**Cheltenham Sands and Gravels& Charmouth Mudstone**		**Charmouth Mudstone**		**Cheltenham Sands and Gravels and Alluvium**	
Units	**mbgl**	**maod**	**mbgl**	**maod**	**mbgl**	**maod**	**mbgl**	**maod**	**mbgl**	**maod**	**mbgl**	**maod**	**mbgl**	**maod**	**mbgl**	**maod**	**mbgl**	**maod**	**mbgl**	**maod**	**mbgl**	**maod**	**mbgl**	**maod**	**mbgl**	**maod**	**mbgl**	**maod**
Datum		**26.2**		**26.85**		**33.9**		**27.00**		**26.95**		**26.95**		**27.91**		**27.5**		**26.4**		**23.91**		**26.85**		**23.3**		**25.35**		**24.7**
13/08/2021	-	-	-	-	-	-	3.71	23	1.29	25.66	1.45	25.5	2.52	25.39	1.33	26.17	1.65	24.75	-	-	2.43	24.42	1.7	21.6	-	-	-	-
20/09/2021	1.1	25.1	1.34* / 1.45**	25.51 */25.4 **	1.67	32.23	3.16	23.84	1.3	25.65	1.6	25.35	2.48	25.43	1.62	25.88	1.41	24.99	1.3	22.61	2.23	24.62	1.6	21.7	-	-	-	-
05/10/2021	2.87	23.33	0.75* / 1.10**	26.1** /25.7 5**	1.43	32.47	3.48	23.52	0.11	26.84	1.68	25.27	2.12	25.79	1.51	25.99	1.28	25.12	1.72	22.19	2.29	24.56	1.31	21.99	-	-	-	-
19/10/2021	2.61	23.59	0.71* / 0.90**	26.14 **/25. 95**	3.62	30.28	2.91	24.09	0.91	26.04	0.4	26.55	2.43	25.48	0.9	26.6	1.15	25.25	1.55	22.36	2.4	24.45	1	22.3	-	-	-	-
22/11/2021	2.67	23.53	0.22* / 1.87**	26.63 **/24. 98**	1.42	32.48	1.94	25.06	0.92	26.03	1.35	25.6	2.12	25.79	1.32	26.18	1.04	25.36	1.41	22.5	2.27	24.58	0.8	22.5	-	-	-	-

Monitored formation	Charmouth Mudstone		Cheltenham Sands and Gravels*/ Charmouth Mudstone**		Cheltenham Sands and Gravels& Upper Charmouth Mudstone		Charmouth Mudstone		Charmouth Mudstone		Charmouth Mudstone		Cheltenham Sands and Gravels& Charmouth Mudstone		Charmouth Mudstone		Charmouth Mudstone		Charmouth Mudstone		Charmouth Mudstone		Cheltenham Sands and Gravels& Charmouth Mudstone		Charmouth Mudstone		Cheltenham Sands and Gravels and Alluvium	
Units	**mbgl**	**maod**	**mbgl**	**maod**	**mbgl**	**maod**	**mbgl**	**maod**	**mbgl**	**maod**	**mbgl**	**maod**	**mbgl**	**maod**	**mbgl**	**maod**	**mbgl**	**maod**	**mbgl**	**maod**	**mbgl**	**maod**	**mbgl**	**maod**	**mbgl**	**maod**	**mbgl**	**maod**
Datum		**26.2**		**26.85**		**33.9**		**27.00**		**26.95**		**26.95**		**27.91**		**27.5**		**26.4**		**23.91**		**26.85**		**23.3**		**25.35**		**24.7**
13/12/2021	3.16	23.04	0.30* / 0.78**	26.55 **/26. 07**	1.3	32.6	1.24	25.76	0.96	25.99	2.88	24.07	2.24	25.67	1.51	25.99	0.91	25.49	1.25	22.66	2.05	24.8	0.45	22.85	0.49	24.86	0.87	23.83
24/01/2022	3	23.2	0.37* / 0.70**	26.48 **/26. 15**	1.22	32.68	1.86	25.14	0.89	26.06	1.31	25.64	2.3	25.61	1.32	26.18	0.96	25.44	1.28	22.63	2	24.85	0.7	22.6	0.72	24.63	0.98	23.72
14/02/2022	2.95	23.25	1.67* / 0.61**	25.18 **/26. 24**	1.25	32.65	1.44	25.56	0.82	26.13	5.98	20.97	1.83	26.08	1.33	26.17	0.75	25.65	1.2	22.71	1.86	24.99	0.35	22.95	0.39	24.96	0.56	24.14

*Shallow install/**deep install

Table 8-10 - Summary of status, RNAG, and objectives for WFD groundwater bodies within the study area.

Water body name (Water Body ID)	2019 (Cycle 2) overall status	RNAG	Objective
Severn Vale - Secondary Combined (GB40902G204900)	Good	N/A – already at Good status	Achieved at Good
Warwickshire Avon - Secondary Mudrocks (GB40902G990900)	Good	N/A – already at Good status	Achieved at Good

Designated sites

8.6.30. A search was performed for GWDTEs within the 1 km study area. The results concluded that there are no GWDTEs in this area. The Coombe Hill Canal SSSI is a GWDTE located just to the west of the 1 km study area. However, as it overlies the Triassic Branscombe Mudstone Formation, a different aquifer to that underlying the study area, it has not been assessed further in relation to groundwater effects.

Groundwater abstractions and discharges

8.6.31. There are no Source Protection Zones (SPZ) within the study area.

8.6.32. Based on Envirocheck ® data[21], there are no licensed groundwater abstractions within the study area. There is a single groundwater discharge located approximately 250 m from the M5. A review of private abstractions has been supplied by Tewkesbury Borough Council, identified that there are no private abstractions located within the study area.

8.6.33. One spring was identified within the study area using OS mapping (NGR SO 91661 24606). The spring is located on the superficial alluvium deposits, proximal to the Cheltenham sands and gravels. A site walkover on the 25 March 2022 concluded that the spring supplies Uckington Moat and is hydraulically connected to localised shallow groundwater. However, the moat also receives inflow from overland drains and surface run off.

Groundwater summary

8.6.34. The baseline information shows the two bedrock and two superficial aquifers are the only groundwater receptors. As these aquifers are not principal, based on DMRB LA 113, they will be classified with Medium importance. Although the spring provides input to Uckington Moat, as the moat is not classified as a GWDTE, the importance remains Medium.

Flood risk

Flood risk from watercourses

8.6.35. The study area is drained by the River Chelt (a designated Main River) and the Leigh Brook (an ordinary watercourse) which combine downstream of the M5 motorway. The flood risk to the study area arising from these watercourses has been assessed. Flood risk from the Staverton Stream, a minor watercourse and a tributary of the River Chelt, crosses the B4634 near the southern end of the Link Road and has been assessed separately from the River Chelt. Additional watercourses are present outside of the watershed and have been identified for water quality and WFD assessment: they do not

[21] Landmark, 2019. Envirocheck Reports.

warrant detailed assessment for flood risk where there is no direct (hydraulic) interaction with the Scheme.

The Environment Agency's Flood Map for Planning[22] identifies areas potentially at risk of flooding from fluvial or tidal sources (

[22] Environment Agency, 2020. Flood Map for Planning. [Online] Available at: https://flood-map-for-planning.service.gov.uk/ [Accessed 01 March 2021].

8.6.36. Figure 8-5). The areas not within Zone 2 or 3 are by default Flood Zone 1 (although this may include areas not assessed by the Environment Agency such as Ordinary Watercourses). The zones are defined in the NPPF as follows:

- Flood Zone 1 (Low Probability) comprises land assessed as having a less than 1 in 1,000 annual probability of river or sea flooding (<0.1% annual exceedance probability).
- Flood Zone 2 (Medium Probability) comprises land assessed as having between a 1 in 100 and 1 in 1,000 annual probability of river flooding (1% – 0.1% annual exceedance probability), or between a 1 in 200 and 1 in 1,000 annual probability of sea flooding (0.5% – 0.1% annual exceedance probability) in any year.
- Flood Zone 3 (High Probability) comprises land assessed as having a 1 in 100 or greater annual probability of river flooding (>1% annual exceedance probability), or a 1 in 200 or greater annual probability of flooding from the sea (>0.5%) annual exceedance probability in any year.

8.6.37. The land to the north of the A4019, alongside the Leigh Brook, is identified in the Flood Map for Planning[23] as being within Flood Zone 1. However, this land relates to the ordinary watercourse and it is likely that no flood mapping has been undertaken for that area. Significant areas of land just south of the A4019 and east of the M5 motorway are classified as Flood Zone 2 and 3. These floodplain areas are associated with the River Chelt. Part of the residential area at Withybridge Gardens, is located in Flood Zone 3, although some is shown to be in Flood Zone 1. To the south of the River Chelt, the floodplain is less extensive and most of the land is identified within Flood Zone 1.

8.6.38. Large areas of land to the west of the M5 motorway, including the hamlets of Knightsbridge, Coombe Hill and Boddington, are located within Flood Zone 2 with narrower areas following the river corridors under Flood Zone 3.

8.6.39. A new 1D-2D linked hydraulic model of the River Chelt and Leigh Brook has been developed for this Scheme, using the Environment Agency's Middle Chelt model (The Middle Chelt Hydraulic Model, August 2012); supplemented with a model (the Boddington Model) prepared for Robert Hitchens Ltd in August 2019 which covers an area downstream of the M5 motorway. The new model also includes the updated (2019) LiDAR, topographic survey of the Leigh Brook (2019), and was enhanced throughout, with new survey data at the M5 motorway and other critical structures. New hydrology has been applied to the model based on the Environment Agency's flood estimation guidelines[24]. This model and the hydrology have been by reviewed by external consultants on behalf of the Environment Agency (March 2021).

8.6.40. The baseline flood model for the 1% annual exceedance probability event (1 in 100-year return period), and other events, are described in the FRA (Appendix 8.1 – TR010063/-APP/-6.15) and can be summarised as:

- There is flooding upstream of the M5 motorway embankment, north of the A4019 on the Leigh Brook floodplain, located upstream of the Leigh Brook culvert and also west of the upstream point of the Leigh Brook watercourse, that would result in flooding to the properties near Uckington Farm.
- The flooding upstream of the M5 motorway embankment, south of the A4019, reaches just under 1 km east, but not as far as Uckington. The flooded depth by the M5 motorway is approximately 0.8 m at Withybridge Gardens (from the River Chelt).

[23] Environment Agency, 2020. Flood Map for Planning. [Online] Available at: https://flood-map-for-planning.service.gov.uk/ [Accessed 01 March 2021].
[24] Environment Agency, 2020. Flood risk assessments: climate change allowances. [Online] Available at: https://www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances [Accessed 01 March 2021].

8.6.41. The 0.1% annual exceedance probability event (1 in 1,000-year return period) is predicted to cause greater extents of flooding than the 1% annual exceedance probability event (1 in 100-year return period) and the design event (includes climate change), and can be summarised as:

- Significant overtopping of the A4019 from the River Chelt, resulting in widespread flooding in the Leigh Brook floodplain east of the motorway. In particular, there is more extensive flooding upstream of the Leigh Brook culvert than previously described events.
- Widespread out of bank flooding along the Leigh Brook, west of the motorway.
- More significant flooding upstream of the M5 motorway embankment than previously described events, particularly at the eastern end of the River Chelt floodplain. This is, evidenced by higher peak flows passing through the River Chelt culvert compared to those in the 1% annual exceedance probability event and the design event.
- Widespread out of bank flooding along the Chelt, west of the motorway, in the fields east of Boddington House and Boddington Manor.

8.6.42. The modelling confirms the Environment Agency's advice that that flood risk from the River Chelt and Leigh Brook is a major consideration in this area.

Flood risk from surface water

8.6.43. The Environment Agency's Risk of Flooding from Surface Water map[25] (Figure 8-7) indicates that the risk of surface water flooding is generally low across the area. Medium and high flood risk (i.e., 1% to 3.33% Annual Exceedance Probability (AEP) events respectively) are identified in areas immediately north-east and south-east of the M5 Junction 10, with the highest risk located against the motorway embankment. In particular, surface water appears to pond along the north-east border of the M5 Junction 10 southbound off slip road and extend approximately 750 m north from the junction. This ponding is shown to affect properties on the north bank of the Leigh Brook.

8.6.44. A high risk (1% Annual Exceedance Probability (AEP) event) of surface water flood risk is indicated south of the B4634 highway at the southern end of the Link Road. This arises from a minor watercourse alongside Hayden Lane with a shallow floodplain that eventually joins that of the River Chelt at the M5 motorway. This area of flooding has been confirmed through separate hydraulic modelling of this minor watercourse.

8.6.45. An area of low to high surface water flood risk (0.1% to 3.33% AEP) is located at the M5 motorway crossing of the River Chelt, approximately 800 m south from the M5 Junction 10. Surface water is shown to pond within this area, sitting beside the motorway off either bank and extending south to the unnamed watercourse that passes through the Staverton culvert. This flooding affects residential properties at Butlers Court.

Figures 8-5 to 8-7 are provided in Appendix 8.4 (application document TR010063/-APP/-6.15).

[25] Environment Agency, 2020. Flood risk map for Surface Water. [Online] Available at: Learn more about flood risk - GOV.UK (check-long-term-flood-risk.service.gov.uk) [Accessed 01 March 2021].

Figure 8-5 - Environment Agency Flood map for Planning

Figure 8-6 - Baseline flood map showing modelled 1 in 100yr with CC extents

Figure 8-7 - Environment Agency Risk of Flooding from Surface Water

Flood risk from groundwater

8.6.46. Groundwater flooding of land can occur when groundwater levels rise close to or above ground surface. Groundwater flooding is most likely to occur in low-lying areas underlain by permeable rocks (aquifers).

8.6.47. The BGS susceptibility to groundwater flooding maps show that the study area is at high to medium-high risk of groundwater flooding.

Vulnerability to flood risk

8.6.48. Receptors in the areas identified as being at flood risk include residential properties, farmland and highway. Under the NPPF these are classified as a mix of essential infrastructure, more, highly and less vulnerable development. Where there are different vulnerabilities in a group of receptors, the highest vulnerability is assigned to give a precautionary representation, rather than identify each individual receptor. In accordance with DMRB LA 113, the flood risk receptors were classified as having Medium, High or Very High importance.

8.6.49. The importance of each flood risk receptor is listed below in Table 8-11.

Future baseline

Surface water

8.6.50. There are areas of land near the Scheme which have the potential to alter the existing baseline conditions of the surface water environment. This is particularly in relation to the Leigh Brook which falls within the JCS Safeguarded development land to the north-west of Cheltenham. Any development on this land could alter the baseline conditions of the Leigh Brook. There is potential that there could be improvements to this watercourse if developments in this land are subject to Biodiversity Net Gain (BNG) requirements under the Environment Act (2021)[26].

8.6.51. No other changes are expected to the surface water baseline conditions in the future.

Groundwater

8.6.52. The future baseline conditions of the groundwater environment are unlikely to change.

Flood risk

8.6.53. In the future, surface water flood risk, groundwater flood risk and fluvial flood risk are likely to be exacerbated by climate change. The extent of Flood Zones associated with the River Chelt and the Leigh Brook are indicated, in the FRA, to increase. In those future year, problems could be experienced with watercourse structures no longer being able to cope with the rate of, or volume, of water. Such a baseline is applied in the FRA through its use of a 'design flood'.

8.6.54. The 1% annual exceedance probability event (1 in 100-year return period) with 53% allowance for climate change, shown in Figure 8-6, is predicted to cause additional flooding, specifically:

[26] Although BNG is not currently a statutory requirement, it will become statutory in 2023 (2025 for NSIPs).

- Significant overtopping of the A4019 from the River Chelt, resulting in widespread flooding in the Leigh Brook floodplain east of the motorway, and at Piffs Elm west of the motorway;
- Widespread out of bank flooding along the Leigh Brook, west of the motorway;
- Significant flooding east of the motorway upstream of the Piffs Elm (Drain 22), River Chelt and Staverton culverts; and,
- Widespread out of bank flooding along the Chelt, west of the motorway, in the fields east of Boddington House and Boddington Manor.

Summary of baseline conditions

8.6.55. The water receptors scoped into this ES have been assigned an importance in the sections above which are summarised in Table 8-11. Where the indicators of importance identified in the DMRB LA 113 are unknown, a conservative approach has been applied using professional judgement.

Table 8-11 - Summary of water environment receptors and their importance

Type of water receptor	Receptor	Indicator of importance Based on LA 113	Importance
Surface water	River Chelt	WFD designated, Q_{95} approx. 0.298 m^3/s based on NRFA gauge data	High
	Leigh Brook	WFD designated, Q_{95} unknown	High
	MW3	Ordinary watercourse, no WFD designation, Q_{95} unknown	Medium
	Drain 6	Ordinary watercourse, no WFD designation, Q_{95} unknown	Medium
	Drain 8	Ordinary watercourse, no WFD designation, Q_{95} unknown	Medium
	Drain 9	Ordinary watercourse, no WFD designation, Q_{95} unknown	Medium
	Drain 10	Ordinary watercourse, no WFD designation, Q_{95} unknown	Medium
	Drain 11	Ordinary watercourse, no WFD designation, Q_{95} unknown	Medium
	Drain 12	Ordinary watercourse, no WFD designation, Q_{95} unknown	Medium
	Drain 15	Ordinary watercourse, no WFD designation, Q_{95} unknown	Medium
	Drain 16	Ordinary watercourse, no WFD designation, Q_{95} unknown	Medium
	Drain 20	Ordinary watercourse, no WFD designation, Q_{95} unknown	Medium
	Drain 21	Ordinary watercourse, no WFD designation, Q_{95} unknown	Medium
	Drain 22	Ordinary watercourse, no WFD designation, Q_{95} unknown	Medium
	Cheltenham Sand and Gravel	Secondary A Aquifer	Medium

Type of water receptor	Receptor	Indicator of importance Based on LA 113	Importance
Groundwater	superficial aquifer		
	Alluvium superficial aquifer	Secondary A Aquifer	Medium
	Charmouth Mudstone Formation bedrock aquifer	Secondary Undifferentiated aquifer	Medium
	Rugby Limestone Member bedrock aquifer	Secondary A Aquifer	Medium
Flood risk	Uckington North	More vulnerable developments - dwelling houses	High
	Uckington South	Highly vulnerable infrastructure – fire station, more vulnerable developments – dwelling houses, and less vulnerable developments – commercial	Medium to Very High[27]
	Barn Farm East	More vulnerable developments – dwelling houses	High
	Butlers Court	More vulnerable developments - dwelling houses	High
	Millhouse Farm	More vulnerable developments - dwelling houses	High
	A4019 east of M5	Essential transport infrastructure - trunk road public highway	Very High
	Leigh Brook Floodplain - upstream of M5	Less vulnerable – land and building used for agriculture	Medium
	River Chelt Floodplain - upstream of M5	Less vulnerable – land and building used for agriculture	Medium
	M5 Motorway	Essential transport infrastructure	Very High
	River Chelt Floodplain – downstream of M5	Less vulnerable – land and building used for agriculture	Medium
	Elmstone Business Park	More vulnerable developments - dwelling houses, and less vulnerable developments – commercial	Medium to High

[27] Precautionary approach taken to the assessment using a Very High importance in this receptor group

Type of water receptor	Receptor	Indicator of importance Based on LA 113	Importance
	A4019 west of M5	Less vulnerable transport infrastructure non-trunk road public highway	Medium
	Leigh Brook Floodplain – downstream of M5	Less vulnerable – land and building used for agriculture	Medium
	Staverton Stream floodplain	Less vulnerable - farmland	Medium
	B4634	Less vulnerable - transport infrastructure	Medium

8.7. Potential impacts

8.7.1. Potential impacts from the Scheme to surface water quality, hydromorphology, flood risk and groundwater have been outlined below. Following this, an assessment has been undertaken to outline the impacts as a result of the construction and operation of the Scheme with the embedded mitigation in place. The DMRB LA 104 standard is clear that embedded mitigation is included in the best practice design approach. Embedded mitigation covers the project design principles adopted to avoid or prevent adverse environmental effects, whereas essential mitigation are those measures subsequently required to reduce and if possible offset likely significant adverse environmental effects, in support of the reported significance of effects in the environmental assessment. An assessment of the Scheme with embedded mitigation is required to be able to identify requirements for essential mitigation. Embedded mitigation has been outlined as part of the Assessment of Impacts in Section 8.7 and essential mitigation is outlined in Section 8.8.

Potential construction impacts

8.7.2. Potential impacts from Scheme construction activities are outlined in the sections below. These are generic construction impacts associated with the construction of new roads and could potentially occur across the whole of the Scheme's extent.

Surface water quality

8.7.3. Impacts to surface water quality during construction could involve:

- The excavation of materials, and the subsequent deposition of soils, fine sediment, or other construction materials.
- The spillage of fuels or other contaminating liquids from plant used in the construction process.
- The mobilisation of contamination following the disturbance of contaminated ground or groundwater.
- Runoff from construction sites to surface water bodies.

8.7.4. These impacts could result in sediment and/or other contaminants entering watercourses or lakes and affecting the quality of the water which could have implications for the designated sites, abstractions and WFD compliance (TR010063/—APP/-6.15).

Hydromorphology

8.7.5. Construction associated with bridge construction may result in localised damage to channel and riparian features and disruption of the natural hydraulic and sediment transport processes leading to loss of habitats and destabilisation of river banks and bed.

8.7.6. Construction associated with culvert replacements and extensions may result in a) localised damage to channel and riparian features and b) disruption of the natural hydraulic and sediment transport processes.

8.7.7. Realignment of minor watercourses to connect to new culverts or extended old culverts may result in damage to channel features, substrate and riparian zones.

8.7.8. Realignment of ephemeral drainage ditches due to construction of Scheme components may result in temporary habitat loss.

8.7.9. There is a potential for an increase in sediment ingress from bare ground and construction activities across the study area as a result in vegetation loss and surface water runoff.

Groundwater

8.7.10. Likely significant impacts to groundwater receptors during the construction phase could arise from:

- Deep foundations, which may form rapid vertical flow pathways for pollution into the groundwater body and may form a barrier to groundwater flow, reducing flow to groundwater dependent surface water bodies.
- New cuttings which have the potential to cause a local reduction of groundwater levels.
- Polluted surface water runoff and direct migration of mobile pollutants to groundwater resources from construction vehicles, plant and high-risk activities that may contaminate groundwater resources.

Flood risk

8.7.11. Potential impacts to flood risk during construction of the Scheme could result from:

- Blockages within watercourses and/or impact upon the floodplains ultimately reducing their floodwater storage capability.
- Excavation adjacent to the banks of watercourses can increase the risk of overtopping and/or breach of the bank.
- Temporary stockpiling of material in the floodplain during construction could result in a loss of flood storage and/or divert existing overland flow routes to areas that are not currently affected.
- Diversion of runoff, overland flow paths and watercourses during construction can lead to existing small watercourses being inundated, an increase in flood risk to third parties not currently at risk of flooding and increased risk of surface water flooding.
- Ponds constructed to hold water to manage sediment could cause flooding of local watercourses or adjacent land in the event of overtopping or a breach.
- Construction activities that extend below ground have the potential to be affected by groundwater and affect groundwater flooding.

Potential operation impacts

8.7.12. Potential impacts from Scheme operational activities are outlined in the sections below. These are generic operational impacts associated with the operation of new roads and could potentially occur across the whole of the Scheme's extent.

Surface water quality

8.7.13. During operation, there are potential impacts to surface water quality due to:

- Increased rates and volumes of pollution entering the surface watercourses during operation as a result of a larger impermeable area and increased traffic volumes; and,
- Increased risk of accidental spillage due to larger traffic volumes during operation leading to higher risk of pollution to surface watercourses.

Hydromorphology

8.7.14. Direct physical impacts on the watercourses have the potential to cause direct morphological changes to the watercourses. These may include destabilisation of the channel (changes in erosion and deposition patterns), less dynamic flows, loss of sediment continuity, increased sedimentation, habitat severance, a potential barrier for fish movement and loss of habitat for macrophytes through shading. These physical impacts could affect the status of the watercourses if left unmitigated and could have implications for changes in drainage patterns.

Groundwater

8.7.15. Below ground structures have the potential to cause a rapid vertical flow pathway for pollutants during operation of the Scheme. There is also potential that any below ground structures could cause a barrier to groundwater flow potentially impacting groundwater receptors and hydrologically connected surface water features and water resources.

Flood risk

8.7.16. There is potential for impacts to flood risk during operation of the Scheme through:

- earthworks generating a loss of floodplain.
- encroachment into the watercourses and/or the floodplains.
- blockage and severance of overland flow paths leading to ponding of surface water.
- increases in the paved (impervious) area for new carriageways generating more runoff.

Assessment of impacts

8.7.17. This section outlines the impacts from the Scheme with embedded mitigation in place which has been highlighted where appropriate.

8.7.18. The assessment includes the use of the HEWRAT to assess the impacts from routine runoff on surface water quality and to determine the risk of an accidental spillage causing a pollution event in a watercourse. The impacts from routine runoff and accidental spillages have been assessed for the current road layout and drainage system within the Scheme's footprint and for when the Scheme is in place.

8.7.19. The FRA and WFD assessments (Appendix 8.1 and Appendix 8.2, TR010063/--APP/6.15 respectively) have also been completed and support the assessment of impacts where necessary.

Construction

8.7.20. Potential impacts from construction can be mitigated through best practice measures which are associated with good site practice and preparation of robust method statements. The 1st iteration EMP has been developed and outlines the mitigation measures which will be implemented to mitigate any potential impacts to the water environment during construction of the Scheme. These will include adhering to Guidance such as Guidance on Pollution Prevention (GPPs) and CIRIA C715 Environmental good practice.

8.7.21. An assessment of construction impacts has been undertaken in the following sections. The embedded mitigation has been outlined and the magnitude of impact determined. The overall significance of effects ~~as~~has been stated.

Surface water quality

8.7.22. The EMP (TR010063~~-~~/ ~~APP-~~APP/2.13) 1st iteration outlines the plans which will be produced by the contractor as part of the 2nd iteration. These include the Soil handling management plan, Pollution Prevention and Control Management Plan and Site Waste Management Plan respectively which will ensure:

- All debris arising from the construction and works will be effectively encapsulated and removed from site.
- No pollutants will enter drainage, run-off to a watercourse or be allowed to infiltrate to a groundwater body.
- The contractor will ensure that they have a robust Pollution Response Plan in place before works start.
- Any pollution incident will be contained and cleaned up immediately and reported.
- No storage of oils or chemicals will be allowed within 10 m of a watercourse.

8.7.23. Based on the potential impacts outlined in section 8.7.3 and the mitigation measures outlined above, there are expected to be no changes to surface water quality during construction, resulting in a Neutral significance of effect which is not considered significant.

Hydromorphology

8.7.24. Embedded mitigation measures outlined within the EMP (TR010063~~-~~/ ~~APP-~~APP/2.13) 1st iteration which will mitigate impacts to hydromorphology are similar to those for surface water quality. In addition, the following measures will be applied:

- Bank reprofiling and near channel works will be carried out in an environmentally sensitive manner to reduce temporary impacts to the river habitat and vegetation.
- Where over-pumping is required, e.g., on the Leigh Brook and Drain 22, the pumping extent and duration will be minimised to reduce impacts on hydromorphological regime.
- Where construction works are taking place, care will be taken to reduce potential loss of riparian vegetation to reduce the impacts from surface runoff and sediment entrainment.
- Sediment management measures will be implemented where there is potential for surface water runoff to carry sediments from work areas to watercourses in line with GPPs.

8.7.25. Based on the potential impacts outlined in section 8.7.14 and the mitigation measures outlined above, there are expected to be no changes to the hydromorphology during construction, resulting in a Neutral significance of effect which is and is not considered significant.

Groundwater

8.7.26. Embedded mitigation for the potential impacts to groundwater include the implementation of a piling risk assessment which will consider a full suite of site specific ground investigation data to ensure the piling methods are appropriate. The embedded mitigation associated with surface water quality also applies to groundwater.

8.7.27. Based on the potential impacts outlined in section 8.7.15 and the mitigation measures outlined above, there are not expected to be any changes to groundwater during

construction, resulting in a Neutral significance of effect which is not considered significant.

Flood risk

8.7.28. Construction activities within the functional floodplain will be minimised as far as possible. Where this ~~can not~~cannot be achieved, there will be a requirement to provide temporary compensatory flood storage. To mitigate the impact of earthworks and construction compounds within the wider floodplain, construction work will be phased so that floodplain storage and compensation areas are constructed prior to loss of floodplain volume to ensure no overall adverse impact. It is expected that the permanent flood storage area, and compensatory ~~storage~~floodplain upstream of the link road, will provide sufficient compensatory storage during construction. This will be confirmed through detailed modelling of the construction phase during detailed ~~design, once~~design, once the ~~phasing~~sequencing of activities is known. Specific temporary compensation may be required depending on the phasing and location of the works. Requirements for this temporary storage will be outlined following detailed modelling which will be a requirement of the temporary works Flood Risk Activity Permit. This is not a consent which is secured via the Development Consent Order and will be sought by the Applicant separately as set out in the Consents and Positions Statement [TR010063/APP/3.3].

8.7.29. No specific hydraulic modelling of temporary construction conditions has been undertaken. This will be addressed in ~~: it is assumed that an~~the Environmental Management Plan (EMP) (2nd iteration) which will~~would~~ set out measures and procedures for dealing with construction stage flood risk.

~~8.7.29.~~8.7.30. The Environment Agency flood warning system will be adopted during construction. A suitable flood management plan will be put in place to ensure effective and safe evacuation of personnel (plant and materials if safe to do so) from the areas at risk on receipt of a flood warning.

~~8.7.30.~~8.7.31. Where subsurface works are required, for structural foundations, buried services etc., localised dewatering may be required.

~~8.7.31. No specific hydraulic modelling of temporary construction conditions has been undertaken: it is assumed that an Environmental Management Plan (EMP) (2nd iteration) would set out measures and procedures for dealing with construction stage flood risk.~~

8.7.32. With the ~~potential operational impacts outlined in section 8.7.60 and the~~ construction phase measures outlined above, there ~~is expected to~~could would be at worst, a ~~negligible~~major adverse change in flood risk during the construction which is in line with the operational impacts. These impacts would be as a result of potential localised changes in flood level of up to 100 mm:

- On the floodplain, both upstream and downstream of the Link Road.~~; and,~~
- Due to the diversion of overland flow paths into areas not already flooded – most likely around Butlers Court.

~~8.7.32.~~8.7.33. ~~,~~As these floodplain areas are of Medium importance, ~~resulting in,~~the worst case significance of effect would be ~~at worst, a Moderate Slight~~Moderate ~~or Large effect at all,~~ which is ~~not~~s, ~~which are considered significant.~~ deemed as ~~a~~ significant ~~effect~~. As there is no increase in the frequency or consequence of flooding and~~–~~ those areas of land that could see an increase in flood level are contained within the Order limits, no increase in flood risk, is expected. ~~These~~ The construction mitigation measures can be managed through the Environmental Management Plan (EMP) (2nd iteration) which is secured via Requirement 3 of the DCO and the Flood Risk Activity Permit.~~.~~

Operation

~~8.7.33.~~8.7.34. An assessment of operation impacts has been undertaken in line with the DMRB LA 113 in the following sections. The Scheme activities and associated embedded

mitigation have been outlined and the magnitude of impact determined. The overall significance of effects ~~as~~has been stated.

Surface water quality

~~8.7.34.~~8.7.35. A drainage strategy has been developed to allow for management of volumes and quality of any surface runoff from the highway. The drainage strategy consists of six attenuation basins along the M5, A4019 and the link road. Details of the designs are summarised below. For further details refer to the Drainage Strategy Report in Appendix 2.1 (application document TR010063 – APP 6.15).

- M5 Junction 10 and A4019: Collection systems are to be a kerb and gully arrangement or combined drainage and kerbs as per the existing arrangement. Flows will be conveyed via pipes to new basins prior to discharge to watercourses via new ditches for at least 8 m upstream of the outfalls, where feasible. Due to several private land parcels along the A4019 being retained, there is limited space to add additional open ditch features or swales. Flows are to be restricted to existing rates. Basins will include forebay areas to manage contaminants and contain spillages.
- Link Road: The link road includes road side swales to collect runoff and convey it to new basins. Outgoing pipes from basins will discharge to new ditches at least 8 m upstream of the outfalls. Flows are to be restricted to greenfield runoff rates. Basins will include forebay areas to manage contaminants and contain spillages.
- B4634: Changes to the B4634 Old Gloucester Road junction will result in a new drainage arrangement being required. The majority of runoff is proposed to be collected and attenuated within road side swales prior to discharge to ditches. Some other areas will be served by a kerb and gully arrangement with piped outfalls to ditches where swales are not feasible.
- S1 South: There is no change in the existing mitigation for this catchment, discharge will flow through vegetated ditches prior to entering the River Chelt.
- M5 South of the River Chelt carriageway: There is no change in the drainage layout of this catchment, therefore, no essential mitigation will be implemented. It has been included in the water quality assessment as part of the cumulative impact assessment on the River Chelt.

~~8.7.35.~~8.7.36. The magnitude of impact of the Scheme on water quality is determined by using the results generated by the HEWRAT taking into consideration the influence of embedded mitigation measures which have formed part of the Scheme design.

Routine runoff

~~8.7.36.~~8.7.37. The HEWRAT has been used to assess the impact of routine runoff on surface water quality. This includes the assessment of the acute impacts from soluble pollutants, chronic impacts from sediment related pollutants and compliance with Environmental Quality Standards (EQSs) using annual average concentrations of soluble pollutants. Results of any cumulative assessment are presented in section 8.10.

~~8.7.37.~~8.7.38. The assessment includes assessing the current road layout and drainage system within the Scheme's footprint (hereafter referred to as the current scenario) and the Scheme's proposed road layout and drainage system (hereafter referred to as the Scheme scenario). The Scheme scenario included embedded mitigation.

~~8.7.38.~~8.7.39. Table 8-12 shows the findings of the routine runoff assessment for the current scenario. The results show that the majority of drainage catchments pass all elements of the routine runoff assessment. However, the Combined Basin drainage catchment fails the chronic impacts from sediment related pollutants test and the S2 drainage catchment fails the acute impacts from soluble pollutants test for both copper and zinc and fails the chromic impacts from sediment related pollutant test,

8.7.40. Table 8-13 outlines the details of the drainage design for the Scheme scenario. This includes the embedded mitigation. The results of the routine runoff assessment for the Scheme scenario are presented in Table 8-14.

~~8.7.39. in.~~

~~8.7.40.~~8.7.41. With the Scheme in place, there are beneficial impacts to surface water quality for the combined basin and S2 catchments. The combined basin has seen a Slight benefit due to the chronic impacts from sediment moving from a fail in the current scenario to a pass in the Scheme scenario which includes embedded mitigation.

~~8.7.41.~~8.7.42. Drainage catchment S2 for the Scheme scenario cannot directly be compared to drainage catchment S2 from the current scenario. This is because the drainage has been redesigned in this area of the Scheme and the current drainage catchments S2 and Piffs Elm Culvert combine to form the S2 drainage catchment for the Scheme scenario. Therefore, the results of the routine runoff assessment of the S2 and Piffs Elm Culvert drainage catchments for the current scenario need to both be considered when assigning the S2 Scheme drainage catchment a magnitude of impact. The S2 current drainage catchment failed the acute impact from soluble assessment and the chronic sediment related pollutants assessment. The Piffs Elm Culvert current drainage catchment passed all elements of the routine runoff assessment. Using professional judgement, a conservative approach has been adopted and a Minor beneficial magnitude of impact assigned to the S2 Scheme drainage catchment.

~~8.7.42.~~8.7.43. The remaining drainage catchments all have a negligible magnitude of impact. As the importance of the receiving watercourses is high the significance of effect is slight adverse.

Spillage risk

~~8.7.43.~~8.7.44. The HEWRAT has also been used to provide an indication of the risk of a spillage causing a pollution incident on a receiving watercourse. The risk is defined as the probability that there will be a spillage of pollutant and that the pollutant will reach and impact the watercourse to such an extent that it causes a serious pollution incident. The risk is expressed as the probability of an incident in any one year.

~~8.7.44.~~8.7.45. The assessment includes assessing the current road layout and drainage system within the Scheme's footprint (hereafter referred to as the current scenario) and the Scheme's proposed road layout and drainage system (hereafter referred to as the Scheme scenario). The Scheme scenario included embedded mitigation.

~~8.7.45.~~8.7.46. Table 8-15 shows results from the spillage assessment for the current scenario where the risk is acceptable for all drainage catchments (~~i.e.~~i.e., the annual probability of a pollution incident occurring as a result of a spillage is less than 0.01 (1%)).

~~8.7.46.~~ Table 8-16 shows that the risk is acceptable for all drainage catchments with the Scheme in place (i.e., the annual probability of a pollution incident occurring as a result of a spillage is less than 0.01 (1%)). Drainage catchment A4019 main line at Elms Park has a minor beneficial magnitude of impact. This is because the annual probability of a pollution incident occurring as a result of a spillage is below 0.005 (0.5%) and there is also a reduction in the annual probability of 50% or more when compared to the current scenario Using the DMRB LA 113 standard and professional interpretation this drainage catchment has been assigned a slight beneficial significance.

8.7.47.

8.7.48. Drainage catchments S2 and S1 have a minor adverse magnitude of impact. This is because the annual probability of a pollution incident occurring as a result of a spillage is not below 0.005 (0.5%). However, the annual probability of a pollution incident occurring as a result of a spillage is acceptable as it is less than 0.01 (1%). The drainage catchments include spillage control measures (swale and a basin for drainage basin S2, and a basin

for drainage catchment S1) which would contain a spillage, if one occurred, and prevent the spillage from reaching the Leigh Brook and the River Chelt. Using the DMRB LA 113 standard and professional interpretation this drainage catchment has been assigned a slight adverse significance.

Table 8-12 - Routine runoff assessment results for the current scenario

Drainage catchment	Acute impacts from soluble copper – pass or fail	Acute impacts from soluble zinc – pass or fail	Compliance with EQS for copper (based on PNEC*)	Compliance with EQS for zinc (compliant or non-compliant)	Chronic impacts from sediment related pollutants – pass or fail
J1	Pass	Pass	Compliant	Compliant	Pass
A4019 main line at Elms Park	Pass	Pass	Compliant	Compliant	Pass
Combined basin	Pass	Pass	Compliant	Compliant	Fail
S1	Pass	Pass	Compliant	Compliant	Pass
M5 south of the River Chelt	Pass	Pass	Compliant	Compliant	Pass
S2	Fail	Fail	Compliant	Compliant	Fail
B-road	Pass	Pass	Compliant	Compliant	Pass
Piffs Elm Culvert	Pass	Pass	Compliant	Compliant	Pass

*Predicted No Effect Concentration

Table 8-13 - Surface water quality drainage catchments for the Scheme scenario

Drainage catchment	Receiving watercourse	Impermeable area (ha)	Permeable area (ha)	Change in impermeable area (ha)	Change in permeable area (ha)	Baseline mitigation	Scheme mitigation
J1	Leigh Brook	1.020	0.186	-0.086	+0.006	Vegetated ditch	Basin*
Link Road	River Chelt	1.028	0.240	+1.028	+0.240	N/A	Swale, basin, vegetated ditch
A4019 Main Line at Elms Park	River Chelt	3.336	0.389	+0.880	+0.103	Vegetated ditch	Basin
Combined Basin	Leigh Brook	6.465	1.316	+2.948	+0.573	Vegetated ditch	Swale**, basin, wetland
S1	River Chelt	3.604	0.382	+2.607	-0.096	Vegetated ditch	Basin
S1 South	River Chelt	0.621	0.072			Vegetated ditch	None
M5 South of the River Chelt***	River Chelt	0.480	0.00	0.000	0.000	None	None
S2	Leigh Brook	8.274	3.235	+0.362	+0.614	Vegetated ditch	Swale, basin
B Road	River Chelt	0.624	0.101	+0.128	-0.091	None	None

*Only 0.492 ha (48%) of this catchment drains through the basin.

**Only 1.028 ha (16%) of this catchment drains through the swale.

*** This catchment is outside of the proposed drainage works and hence no data has been collected or modelled as part of the Scheme on the drainage areas. This drainage catchment has been included as it will form part of the cumulative assessment for outfalls into the River Chelt. The area has been estimated using HADDMS and professional judgement.

Table 8-14 - Routine runoff assessment results with Scheme scenario

Drainage Catchment	Acute impacts from soluble copper – pass or fail	Acute impacts from soluble zinc – pass or fail	Compliance with EQS for copper (based on PNEC)	Compliance with EQS for zinc (based on PNEC)	Chronic impacts from sediment related pollutants – pass or fail	Magnitude of impact	Significance
J1	Pass	Pass	Compliant	Compliant	Pass	Negligible	Slight adverse
Link Road	Pass	Pass	Compliant	Compliant	Pass	Negligible	Slight adverse
A4019 main line at Elms Park	Pass	Pass	Compliant	Compliant	Pass	Negligible	Slight adverse
Combined basin	Pass	Pass	Compliant	Compliant	Pass	Minor beneficial	Slight beneficial
S1	Pass	Pass	Compliant	Compliant	Pass	Negligible	Slight adverse
S1 south	Pass	Pass	Compliant	Compliant	Pass	Negligible	Slight adverse
M5 south of the River Chelt	Pass	Pass	Compliant	Compliant	Pass	Negligible	Slight adverse
S2	Pass	Pass	Compliant	Compliant	Pass	Minor beneficial	Slight beneficial
B-road	Pass	Pass	Compliant	Compliant	Pass	Negligible	Slight adverse

Table 8-15 - Spillage assessment results – Current scenario

Drainage catchment	Annual probability of a pollution incident occurring as the result of a spillage	Risk acceptable
J1	0.00010	Yes
A4019 main line at Elms Park	0.00020	Yes
Combined basin	0.00020	Yes
S1	0.00060	Yes
M5 south of the River Chelt	0.00020	Yes
S2	0.00500	Yes
B-road	0.00003	Yes
Piffs Elm Culvert	0.00090	Yes

Table 8-16 - Spillage assessment result –Scheme scenario

Drainage catchment	Annual probability of a pollution incident occurring as the result of a spillage	Risk acceptable	Magnitude of impact	Significance
J1	0.00005	Yes	Negligible	Slight adverse
Link Road	0.000002	Yes	Negligible	Slight adverse
A4019 main line at Elms Park	0.00009	Yes	Minor beneficial	Slight beneficial
Combined basin	0.00011	Yes	Negligible	Slight adverse
S1	0.00556	Yes	Minor adverse	Slight adverse
S1 south	0.00025	Yes	Negligible	Slight adverse
M5 south of the River Chelt	0.00028	Yes	Negligible	Slight adverse
S2	0.00706	Yes	Minor adverse	Slight adverse
B-road	0.00008	Yes	Negligible	Slight adverse

Hydromorphology

8.7.49. Culvert extensions, bridge crossings and bank protection can lead to a reduction in hydromorphological complexity. This loss of channel complexity, together with the shading effect of structures and possible loss of riparian zone/floodplain can lead to a simplification/loss of in-channel, riparian and floodplain habitat. Bridge and culvert structures can also reduce biological or sediment continuity (e.g., reduce the ease with which fish or gravels can move along a channel).

8.7.50. Realignment of river channels and ditches to make space for highway infrastructure has the potential to reduce hydromorphological complexity (e.g., reduced channel length, loss of channel bends and in-channel features such as bars, berms and backwaters). Loss of hydromorphological complexity can lead to a simplification of in-channel, riparian, and floodplain habitat, and potentially lead to an adverse effect on WFD ecological quality elements.

8.7.51. A hydrological assessment has been completed to determine the potential requirements for bank protection through the Link Road River Chelt Bridge with the findings outlined below. Further details of the potential impacts on hydromorphology are outlined in the WFD assessment (Appendix 8.2).

8.7.52. Table 8-17 identifies the surface water receptors which may be impacted by the Scheme in terms of hydromorphology and has outlined the magnitude and significance of impact.

Link Road River Chelt Bridge

8.7.53. As part of the design development following the PEIR, and following consultation with the Environment Agency, assessments have been undertaken to determine the potential for erosion along the River Chelt which could interfere with the bridge abutments, footpaths and fences proposed under the Link Road River Chelt Bridge.

8.7.54. Although the bridge abutments are set back from the bank tops a minimum of 4 m, assessment of historic mapping[28] and satellite imagery also suggests that the channel has migrated up to 5 m since 2005 in places within the study area. Therefore, calculations have been undertaken using maximum discharge (Q), velocity (V) and water stage, and cross-sectional dimensions from the hydraulic modelling to determine the unit stream power.

8.7.55. The unit stream power for all return periods assessed (50% annual exceedance probability (AEP), 10%AEP, 4%AEP and 1%AEP+CC (53%)) indicated the channel (within the vicinity of the proposed structure) has the potential to experience high energy stream power and would therefore be vulnerable to localised erosion. This presumption is supported by existing erosion observed upstream of the site along the River Chelt. The potential for erosion will be further exacerbated by the lack of future vegetation growth due to shading from the structure.

8.7.56. As a result of this work, it has been proposed that some form of bank protection will be required through the structure to protect the bridge abutments, footpath and fencing from potential future erosion. As a worst-case scenario, as part of this ES, it has been assumed that hard bank protection (such as rip-rap) will be required along both banks through the length of the structure (approximately 20.8m of channel). However, at the detailed design stage, further assessment (including a scour assessment) will determine the most pragmatic solution and confirm the need for bank protection, specify the materials and general arrangement which will aim to minimise and, where possible, utilise soft solutions rather than hard bank protection. As a WFD assessment will be required to support the application for a Flood Risk Activity Permit, pre application consultation will take place to align expectations and inform the Environment Agency of the proposed design.

8.7.57. As the impacts to the River Chelt and Leigh Brook are expected to be minor, either a Slight or Moderate significance can be selected based on guidance in LA 104 (Table 8-2). The significance of impact has been assigned as Slight as the impacts are expected to be localised. With the embedded mitigation applied, any potential impacts will be mitigated to a level which is not significant.

[28] National Library of Scotland, 2022. Side by side maps. [Online] Available at: Side by side georeferenced maps viewer - Map images - National Library of Scotland (nls.uk) [Accessed 05 September 2022].

Table 8-17 - Surface water receptors and mechanisms of impact

Scheme activity	Receptor	Receptor importance	Mechanism of impact	Description and embedded mitigation	Magnitude of impact	Significance
The Link Road River Chelt Bridge	River Chelt	High	Riparian vegetation loss, bank reprofiling and bank protection	The Link Road River Chelt Bridge has been designed as a clear span structure with a total deck of 20.8 m and abutments set back a minimum of 4 m from the bank tops. Mitigation measures have been implemented to generate a more natural channel approximately 160 m upstream and 100 m downstream of the crossing including bank reprofiling, floodplain connectivity, vegetation planting, and creation of in channel morphological features such as pools, riffles and large wood. This has resulted in a change in BNG condition score, for an approximate length of 270 m, from Moderate to Fairly Good with a drop in condition class for the 20.8m impacted by the structure (See further details in the Biodiversity Net Gain assessment (application document TR010063/-APP/-6.15)).	Minor adverse	Slight adverse
River Chelt Culvert	River Chelt	High	No impacts on hydromorphology are expected at this stage	The design ensures no changes to the existing River Chelt Culvert dimensions. Enhancement measures are proposed to reprofile the banks of the watercourse upstream to create a more natural two-staged channel. Vegetation management will also take place with details outlined in the Environment Plans (application document TR010063/-APP/-2.13). These measures have resulted in an increase in BNG condition class form Fairly Poor to Moderate.	Minor Beneficial	Slight benefit
Leigh Brook Culvert extension	Leigh Brook	High	Vegetation loss Reduced hydromorphological complexity Potential loss of sediment continuity Loss of open channel	Continuity of natural bed substrate and gradient through the structures will be retained and will be embedded 0.3 m below the surface. The Leigh Brook culvert will be extended from 53.525 m to 69.875 m. Environment plans have been produced to ensure implementation of appropriate riparian vegetation downstream of any new crossing (application document TR010063/-APP/-2.13). The BNG assessment concludes that the 100 m downstream of the Leigh Brook will increase in condition class from Fairly Poor to Moderate.	Minor Adverse	Slight adverse
Piffs Elm Culvert	Drain 22	Medium	Vegetation loss Reduced hydromorphological complexity Potential loss of sediment continuity Loss of open channel	Continuity of natural bed substrate and gradient through the structure will be retained and will be embedded 0.3 m below the surface. Piffs Elm culvert will be extended from 47.54 m to 147.69 m due to incorporation of the M5 Junction 10 slip roads. Baffled headwall and alignment to watercourse on the downstream end will reduce potential for erosion in high flow events.	Minor Adverse	Slight adverse
B4634 Flood culverts	Drain 15	Medium	Vegetation loss Reduced hydromorphological complexity Potential loss of sediment continuity Loss of open channel	Continuity of natural bed substrate, flow and gradient through the structures will be improved due to the culvert realignment. Culverts will be embedded 0.3 m below the surface. The culvert lengths will be kept to a minimum and sized to facilitate any environmental needs. Drain 15 culvert will be replaced and realigned to improve continuity of the upstream watercourse. The baseline lengths are unknown but the replacement will be 25.89 m.	Minor Adverse	Slight Adverse
Existing culvert extensions	Drain 8 Drain 10 Drain 12 Drain 18 Drain 20	Medium Medium Medium Medium Medium	Vegetation loss Reduced hydromorphological complexity Potential loss of sediment continuity	Dimensional details of the minor culvert extensions are unknown at this stage and will be determined at detailed design stage. These culverts will be designed to ensure continuity of the natural bed substrates, flow and gradient through the structures. Culverts will be embedded 0.3 m below the surface and the lengths will be minimised to reduce impact.	Negligible Negligible Negligible Negligible Negligible	Neutral Neutral Neutral Neutral Neutral
Encroachment of drainage channels	Drain 8 Drain 9 Drain 10 Drain 11 Drain 16 Drain 21	Medium Medium Medium Medium Medium Medium	Vegetation loss Reduced hydromorphological complexity Potential loss of sediment continuity	Where watercourse or ditches are realigned or encroached, designs will replicate the natural character of the watercourse and be considered appropriate improvements to the hydromorphological and biological quality of the watercourse. Environment plans have been produced to highlight where ditches will be replaced across the Scheme (application document TR010063/-APP/-2.13).	Negligible Negligible Negligible Negligible Negligible Negligible	Neutral Neutral Neutral Neutral Neutral Neutral
Removal of the A4019 twin culverts and elevation of A4019	Leigh Brook Drain 22	High Medium	Increased flood flow in Drain 22 in the 100year+CC event and higher with decreased flood flows in the Leigh Brook.	A reduction in peak flow in the Leigh Brook from 9.4 m^3/s in the baseline scenario to 3.2 m^3/s with the Scheme in the Q100+CC53%. No embedded mitigation to manage alterations in flows.	Minor Adverse Minor Adverse	Slight Slight

Groundwater

8.7.58. Large sections of the M5 Junction 10 and the Link Road are elevated and/or embanked and will require earthworks. The Piffs Elm interchange bridge (North and South) in addition to the River Chelt crossing comprise of cored bore piling that is ~13 m in depth. Drawings also show shallow sections of cutting to the north of the Junction 10.

8.7.59. The type of embankment that will be used in the Scheme is currently unknown. This is at the discretion of the contractor during construction and has therefore not been specified at this stage. The “worst case scenario” for an embankment type in the context of groundwater (i.e., an embankment design with the deepest below ground works) has been used for the impact assessment. These embankments are estimated to be ~1 mbgl strip foundation comprising impermeable material that run the length of the embankment.

8.7.60. Table 8-18 summarises groundwater receptors and has considered embedded mitigation in the current design and also includes best practice guidance. For example, the completion of a piling risk assessment and implementation of best practice guidance regarding pollution prevention which will be secured as part of the EMP 2nd iteration. Further details of the potential impacts on groundwater are outlined in the WFD assessment (Appendix 8.2 - TR010063/—APP/-6.15).

Table 8-18 - Preliminary significance of impact to groundwater receptors

Scheme activities	Potential receptors	Receptor importance	Mechanism of impact	Embedded mitigation	Potential magnitude of impact	Potential significance
Embankments	All Superficial and bedrock aquifers	Medium	During operation deep foundations and piles may create rapid vertical flow pathways and introduce contamination into the aquifer. They may form a barrier to groundwater flow, potentially reducing groundwater contributions to adjacent water courses and any groundwater abstractions in the water body.	Scheme activity has no sheet piling, maximum depth is ~1 mbgl which is less than the average thickness of the superficial deposits and unlikely to intersect the bedrock aquifer. This is also less than the average groundwater level of the Scheme as deduced from groundwater level monitoring. The embankment type does not have to be the same throughout the Scheme and therefore the lateral continuity of any embankment foundation will not likely extend throughout the whole Scheme. Mitigation is embedded in the form of best practice, including below ground risk assessments (such as piling risk assessments) should they be required.	Negligible	Slight
The Link Road River Chelt Bridge	All Superficial and bedrock aquifers	Medium		Scheme components have been designed with embedded mitigation. Piling type is specified as cored bore piling with a minimum of 1 m distance between each bore and extends approx. 13 mbgl. This design would mitigate any barriers to groundwater flow. Mitigation is embedded in the form of best practice, including below ground risk assessments (such as piling risk assessments) should they be required.	Negligible	Slight
Piffs Elm Interchange Bridge North	All Superficial and bedrock aquifers	Medium			Negligible	Slight
Piffs Elm Interchange Bridge South	All Superficial and bedrock aquifers	Medium			Negligible	Slight
Cuttings	All Superficial and bedrock aquifers	Medium	During operation cuttings may potentially impact groundwater contributions to adjacent water courses and any groundwater abstractions in the water body.	No embedded mitigation has been specified for cuttings throughout the Scheme however, Scheme drawings show cuttings to be shallow and likely <2 m in depth. Mitigation is embedded in the form of best practice, including below ground risk assessments (such as piling risk assessments) should they be required.	Negligible	Slight
Compensatory Flood Storage Area	All Superficial and bedrock aquifers	Medium	During operation, CFSA excavation may alter groundwater flow directions including groundwater contributions to surface watercourses.	No embedded mitigation has been specified for excavations. However, the current CFSA design indicates it is likely to be shallow and vary between 1.5 and 3 m in depth with the intention for part of the CFSA to be in full hydraulic continuity with groundwater. Mitigation is embedded in the form of best practice.	Negligible	Slight

Flood risk

8.7.61. In accordance with the guidance DMRB LA 113 all projects on motorways and all-purpose trunk roads shall be designed to:

- remain operational and safe for users in times of flood.
- result in no net loss of floodplain storage.
- not impede water flows.
- not increase flood risk elsewhere.

8.7.62. These requirements limit the impacts and ensure the inclusion of embedded mitigation. Where these guidelines are not followed potential impacts to flood risk receptors could arise during operation of the Scheme as described above in 8.7.16.

8.7.63. The flood modelling has shown that the Scheme will displace floodwater and significantly impact on the flood risk of its neighbours if the embedded mitigation is not implemented. The embedded mitigation included in the design is described in detail in the FRA (Appendix 8.1 application document TR010063/APP/6.15) and has been informed by ~~.~~ h~~H~~ydraulic modelling.

8.7.64. For the Scheme in terms of flooding, the embedded mitigation includes:

- A drainage strategy to limit the peak rate and overall volume of discharge.
- Compensatory floodplain to offset the volume of water displaced by the Scheme during the design flood, prior to the removal of any existing floodplain. This includes a large (>190,000 m^3) flood storage basin between the M5 motorway and Withybridge Lane, and 2,775 m^3 of compensatory floodplain immediately east of the Link Road.
- A permanent watercourse crossing of the River Chelt designed to convey the design flood with a minimum of 600 mm freeboard to soffit.
- Floodplain conveyance structures through the Link Road. At this stage, the Scheme includes 37 box culvert openings, 36 no being 3 m wide and 1 m tall with an enlarged 6 m wide culvert accommodating an existing field drain.
- Extension of the Piffs Elm and Leigh Brook watercourse culverts underneath the M5 motorway, to suit the new roads at the same size and slope as the existing culverts. The existing River Chelt and Staverton culverts do not require extending as part of this Scheme.
- Extension and additional flood culverts under the B4634 to replace conveyance over the highway in the baseline conditions.

8.7.65. Hydraulic modelling has been used to predict the with-Scheme flood risk in the study area (and hence change from the baseline). The results indicate that the Scheme can sufficiently maintain the hydraulic connectivity, floodplain conveyance and volumetric storage without significant adverse effects on flood risk.

8.7.66. The impact of the Scheme flood model for the present day 1% annual exceedance probability event (1 in 100-year return period) is described in detail in the FRA (Appendix 8.1 - TR010063/~~-~~APP/~~-~~6.15). The effect of the Scheme on the baseline conditions for this event are shown in Figure 8-8 and can be summarised as:

- A reduction in baseline flood levels upstream (east) of the M5 motorway embankment, south of the A4019, resulting from excavated (reduced) ground levels where the flood storage area is proposed.
- A reduction in baseline flood levels downstream of the Piffs Elm and Staverton culverts, extending west to Boddington Road.

- A change in the depth of flooding immediately upstream and downstream of the proposed Link Road: a mix of increases and decreases in flooding associated with the proposed Link Road culverts.
- Intended new flooding in the compensatory floodplain, immediately upstream of the Link Road (the land was previously flood free).
- Deeper flooding in the flood storage area by the M5 motorway as a result of excavated (reduced) ground levels.
- A reduction in baseline flood levels near The Green Road in Uckington, west of the upstream point of the Leigh Brook watercourse, resulting in less flooding to the properties near Uckington Farm.
- No other significant changes to flood levels in Leigh Brook floodplain, upstream and downstream of motorway.
- A small area of increased flood depth (approximately 40 mm) immediately downstream of the B4634 culvert, off the Staverton Stream.
- No flooding of the A4019 highway at Piffs Elm.

8.7.67. The 1% annual exceedance probability event (1 in 100-year return period) with allowance for climate change (+53%) (the design flood) is described in detail in the FRA. The effect of the Scheme on the baseline conditions for this event are shown in Figure 8-9 and can be summarised as:

- A reduction in baseline flood levels upstream of the M5 motorway embankment, south of the A4019.
- New flooding filling the compensatory floodplain, upstream of the proposed Link Road. Increases and decreases in baseline flood levels both upstream and downstream of the proposed Link Road culverts.
- Deeper flooding in the flood storage area by the M5 motorway as a result of excavated (reduced) ground levels.
- No flooding of the A4019 and property at Piffs Elm (Elmstone Business Park and Stanboro Cottage), downstream (west) of the M5 motorway embankment, where the Scheme prevents flows from passing over the highway.
- A significant reduction in baseline flood levels in the Leigh Brook floodplain, upstream and downstream of the motorway, due to the Scheme removing the culverts under the A4019 and also raising the A4019 and preventing extreme floods from overtopping this road and entering the Leigh Brook catchment.
- A small area of increased flood depth (approximately 40 mm) immediately downstream of the B4634 culvert, off the Staverton Stream, but with a 20 mm reduction in flood level on the farmland. The B4634 highway is still predicted to flood, albeit over a shorter length and flood levels drop.

8.7.68. Table 8-19 details the magnitude and significance of effects from flood risk, applying the following assumptions:

- Receptors are grouped by area.
- The magnitude and impact for each receptor group was assessed using the typical impact on peak flood levels for the whole group.
- The magnitude and impact for each receptor group was based on the modelled 1% AEP event (1 in 100-year return period) with climate change (+53% increase in flow applied).
- As the receptor group at Barn Farm East has a High importance (DMRB LA 113) and benefits from a reduction in peak flood level significantly greater than the 100 mm required for a Major beneficial impact (DMRB LA 113) (the reduction being 650 mm), the significance of effect for this group has been classified as

Very Large rather than Large (DMRB LA 113 suggests either Large or Very Large).

- As the receptor groups at the Leigh Brook floodplain and River Chelt floodplain have a Medium importance (DMRB LA 113) and benefit from a widespread reduction in peak flood levels greater than the 100 mm required for a Major beneficial impact (DMRB LA 113), the significance of effect for this group has been classified as Large rather than Moderate (DMRB LA 113 suggests either Moderate or Large).

Figures 8-8 and 8-9 provided in Appendix 8.4 (application document TR010063/--APP/-6.15)

Figure 8-8 - Scheme impact on flood level at the 1% AEP event (1 in 100-year return period)

Figure 8-9 - Scheme impact on flood level at the 1% AEP event (1 in 100-year return period) with climate change

Table 8-19 - Magnitude and significance of impact from flood risk during operation

Receptor	Impact (1% AEP with CC)	Magnitude of impact (based on 1% AEP with CC)	Significance (based on 1% AEP with CC)
Uckington North (high importance)	No change (0 mm) compared to baseline peak flood levels for majority of receptors (37 out of 54 receptors). Reduction of 10 mm to baseline peak flood levels for 17 receptors.	No Change Negligible	Neutral Slight Beneficial
Uckington South (very high importance)	No change (0 mm) compared to baseline peak flood levels for all receptors.	No Change	Neutral
Barn Farm East (high importance)	One receptor impacted by typically a 650 mm reduction compared to baseline peak flood levels.	Major Beneficial	Very Large Beneficial
Butlers Court (high importance)	No change (0 mm) compared to baseline peak flood levels for all receptors.	No Change	Neutral
Millhouse Farm (high importance)	No change (0 mm) compared to baseline peak flood levels for all receptors.	No Change	Neutral
A4019 – east of M5 (very high importance)	No change from peak flood levels, but Scheme raises A4019. Therefore, existing baseline overtopping and flooding (with average depth of 500 mm) is prevented.	Major Beneficial	Very Large Beneficial

Leigh Brook Floodplain - upstream of M5 (medium importance)	Reduction of between 10 and 750 mm compared to baseline peak levels, across majority of Leigh Brook floodplain upstream of the M5.	Major Beneficial	Large Beneficial
River Chelt Floodplain - upstream of M5 (medium importance)	Some increases of up to 230 mm compared to baseline peak flood levels, located immediately upstream of the Link Road due to new flooding in the proposed compensatory floodplain area (a Major impact). The impact outside of the compensatory floodplain is limited to an increase of 60 mm (a Moderate impact). However, a reduction of between 10 and 140 mm compared to baseline peak flood levels is predicted across majority of River Chelt floodplain, mainly located around the proposed flood compensation area, as well as upstream and downstream of Link Road. There is large variation in the impact on flooding across the River Chelt floodplain, even within discrete land parcels and fields. The FRA provides depth difference grids which show the differences spatially.	Some areas of Major Adverse but majority is Major Beneficial	Some **Large Adverse** but majority is Large Beneficial
M5 Motorway (very high importance)	No change (0 mm) compared to baseline peak flood levels for all receptors.	No Change	Neutral
River Chelt Floodplain – downstream of M5 (medium importance)	Reduction of between 10 and 150 mm compared to baseline peak flood levels, located downstream of the Piffs Elm culvert, extending west to Boddington Road.	Major Beneficial	Large Beneficial
Elmstone Business Park (high importance)	Flooding of the receptor is prevented by the Scheme with its minor raising of the verge on the southern side of the road. This is a beneficial impact, reducing flood levels by up to 140 mm (removing the flooding).	Major Beneficial	Very Large Beneficial
A4019 – west of M5 (medium importance)	Flooding of the highway is prevented by the Scheme with its minor raising of the verge on the southern side of the road. This is a beneficial impact, reducing flood levels by up to 90 mm (removing the flooding) which is classified as a minor impact.	Minor Beneficial	Slight Beneficial

Leigh Brook Floodplain – downstream of M5 (medium importance)	Widespread reduction of between 50 and 200 mm compared to baseline peak flood levels, north and south of Leigh Brook watercourse, downstream of M5.	Major Beneficial	Large Beneficial
Staverton Stream floodplain (medium importance)	Up to 20 mm reduction in peak flood levels upstream of the B4634. There are some localised increases of up to 40 mm besides the watercourse between the B4634 and Withybridge Lane although the impact on the surrounding farmland is less with a widespread 10-20 mm reduction in peak level. Note that during the 20% annual exceedance probability event (1 in 5-year return period) and 10% annual exceedance probability event (1 in 10-year return period) there is a reduction in peak flood levels upstream of the B4634 but with some 20-30 mm increases across the farmland between the B4634 and Withybridge Lane.	Mostly Minor Beneficial with some Minor Adverse	Slight Adverse
B4634 highway (medium importance)	The Scheme prevents the highway from flooding during the 1% AEP, but still overtops in the 1% AEP with climate change. This is a beneficial impact, reducing flood levels by over 50 mm (removing the flooding along some of the highway) which is classified as a moderate impact. Note that the highway is predicted to currently flooded once every 5 years.	Moderate Beneficial	Moderate Beneficial

8.8. Mitigation measures

8.8.1. Where the assessment, using the DMRB LA 113 methodology, identifies any significant adverse effects, essential mitigation measures should be implemented as part of the next phase of design. The proposed mitigation measures would be in addition to the embedded mitigation within the project's design which has been outlined in the section 8.7, such as SuDS pollution control measures on outfalls (if appropriate) and measures within the EMP to control and prevent polluted run-off. A 1st iteration EMP has been developed (application document TR010063/~~-~~APP/~~-~~7.3) and will be updated during construction and handover to operation (2nd iteration EMP and 3rd iteration EMP respectively).

8.8.2. Where required, the ~~Essential~~ essential mitigation measures have been highlighted below.

Construction

Surface water quality

8.8.3. With the embedded mitigation in place, the impacts to water quality during construction are not expected to be significant. Therefore, no essential mitigation is required.

Hydromorphology

8.8.4. With the embedded mitigation in place, the impacts to hydromorphology during construction are not expected to be significant. Therefore, no essential mitigation is required.

Groundwater

8.8.5. With the embedded mitigation in place, the impacts to groundwater during construction are not expected to be significant. Therefore, no essential mitigation is required.

Flood risk

8.8.6. Even with the appropriate construction mitigation measures being implemented, the impacts to flood risk during construction could be locally significant (Moderate ~~and Large~~ Adverse), with a localised increased in flood depth. However, no increase in the frequency or consequence of flooding, and hence flood risk, is expected. Notwithstanding this, those areas of land that could see an increase in flood level are contained within the Order limits. No essential mitigation is required.

Operation

Surface water quality

8.8.7. Appropriate embedded mitigation measures have been implemented as outlined in Table 8-13 which provides sufficient mitigation to ensure no significant impacts are incurred and therefore no essential mitigation is required.

Hydromorphology

8.8.8. Although there are not expected to be any significant impacts, additional assessment will be required at the detailed design stage to support any required bank protection on the River Chelt. This will involve a scour assessment and determination of the most pragmatic solution to ensure stability of the Link Road River Chelt Bridge and will be compliant with the DMRB BD97/12[29]. The assessment will confirm the need for bank protection, specify the materials and general arrangement which will minimise and, where possible, exclude hard bank protection. Where this is not possible further measures to mitigate for this will

[29] The Assessment of Scour and Other Hydraulic Actions at Highway Structures.

be explored, such as naturalised bank toe frontages comprising wood etc. The preferred approach will be discussed with the Environment Agency through consultation to ensure expectations are aligned.

8.8.9. A BNG assessment has been completed to support this ES (Appendix 7.18 - application document TR010063/-–APP/ 6.15) and will be updated to ensure the final design is in line with the project targets.

8.8.10. In addition, a flood risk model will be implemented at the detailed design stage to ensure that the implementation of large woody features within the channel and on the banks does not have a negative impact on the flood risk along the River Chelt.

Groundwater

8.8.11. Appropriate mitigation measures have been implemented as part of the embedded mitigation measures as outlined in Table 8-18. There are not expected to be any significant impacts to groundwater, therefore, no essential mitigation is required.

Flood risk

8.8.12. The assessment has demonstrated some increases in flood levels affecting farmland (classified in the NPPF as less vulnerable and hence of medium importance). The predicted changes in flood depth are not more than 100 mm: the guidance in DMRB LA 113 describes this as a Moderate impact, with an effect of Moderate or Large significance, and hence recorded as a significant environmental effect. These effects require essential mitigation to be considered.

8.8.13. Hydraulic modelling has been undertaken to test essential mitigation for the significant adverse effects (as described in Table 8-19). The essential mitigation measures tested were:

- Use of larger conveyance structures for new and replacement crossings of the watercourses and floodplains, particularly at the Link Road. The number, size and location of the multiple culverts was tested to check whether mitigation could negate the localised adverse effects. No suitable combination was determined without transferring the significant effect elsewhere.
- Inclusion of additional or larger compensatory floodplain or storage.

8.8.14. The works identified that whilst mitigation could be implemented, the environmental and economic cost of doing so would outweigh the benefits, with those identified significant adverse effects having no material impact on flood risk in the first place: whilst flood levels were predicted to increase in localised areas, typically by less than 100 mm, the impact on the probability of flooding, and its consequence, was considered to be neutral and at worst case, negligible. This is described more in the FRA (Appendix 8.1-_—TR010063/—APP/–6.15).– It was concluded that the unmitigated significant adverse effects do not change the flood risk to those areas.

8.8.15. As such, to prevent the wider adverse impacts of any additional flood storage, compensatory floodplain, or conveyance structures, the Order limits have been set to encompass the parcels of land affected and consultation undertaken with the landowners on the small increase in flood levels. A right for the predicted increases in flood level are sought through the DCO for these areas, which cover:

- 6 fields of existing farmland either side of the Link Road (increases and decreases in flood level of 190 mm and 290 mm respectively in the compensatory floodplain, and ±60 mm outside of that).
- 3 fields of existing farmland alongside the Staverton Stream, between the B4634 and Withybridge Lane (increases in flood level of up to 40 mm, but with a widespread 10 mm – 30 mm).

8.8.16. The effects in these areas are described as significant adverse, as defined by LA113, but do not relate to new flooding, and instead simply a change in the pattern of existing flooding. Furthermore, the FRA has determined that there will be no material increase in flood risk, despite an increase in peak flood level on these land parcels.

8.8.17. Whilst the Scheme is not predicted to increase flood risk elsewhere, albeit with a non-material increase alongside the Staverton Stream, the Scheme is consulting with the affected landowners to demonstrate that they are fully aware of the small increases in peak flood level. At the same time, a right is also being sought through the DCO process to permit some increased depth of flooding on the farmland.

8.9. Residual effects

8.9.1. An assessment of residual impacts has been undertaken and summarised in the below sections. This has assumed that embedded (best practice) and essential mitigation will be incorporated during construction and will be secured by the EMP (1st to 3rd iterations).

Construction

Surface water quality

8.9.2. Likely impacts from road construction activities are typically temporary and can be mitigated through good engineering practices.

8.9.3. For surface water receptors, subject to the implementation of all mitigation measures, the overall effect on surface water during construction has been assessed as Neutral which is not considered significant.

8.9.4. As no significant effects on surface water features have been identified, no significant effects on licensed abstractions or consented discharges are predicted.

8.9.5. The WFD assessment has been completed and has concluded that temporary impacts are not likely to cause a deterioration to the water quality elements of the WFD at a water body scale (Appendix 8.2 – TR010063/~~—~~APP/~~-~~6.15).

Hydromorphology

8.9.6. Likely significance of effect on hydromorphology from construction activities are the same as those stated for surface water quality therefore the overall effect on hydromorphology during construction has been assessed as Neutral which is not considered significant.

8.9.7. Similarly, the WFD assessment has been completed and has concluded that temporary impacts are not likely to cause a deterioration to the biological elements of the WFD at a water body scale (Appendix 8.2 – TR010063/~~—~~APP/~~-~~6.15).

Groundwater

8.9.8. Likely impacts from road construction activities are typically temporary and can be mitigated through good engineering practices.

8.9.9. For groundwater receptors, subject to the implementation of all mitigation measures, the overall effect from construction on groundwater has been assessed as Neutral which is not considered ~~significant~~significant.

Flood risk

8.9.10. For the flood risk receptors, the overall effect of the Scheme on flood risk during construction remains unchanged, ~~being~~ atbeing at worst, ~~Moderate Slight~~Moderate~~and Large Adverse~~ due to potential increases in flood levels. ~~These are not significant effects and will need to be addressed through Environmental Management Plan (EMP) (2nd iteration).It is likely that detailed~~Detailed flood risk modelling of the construction phase will be a requirement of the Temporary Flood Risk Activity Permit. The modelling will need to

show that the sequencing of construction allows for sufficient compensatory flood storage to be provided to ensure no increased risk of flooding during construction.

Operation

Surface water quality

8.9.11. Water quality assessments have been completed for the current scenario and with the Scheme in place for routine runoff and spillage risk. This has accounted for the mitigation embedded into the design.

8.9.12. A summary of the water quality results is presented in Table 8-20. Table 8-21 provides the overall residual impacts for water quality.

8.9.13. Even though Table 8-20 shows a minor adverse impact to both the Leigh Book and the River Chelt the risk of a spillage causing a pollution incident is acceptable. Spillage control measures are in place on these drainage catchments and these measures would contain a spillage, if one occurred, and prevent the spillage from reaching the Leigh Brook and the River Chelt.

Table 8-20 - Residual impacts on the surface water quality during operation.

Test	Receptor	River Chelt	Leigh Brook
Routine runoff	Number of drainage catchments with Minor beneficial impact	0	2
	Number of drainage catchments with negligible impact	6	1
Spillage	Number of drainage catchments with minor beneficial impact	1	0
	Number of drainage catchments with negligible impact	4	2
	Number of drainage catchments with minor adverse impact	1	1

Hydromorphology

8.9.14. Residual impacts to hydromorphology are outlined in Table 8-21 below. This has assumed that all mitigation is implemented.

Groundwater

8.9.15. The overall residual magnitude of impact on groundwater receptors during operation is predicted to be Negligible resulting in Neutral significance of effects (Table 8-21).

Flood risk

8.9.16. Subject to the implementation of all mitigation, and with the assumptions set out in section 8.11 below, the worst-case residual impact on all flood receptors (outside of the permanent land take) during operation remains Major Adverse (> 100 mm increase in peak flood level) resulting in a Large Adverse significance of effect (as described by LA113). These residual impacts to flood risk are outlined in Table 8-21 below.

8.9.17. However, whilst an increase in peak flood level is predicted for ~~three~~ two receptors, the change in the probability and consequence of flooding is neutral at ~~two~~ one of them (Link Road), and negligible at the other (farmland alongside the Staverton Stream). These lead to no, or a non-material, increase in flood risk at the ~~three~~ two receptors assessed as incurring a significant environmental effect.

Summary

8.9.18. The residual significance of effect on the water environment during operation are outlined in Table 8-21.

Table 8-21 - Residual impacts on the water environment during operation.

Receptor	Importance as outlined in Table 8-11	Magnitude of impact	Significance of effect
	Surface water quality -	routine runoff	
River Chelt - drainage catchments Link Road, A4019 main line at Elms Park, S1, S1 south, M5 south of the River Chelt and B-road	High	Negligible	Slight adverse
Leigh Brook - drainage catchment J1	High	Negligible	Slight adverse
Leigh Brook - drainage catchments Combined basin and S2	High	Minor beneficial	Slight benefit
	Surface water quality -	spillage	
River Chelt - drainage catchments Link Road, S1 south, M5 south of the River Chelt and B-road	High	Negligible	Slight adverse
River Chelt - drainage catchment A4019 main line at Elms Park	High	Minor beneficial	Slight benefit
River Chelt – drainage catchment S1	High	Minor adverse	Slight adverse
Leigh Brook - drainage catchments J1 and Combined basin	High	Negligible	Slight adverse
Leigh Brook - drainage catchment S2	High	Minor adverse	Slight adverse
	Hydromorphology		
River Chelt	High	Minor adverse	Slight adverse
Leigh Brook	High	Minor adverse	Slight adverse
Drain 8	Medium	Negligible	Neutral
Drain 9	Medium	Negligible	Neutral
Drain 10	Medium	Minor adverse	Slight adverse
Drain 11	Medium	Negligible	Neutral
Drain 12	Medium	Minor adverse	Slight adverse
Drain 15	Medium	Minor adverse	Slight adverse
Drain 16	Medium	Negligible	Neutral
Drain 20	Medium	Minor adverse	Slight adverse
Drain 21	Medium	Minor adverse	Slight adverse

Groundwater			
Cheltenham Sand and Gravel superficial aquifer	Medium	Negligible	Neutral
Alluvium superficial aquifer	Medium	Negligible	Neutral
Charmouth Mudstone Formation bedrock aquifer	Medium	Negligible	Neutral
Rugby Limestone Member bedrock aquifer	Medium	Negligible	Neutral
Flood risk			
Uckington North	High	No change to Negligible	Neutral to Slight benefit
Uckington South	Very high	No change	Neutral
Barn Farm East	High	Major beneficial	Very Large benefit
Butlers Court	High	No Change	Neutral
Millhouse Farm	High	No Change	Neutral
A4019 – east of M5	Very high	Major beneficial	Very Large benefit
Leigh Brook Floodplain - upstream of M5	Medium	Major beneficial	Large benefit
River Chelt Floodplain - upstream of M5	Medium	Localised areas of Major Adverse but majority is Major beneficial	**Large adverse** With majority Large benefit
River Chelt Floodplain – downstream of M5	Medium	Major beneficial	Large benefit
Elmstone Business Park (residential)	High	Major beneficial	Very Large beneficial
M5 motorway	Very high	No change	Neutral
A4019 – west of M5	Very high	Minor beneficial	Large benefit
Leigh Brook Floodplain – downstream of M5	Medium	Major beneficial	Large benefit
Staverton Stream floodplain	Medium	Minor adverse	Slight adverse
B4634	Medium	Moderate Beneficial	Moderate Beneficial

8.10. Cumulative effects

8.10.1. This section considers the cumulative effects of the Scheme and the Scheme interacting with other Reasonably Foreseeable Future Projects (RFFPs) within the road drainage and water environment topic.

8.10.2. The further consideration of cross-topic intra-Scheme and inter-project cumulative effects is reported in Chapter 15 - Cumulative Effects Assessment (application document TR010063/—APP/-6.13).

Intra-Scheme cumulative assessment

8.10.3. The focus of the intra-Scheme CEA is understanding how receptors may experience a number of different types of impacts from the Scheme at the same time. Within the topic assessments, the road drainage and water environment methodology includes some elements that are inherently cumulative and others where there is only a single source of impact. This section considers each element of the assessment in turn, then notes the receptors that feature across different elements of the assessment.

Water quality

8.10.4. Following the DMRB LA 113 ~~standard~~standard for assessment of impacts associated with soluble pollutants, outfalls within 1 km of each other on the same watercourse must be aggregated for the cumulative assessment. In the current scenario there is a single instance where multiple discharges are within 1 km of each other, these are the discharges from the Combined Basin drainage catchment and the S2 drainage catchment. As part of the Scheme's drainage strategy, there are two instances where there are multiple discharges to a receptor within 1 km of each other. These are:

- S1 and S1 South.
- J1 and Combined Basin.

8.10.5. Table 8-22 shows the results of the cumulative assessment. Based on the significance matrix in DMRB LA 104 the significance of effect is Slight adverse. Even though minor beneficial impacts were identified for the individual assessment of the Combined Basin drainage catchment, this benefit could not be proved for the cumulative assessment. This is because according to the DMRB LA 113 standard to achieve a minor beneficial magnitude of impact a comparison needs to be made between the results of the assessment for the current scenario and the Scheme scenario. A cumulative assessment was not undertaken for these two drainage catchments for the current scenario because the outfalls were not within 1 km. However, the outfall location for the Combined Basin drainage catchment moved in the Scheme drainage design, which meant a cumulative assessment was required.

8.10.6. The results show that the cumulative effects are not expected to be any greater than those outlined in Table 8-21 – i.e. no significant adverse cumulative effects on water quality.

Table 8-22 - Intra-scheme cumulative impact on water quality

Scenario	Drainage catchments	Acute impacts from soluble copper – pass or fail	Acute impacts from soluble zinc – pass or fail	Compliance with site specific Environmental Quality Standard (EQS) for copper (compliant or non-compliant)	Compliance with site specific EQS for zinc (compliant or non-compliant)	Chronic impacts from sediment related pollutants – pass or fail	Magnitude of impact	Significance
Current	S2 and Combined Basin	Fail	Fail	Compliant	Compliant	Fail	Moderate adverse	Large adverse
	S1 and M5 south of the River Chelt	Pass	Pass	Compliant	Compliant	N/A	Negligible	Slight adverse
With Scheme	J1 and Combined Basin	Pass	Pass	Compliant	Compliant	Pass	Negligible	Slight adverse
	S1, S1 south and M5 south of the River Chelt	Pass	Pass	Compliant	Compliant	Pass	Negligible	Slight adverse

Hydromorphology

8.10.7. A WFD assessment has been completed which assesses the potential impacts to hydromorphology at a water body scale. This combines all potential impacts to hydromorphology from the Scheme into a single potential impact for each river water body catchment and is therefore inherently cumulative.

8.10.8. The results of the assessment demonstrate that there is likely to be Minor impact on hydromorphology within the River Chelt and the Leigh Brook catchments as a result of the Scheme. This means that there is likely to be low risk of deterioration to Hydromorphological status of the WFD water bodies as a result of the Scheme. Therefore, there is not expected to be any significant cumulative effects on hydromorphology from the Scheme.

Groundwater

8.10.9. In line with the DMRB LA 113, impacts to groundwater are considered at groundwater aquifer scale. As this Scheme lies entirely within a single bedrock aquifer and a single hydrologically connected superficial aquifer, all impacts from the Scheme on groundwater flow and levels have been assessed in combination, following an inherently cumulative methodology. Therefore, the conclusions set out in section 8.9 are also applicable and there are not expected to be any significant cumulative effects on groundwater.

Flood risk

8.10.10. A Flood Risk Assessment (FRA) has been completed that predicts the potential impacts to flood risk to and from the Scheme into a spatially varying impact for the study area. The results of the assessment demonstrate that there is, overall, likely to be a neutral effect (if not beneficial) on flood risk within the River Chelt and the Leigh Brook catchments as a result of the Scheme and there are not expected to be any significant cumulative effects on flood risk.

Combined water environment effects

8.10.11. The methodology for Road Drainage and the Water Environment assessment requires impacts to be reported individually for each receptor on the basis of different categories (i.e. water quality, hydromorphology, groundwater and flood risk), being separate from other aspects. As a result of this approach, different receptors may be noted as experiencing impacts of more than one aspect within this chapter.

8.10.12. Table 8-23 draws together these findings to indicate which receptors have been identified as likely to experience more than one type of impact related to water quality, hydromorphology or groundwater and are therefore considered relevant to the intra-Scheme assessment.

8.10.13. Although the groundwater receptors do not directly align with the receptors for water quality and hydromorphology, there is potential for changes in groundwater levels and quality to also impact on surface water receptors if there is hydrological connectivity. However, as there is likely to be negligible impact on groundwater levels within the study area, there is likely to be negligible impact on any of the surface water (water quality and hydromorphology) receptors in combination to groundwater.

8.10.14. As the River Chelt, Leigh Brook, Drain 8 and Drain ~~15 will~~15 will all receive discharge from the highways drainage design, and will also be impacted by hydromorphology, there is potential for in combination effects. However, these effects are not expected to exceed the significance outlined in Table 8-21. Water quality and hydromorphology are both considered within the WFD assessment for each catchment. The assessment concluded that there was overall likely to be localised adverse impacts on the WFD of each water body which is not considered significant.

8.10.15. There is potential for flood risk to impact on five of the watercourses outlined here. There will be a decrease in flood risk in the Leigh Brook and Drain 22 with all other receptors

seeing variation in flood risk changes as part of the Scheme. Further details can be found in the FRA (Appendix 8.1). As impacts from water quality are most likely to be significant during low flow events rather than high flow, any changes in flood risk are expected to have a negligible impact on the water quality of receptors.

8.10.16. Increased flood flows may also alter hydromorphological processes due to greater erosion and transportation of material. The WFD assessment has outlined the impact to hydromorphology due to changes in peak flows. The assessment concluded that there was overall likely to be localised adverse impacts on the WFD of each water body which is not considered significant.

8.10.17. In summary it is not expected that these cumulative impacts will exceed the significance outlined in Table 8-21. The CEA therefore concludes that the in-combination intra-Scheme effects within the topic are unlikely to be ~~significant..~~significant.

Table 8-23 - Receptors potentially effected by multiple water environment topics

Receptor	Water quality	Hydromorphology	Groundwater	Flood risk
River Chelt	✓	✓	✓	✓
Leigh Brook	✓	✓	✓	✓
Drain 22	-	✓	✓	✓
Drain 12	-	✓	✓	✓
Drain 8	✓	✓	✓	-
Drain 15	✓	✓	✓	✓

Inter-project cumulative assessment

8.10.18. To complete the cumulative effects assessment inter-project 'within topic' element, the road drainage and water environment assessment has been completed with reference to the list of RFFPs that has been developed for the Scheme. The list is based on a review of all developments known to the planning system using the methodology described in Chapter 4 – Environmental Assessment Methodology of the ES (application document TR010063/~~ —~~APP/~~-~~6.2).

8.10.19. The RFFP long-list has been screened to identify projects that are considered to have a realistic prospect of interacting with the Scheme during construction and operation for each of the water environment topics. Table 8-24 outlines the RFFPs screened into this assessment and the relevant water topics to be considered.

8.10.20. The following information was used as part of the screening assessment, which was undertaken using professional judgement.

- If the development was in the River Chelt or Leigh Brook catchments, as these have greatest potential for interaction with Scheme impacts.
- Size of the development area, with a tendency towards focusing on larger and non-domestic projects.
- Distance from a watercourse within those catchments, with a bias towards those closest to watercourses.
- If a development lies within an area at risk of flooding, with a tendency to screen in those at greater risk.
- Type of development and likely associated ~~activities ,~~activities, with a bias towards highways schemes and those with greater potential to involve substantial earthworks and/or impacts to water bodies and overland flow.

Table 8-24 - Developments likely to have potential cumulative impact each water topic

Development	Application reference	Surface water quality	Hydro-morphology	Groundwater	Flood risk
Barns At Hayden Barn Hayden Farm Hayden Lane Boddington Cheltenham Gloucestershire GL51 0SR	19/00937/PDAD		✓	-	✓
A & B Buildings At Pilgrove Farm Pilgrove Farm Old Gloucester Road Boddington Cheltenham Gloucestershire GL51 0SW	19/00907/PDAD	✓	-	-	-
Pilgrove Cottage Old Gloucester Road Cheltenham Gloucestershire GL51 0SW	22/02172/FUL	✓	-	-	-
Warners Of Cheltenham Blaisdon Way Cheltenham Gloucestershire GL51 0WH	20/02132/FUL	✓	✓	-	✓
Gallagher Retail Park Tewkesbury Road Cheltenham Gloucestershire	17/01459/FUL and 17/00827/FUL	✓	-	-	✓
North West Cheltenham Development Area phase 1 (Swindon Farm)	20/00759/FUL Relating to part of the land allocated under Policy A4	✓	✓	-	✓
Land North West Manor Road Runnings Road Cheltenham Gloucestershire	19/01260/OUT	✓	-	-	✓
Gallagher Retail Park Tewkesbury	21/01204/FUL	✓	-	-	-

Development	Application reference	Surface water quality	Hydro-morphology	Groundwater	Flood risk
Road Cheltenham Gloucestershire					
Gallagher Retail Park Tewkesbury Road Cheltenham Gloucestershire	21/02120/FUL	✓	-	-	-
Pigeon House Farm The Green Uckington Cheltenham Gloucestershire GL52 9QB	22/00466/FUL	✓	-	-	✓
Uckington Farm The Green Uckington Cheltenham Gloucestershire GL51 9SR	22/01163/FUL	✓	-	-	✓
Land Known as Evergreen Spiritual Pathways The Green Uckington Cheltenham Gloucester GL51 9SS	22/00164/PIP	✓	-	-	✓
Douglas Equipment Village Road Cheltenham Gloucestershire GL51 0AB	22/00474/FUL	✓	-	-	✓
Safeguarded land to the north-west of Cheltenham	Policy SD5	✓	✓	✓	✓
West Cheltenham Development Area	22/01817/OUT Relating to part of the land allocated under Policy A7	✓	✓	✓	✓
North West Cheltenham Development Area	16/02000/OUT Relating to land allocated under Policy A4	✓	✓	✓	✓
Development land allocated	21/00872/REM Relating to land	✓	-	✓	✓

Development	Application reference	Surface water quality	Hydro-morphology	Groundwater	Flood risk
in Cheltenham Local Plan north of B4634	allocated under Policy HD8				

Water quality

8.10.21. Drainage strategies will be in place or proposed for the developments screened into this assessment due to requirements under the NPPF. The NPPF Paragraph 167 states that local planning authorities should ensure sustainable drainage systems are implemented unless there is clear evidence this would be inappropriate. The implementation of sustainable drainage systems will reduce the impacts of development on water quality in line with local planning policy as outlined in Table 8-1. The appropriate measures will be secured through the planning process which will adhere to the NPPF and local plans. These separate drainage systems will accommodate their own temporary drainage requirements during the construction phases and appropriate mitigation that will ensure no significant impacts to water through construction and operational phases.

8.10.22. Also due to the character of these sites being residential or retail, there are likely to be negligible new sources of pollution during their operation. However, there is potential for increased traffic in the area surrounding the developments which has the potential to have a cumulative impact on water quality.

8.10.23. For the North West Cheltenham Development Area (16/02000/OUT) the Design and Access Statement has been reviewed to understand any potential impacts from the drainage strategy. It was stated that drainage with the scheme will mimic the existing rates of runoff to the surrounding watercourses, therefore ensuring volumes are maintained. It is also stated that SuDS in the form of swales, attenuation basins and soakaways will provide a level of treatment to the rainwater runoff quality to ensure there is no contamination of receiving water bodies. No other publicly available information was available for review in association with other developments within this assessment.

8.10.24. An assessment has been completed to understand the impact of the increased traffic flow caused by the RFFPs relating to the strategic development sites allocated or safeguarded in the JCS on surface water quality. Traffic flows have been modelled for the Scheme and for the Scheme with the strategic development sites in operation. Even though traffic flows are higher for the Scheme with the strategic development site, compared to just the Scheme, the same input data would be used for the routine runoff assessment. This is because the routine runoff assessment requires traffic flow data to be input in bands (>10,000 and <50,000, >=50,000 and <100,000 and >=100,000) and the increase in traffic flows for the Scheme with the strategic development sites did not result in a large enough increase to move into the next band. Therefore, the information outlined within the ES is relevant for the cumulative assessment.

8.10.25. The accidental spillage assessment has been completed with the increased traffic flows associated with the strategic development sites. The results are presented in Table 8-25 and show that the risk is acceptable (i.e. the annual probability of a pollution incident occurring as a result of a spillage is less than 0.01 (1%)). As a result of the mitigation implemented as part of the Scheme, and the requirement for mitigation on the additional developments (due to the NPPF), it is concluded that there should be no significant adverse residual cumulative inter-project effects on water quality during construction or once the Scheme and RFFPs are operational.

Table 8-25 - Results of Inter Scheme cumulative spillage assessment

Drainage catchment	Annual probability of a pollution incident occurring as the result of a spillage	Risk acceptable
J1	0.00005	Yes
Link Road	0.000007	Yes
A4019 main line at Elms Park	0.00011	Yes
Combined basin	0.00016	Yes
S1	0.00435	Yes
S1 south	0.00025	Yes
M5 south of the River Chelt	0.00028	Yes
S2	0.00292	Yes
B-road	0.00008	Yes

Hydromorphology

8.10.26. The main assessment concludes that Leigh Brook is currently of a High importance and experiences a Slight adverse impact from the Scheme, which does not result in a significant adverse effect. The cumulative assessment has highlighted that there is potential for improvements to the Leigh Brook as a result of cumulative impacts of the North West Cheltenham Development Area and safeguarded land to the north-west of Cheltenham developments, in combination with the Scheme.

8.10.27. The Design and Access Statement for the North West Cheltenham Development Area (16/02000/OUT) states that 'The most significant and important site features i.e. water courses, hedgerows and the majority of mature trees are retained and protected as key components within Green Infrastructure' Although, at this stage, there is no design information to determine the cumulative effects, there is likely to be hydromorphological and ecological benefits to the Leigh Brook upstream of the M5 which could result in an overall benefit to the receptor to align with the requirements of the WFD. BNG may be a requirement of the planning for safeguarded land to the north-west of Cheltenham and North West Cheltenham Development Area and should be considered throughout the design stages.

8.10.28. Notwithstanding the above, at this stage, there is uncertainty about the nature and magnitude of any cumulative effects as a result of the Scheme and the North West Cheltenham Development Area and safeguarded land to the north-west of Cheltenham developments acting in combination. This is because the larger of the two RFFPs has yet to secure planning consent and the detailed design proposals are not yet known for the full extent of the land allocated in the JCS. Adopting a precautionary approach, the potential for benefits is noted, but this is not associated with a significant cumulative in-combination residual effect on the Leigh Brook.

8.10.29. There are not expected to be any other significant cumulative effects on hydromorphology as a result of the RFFPs shortlisted for further consideration.

Groundwater

8.10.30. The cumulative groundwater impact assessment has screened in the largest of the RFFPs, comprising the strategic development sites from the JCS. Each of these developments is residential and/or employment led mixed use, meaning that it is unlikely that they would require significant below ground structures or dewatering. Therefore, it is

expected that any impact from these developments in combination with the Scheme on the groundwater receptors will be negligible.

Flood risk

8.10.31. The CEA is underpinned by the assumption that separate FRAs will be in place or proposed by the relevant developers for the RFFPs that have been scoped into the assessment. The strategic development sites represent the largest of the RFFPs and separate mitigation will be required to mitigate any flood risk impacts as a result of these developments, including both loss of floodplain storage and flow conveyance.

8.10.32. For all relevant RFFPs, mitigation will be in line with the ~~NPPF~~NPPF, and it is assumed that for each RFFP, it will ensure no overall increase in flood risk. As a result of these assumptions and taking account of the embedded mitigation for the Scheme, the conclusion is that there will be no significant cumulative additive inter-project effects relating to flood risk as a result of the RFFPs that have been scoped in.

Summary of cumulative effects

8.10.33. In summary, the assessment of cumulative effects has considered intra-Scheme and inter-project impacts. Based on an assessment of the additive and in-combination effects on each receptor and the in-combination effects of all water topics on each receptor, it is expected that there will be no significant cumulative intra-Scheme effects within topic. The assessment of inter-project effects has determined that no significant residual cumulative effects are expected within topic, on the assumption that legislation and guidance is followed for all RFFPs.

8.11. Assumptions and limitations

Surface water quality

8.11.1. Watercourses within the study area have been identified through assessment of Ordnance Survey data and background mapping. However, this data may not highlight all of the small agricultural ditches in the area. Although this may limit the identification of baseline receptors, it is assumed that any watercourses which are not within the Ordnance Survey or background mapping data is likely to be small and of a very low value therefore unlikely to be impacted in any significant manner.

Hydromorphology

8.11.2. The limitations noted for surface water quality are also relevant for hydromorphology.

8.11.3. The watercourse features and processes (outlined in detail within the WFD assessment) may vary with time, seasonality, and high flow events. Site surveys were undertaken under relatively dry conditions, and the overall watercourse function and stability were inferred through professional judgement and the interpretation of features on site.

8.11.4. Some drainage ditches were not seen as part of the PCF Stage 2 or Stage 3 site visits due to land access not being granted or health and safety concerns. Where a site visit was not possible, these watercourses have been characterised through desk study using openly available data and professional judgement.

Groundwater

8.11.5. Assessment of impacts to groundwater have been based on currently available site specific data and online publicly available data. It is not anticipated that any additional monitoring would change the fundamental conceptual understanding of groundwater within the Scheme. The assessment assumes that best practice is followed and all aforementioned embedded mitigations (i.e., core bore piling, piling risk assessments and the safe disposal of water) are adhered to throughout the construction and operation of the Scheme.

Flood risk

8.11.6. This assessment has relied upon the accuracy and level of detail of the new Baseline hydraulic model which has been reviewed and accepted by the Environment Agency. The accuracy of hydraulic modelling is primarily dependent on the quality of hydrological and topographical data, such as LiDAR data. Whilst the baseline model has been calibrated, key factors include the availability of observed flow and flood level data.

8.11.7. The Scheme hydraulic model was reviewed by the Environment Agency in July 2022 and accepted with only minor comments.

8.11.8. The flood modelling undertaken applies a +53% increase in peak flow for 100-years in the future (being 2121). This takes account of the Environment Agency's climate change guidance which is in line with UKCP18.

8.12. Chapter summary

8.12.1. The spatial scope of the assessment has included features of the water environment within 1 km of the Scheme as a minimum.

8.12.2. The assessment has considered the impacts (both construction and operation) on surface water (quality and hydromorphology), groundwater (quality, levels and flows), and flood risk from rivers, surface water and groundwater.

8.12.3. Key water environment receptors within the study area include:

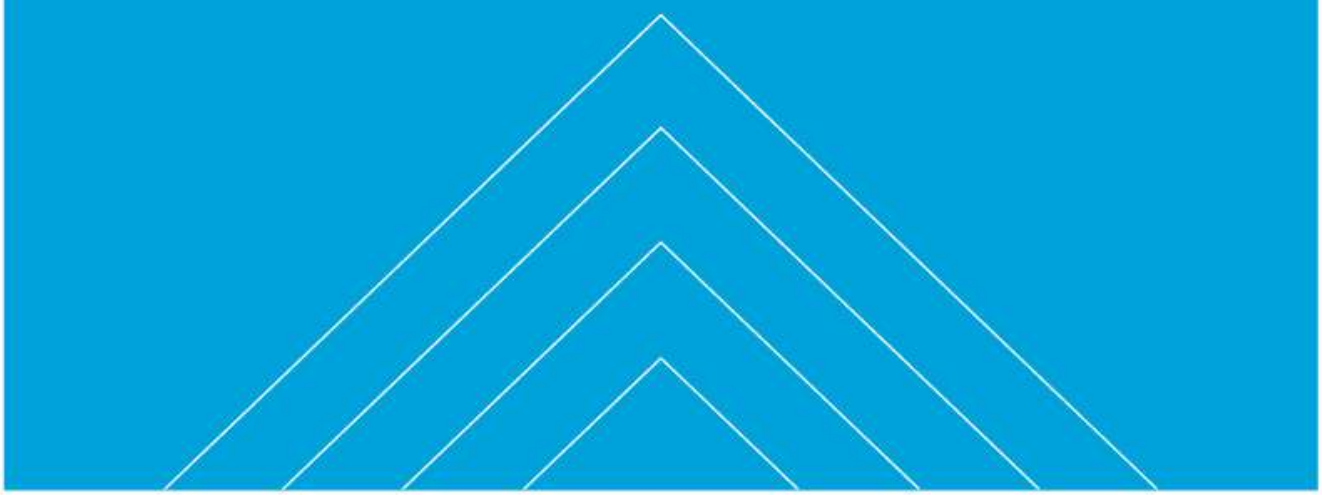
- The River Chelt: a WFD water body and Main River.
- 13 ordinary watercourses including the Leigh Brook.
- Infrastructure and development in Flood Zones 2 and 3 associated with the River Chelt and the Leigh Brook.
- Cheltenham Sand and Gravel Secondary A aquifer.
- Alluvium Secondary A aquifer.
- Rugby Limestone Member Secondary A aquifer.
- Severn Vale - Secondary Combined WFD groundwater body.
- Warwickshire Avon - Secondary Mudrocks WFD groundwater body.

8.12.4. At this stage, there are potential significant adverse effects localised to the River Chelt floodplain on the existing farmland. Those effects are determined to cause no increase in flood risk, although will still see localised adverse impacts (increase in flood depth by 10 mm to 230 mm). The Scheme is consulting with the landowners on the increases in peak flood level, and has included these areas inside the Order limits.

8.12.5. All other impacts have been mitigated so as not to cause any significant effects through the implementation of embedded and essential mitigation which has included updates to the Scheme design along with the implementation of best practice construction activities.

8.12.6. The FRA and WFD compliance assessments (Appendix 8.1 and Appendix 8.2) have been completed based on the same embedded and essential mitigation. The outcomes show that the Scheme is compliant with the requirements of the NPPF and the NPS NN and is compliant with WFD objectives, as demonstrated in the Planning Statement and Schedule of Accordance with National Policy Statement (application document TR010063/APP/7.1).

Appendices



Appendix 8.1 - Flood Risk Assessment

Appendix 8.1 – Flood Risk Assessment is provided as a separate document (application document TR010063 – APP 6.15).

Appendix 8.2 - WFD Compliance Assessment

Appendix 8.2 – WDF Compliance Assessment is provided as a separate document (application document TR010063 – APP 6.15).

Appendix 8.3 - Surface water quality assessment

Appendix 8.3 – Surface Water Quality Assessment is provided as a separate document (application document TR010063 – APP 6.15).

Appendix 8.4 - Road drainage and the water environment chapter figures

Appendix 8.4 – Road drainage and the water environment chapter figures is provided as a separate document (application document TR010063 – APP 6.15).

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