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14 Road Drainage and the Water Environment

14.1 Introduction

14.1.1 This chapter presents the Preliminary Environmental Information (PEI) in relation to the road drainage and the water environment.

14.1.2 The chapter describes the baseline conditions of the existing water environment in the study area and the methodology used to assess potential impacts during the construction and operational phases of the project, before presenting the preliminary results of these assessments and any further mitigation measures or monitoring deemed necessary. It considers the potential effects on the quality and quantity of surface and ground waters, geomorphology and flood risk that may result from construction activities, operational road drainage and accidental spillages.

14.1.3 The methodology used follows the requirements *of Design Manual for Roads and Bridges (DMRB) LA 104 Environmental assessment and monitoring (DMRB LA 104)* (Highways England, 2020a)[1] and *DMRB LA 113 Road drainage and the water environment (DMRB LA 113)* (Highways England, 2020b)[2].

14.1.4 A Water Framework Directive (WFD) compliance assessment, Hydrogeological Impact Assessment (HIA) and Flood Risk Assessment (FRA) will be reported within the Environmental Statement (ES) (and presented as appendices) which will accompany the Development Consent Order (DCO) application.

14.1.5 Associated effects on ecology (including aquatic ecology) are considered in Chapter 6: Biodiversity, although ecological proxy indicators of water quality may be considered in assessment of effects in the Road drainage and the water environment ES Chapter and WFD compliance assessment. Effects on ground conditions and water quality arising from existing land contamination are considered in Chapter 9: Geology and Soils.

14.1.6 The technical reviewer of the surface water components of the PEI Report is a water environment specialist holding an MSc in Catchment Dynamics and Management (University of Leeds) and a PhD in geomorphology and remote sensing (University of Salford). They are a Chartered Water and Environmental Manager (C.WEM), Chartered Scientist (CSci), Chartered Environmentalist (CEnv) and are a Member of the Chartered Institute of Water and Environmental Managers (MCIWEM) and a Fellow of the Royal Geographical Society (FRGS). They are also a Visiting Professor in the Department of Engineering at Newcastle University.

14.1.7 The technical reviewer of the groundwater components of the PEI Report and relevant associated appendices is a specialist in limestone hydrogeology, with 22 years' experience as a hydrogeologist. They hold a PhD in hydrogeology (University of Huddersfield) and an MSc in engineering geology (University of Durham) and are a member of the International Association of Hydrogeologists.

[1] Highways England (2020a) Design Manual for Roads and Bridges LA 104 Environmental assessment and monitoring, available at: https://www.standardsforhighways.co.uk/prod/attachments/0f6e0b6a-d08e-4673-8691-cab564d4a60a?inline=true [accessed 3 September 2021]

[2] Highways England (2020b) Design Manual for Roads and Bridges LA 113 Road Drainage and the Water Environment, available at: https://www.standardsforhighways.co.uk/prod/attachments/d6388f5f-2694-4986-ac46-b17b62c21727?inline=true [accessed 3 September 2021]

14.2 Legislative and Policy Framework

Legislation

14.2.1 The following key legislation is relevation to this assessment:

- Environmental Permitting (England and Wales) (Amendment) (EU Exit) Regulations 2019
- Environment (Amendment etc.) (EU Exit) Regulations 2019
- Environmental Protection Act 1990
- Environment Act 1995
- Environmental Permitting (England and Wales) Regulations 2016
- Water Resources Act 1991
- Water Environment (Water Framework Directive) (England and Wales) Regulations 2017 (WFD)
- Land Drainage Act 1991
- Water Act 2014
- Water Resources (Abstraction and Impounding) Regulations 2006
- Water Abstraction and Impounding (Exemptions) Regulations 2017
- Flood Risk Regulations 2009
- Water Supply (Water Quality) Regulations 2018
- Flood and Water Management Act 2010
- Environmental Damage (Prevention and Remediation) (England) Regulations 2015
- Water Framework Directive (Standards and Classification) Directions (England and Wales) 2015
- Groundwater (Water Framework Directive) (England) Direction 2016
- Conservation of Habitats and Species Regulations 2017 (the 'Habitat Regulations 2017')

National policy statement for national networks

14.2.2 The primary policy basis for deciding whether or not to grant a Development Consent Order (DCO) is the *National Policy Statement for National Networks (NPSNN)* (Department for Transport, 2014)[3], which sets out policies to guide how DCO applications will be decided and how the effects of national networks infrastructure should be considered by the relevant decision maker. The policies for the conservation of the water environment include statements that:

"Infrastructure development can have adverse effects on the water environment, including groundwater, inland surface water, transitional waters and coastal waters. During the construction and operation, it can lead to increased demand for water, involve discharges to water and cause adverse ecological effects resulting from physical modifications to the water environment. There may also be an increased risk of spills and leaks of pollutants to the water environment. These effects could lead to adverse impacts on health or on protected species and habitats…and could, in particular, result in surface waters, groundwaters or protected areas112 failing to meet environmental objectives established under the Water Framework Directive." (NPSNN paragraph 5.219)

[3] Department for Transport (2014) National Policy Statement for National Networks, available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/387222/npsnn-print.pdf [accessed 06 September 2021]

14.2.1 The *NPSNN* also advises:

"Applicants should make early contact with the relevant regulators, including the Environment Agency, for abstraction licensing and with water supply companies likely to supply the water. Where a development is subject to EIA and the development is likely to have significant adverse effects on the water environment, the applicant should ascertain the existing status of, and carry out an assessment of the impacts of the proposed project on water quality, water resources and physical characteristics as part of the environmental statement."

14.2.2 Table 14-1: Relevant NPSNN policies for the road drainage and water environment assessment: Relevant NPSNN policies for the road drainage and water environment assessment methodology,**Error! Reference source not found.** identifies the *NPSNN* policies relevant to the road drainage and water environment assessment methodology.

Table 14-1: Relevant NPSNN policies for the road drainage and water environment assessment methodology

Relevant NPSNN paragraph reference	Requirement of the NPSNN (paraphrase)
4.36 to 4.47	NPSNN sets out the need to take effects of climate change adaption into account, and the impacts of climate change when planning location, design, build and operation should be considered. An environment statement should set out how the scheme will take account of the projected impacts of climate change.
4.48 to 4.56	NPSNN sets out the need for pollution control and other environmental protection regimes, including consenting and licensing regimes. Pollution control involves the prevention of pollution using measures to stop or limit the releases of substances from different sources to the environment to the lowest practicable level. It also ensures that water quality meets standards that guard against the impacts to the receiving environment or human health. It requires that the scheme takes into account the full account of environmental impacts, which may require close cooperation with the Environment Agency and other bodies, to ensure that in the case of pollution events they are satisfied that potential releases can be adequately regulated under the relevant pollution control framework. It also requires that cumulative effects of pollution, including that from existing sources and the scheme are considered.
5.90 to 5.115	*NPSNN* sets out how flood risk impacts should be considered, including that flood risk will not be increased elsewhere and is only appropriate in areas at risk of flooding where it can be demonstrated that: • The most vulnerable development is located in areas of lowest flood risk unless there are overriding reasons to prefer a different location. • Development is appropriately flood resilient and resistant, including safe access and escape routes where required. • Any residual risk can be safely managed, including by emergency planning. • Priority is given to the use of sustainable drainage systems (SuDS).

	The Flood Risk Assessment should: • Consider the risk of all forms of flooding arising from the scheme (including in adjacent parts of the United Kingdom), in addition to the risk of flooding to the scheme, and demonstrate how these risks will be managed and mitigated (where relevant), so that the development remains safe throughout its lifetime. • Consider the impacts of climate change, clearly stating the development lifetime over which the assessment has been made. • Consider the vulnerability of those using the infrastructure, including arrangements for safe access and egress. • Include a residual risk assessment after mitigation measures have considered and demonstrate that they are acceptable for the scheme. • Consider if there is a need to remain operational during a worst-case flood event over the schemes' lifetime. • Provide the evidence for the Secretary of State to apply the Sequential Test and Exception Test, as appropriate.

National planning policy framework (NPPF)

14.2.3 The *NPPF* (Ministry of Housing, Communities and Local Government, 2021)[4] originally published in March 2012 and most recently updated in July 2021, sets out the government's planning policies for England and provides a framework within which locally prepared plans can be produced. The NPPF is "an important and relevant matter to be considered in decision making for NSIP".

Local policy

14.2.4 The following local policies are relevant to the assessment:

- Cumbria County Council - *Local Flood Risk Management Strategy Public Summary* (Cumbria County Council, 2015)[5]
- Cumbria County Council – Flood Risk Regulations 2009 - Preliminary Flood Risk Assessment, Cumbria Area Preliminary Appraisal Report (Cumbria County Council, 2011)[6]
- Cumbria County Council - Cumbria Minerals and Waste Local Plan Strategic Flood Risk Assessment (Cumbria County Council, 2018)[7]

[4] Ministry of Housing, Communities and Local Government (2021) The National Planning Policy Framework, available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1005759/NPPF_July_2021.pdf [accessed 3 September 2021]
[5] Cumbria County Council (2015) Local Flood Risk Management Strategy, available at: https://cumbria.gov.uk/elibrary/Content/Internet/544/3887/5894/4212914848.PDF [accessed 3 September 2021]
[6] Cumbria County Council (2011) Flood Risk Regulations 2009 – Preliminary Flood Risk Assessment: Cumbria Area Preliminary Appraisal Report, available at: https://cumbria.gov.uk/elibrary/Content/Internet/544/3887/6729/43221161446.PDF [accessed 3 September 2021]
[7] Cumbria County Council (2018) Cumbria Minerals and Waste Local Plan Strategic Flood Risk Assessment, available at:

- Cumbria County Council - Cumbria Development Design Guide, (Cumbria County Council, 2017)[8]
- Eden District Council - Eden Local Plan 2014 to 2032 (Eden District Council, 2014)[9]
- Eden District Council - Strategic Flood Risk Assessment, (Eden District Council, 2020)[10]
- Solway Tweed River Basin District Flood Risk Management Plan 2015- 2021 (Environment Agency, 2016)[11]
- Eden District Council - Core Strategy Development Plan Document (Eden District Council, 2010)[12]
- Durham County Council - Local Flood Risk Management Strategy 2016-2020 (Durham County Council, 2017)[13]
- Durham County Council - Sustainable Drainage Systems (SuDS) Adoption Guide (Durham County Council, 2017[14]
- Durham County Council - Preliminary Flood Risk Assessment, (Durham County Council, 2016)[15]
- River Tees CFMP (Environment Agency, 2009)[16]

https://www.cumbria.gov.uk/elibrary/Content/Internet/538/755/1929/43284123739.pdf [accessed 3 September 2021]

[8] Cumbria County Council (2017) Cumbria Development Design Guide, available at: https://cumbria.gov.uk/elibrary/Content/Internet/544/3887/43115144751.PDF [accessed 3 September 2021]

[9] Eden District Council (2014) Eden Local Plan 2014 to 2032, available at: https://www.eden.gov.uk/media/5032/edenlocalplan2014-2032finalwithoutforeword.pdf [accessed 3 September 2021]

[10] Eden District Council (2020) Eden Level 1 Strategic Flood Risk Assessment, available at https://www.eden.gov.uk/media/5918/2018s0424_eden_district_council_sfra_final_report_v30.pdf [accessed 3 September 2021]

[11] Environment Agency (2016) Solway Tweed River Basin District Flood Risk Management Plan 2015- 2021, available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/507132/LIT_10218_SOLWAY_TWEED_FRMP_PART_B.pdf [accessed 3 September 2021]

[12] Eden District Council (2010) Core Strategy Development Plan Document Joint Core Strategy, available at https://www.eden.gov.uk/media/5551/core-strategy-dpd-final.pdf [accessed 3 September 2021]

[13] Durham County Council (2017) Local Flood Risk Management Strategy 2016-2020, available at: https://www.durham.gov.uk/media/20637/Local-Flood-Risk-Management-Strategy/pdf/LocalFloodRiskManagementStrategy.pdf?m=636735625812300000 [accessed 3 September 2021]

[14] Durham County Council (2017) Sustainable Drainage Systems (SuDS) Adoption Guide 2016, available at: https://www.durham.gov.uk/media/9133/Sustainable-Drainage-System-Adoption-Guidance-2016/pdf/SustainableDrainageSystemAdoptionGuidance2016.pdf?m=636735630462400000 [accessed 3 September 2021]

[15] Durham County Council (2016) Preliminary Flood Risk Assessment, available at: https://www.durham.gov.uk/media/9944/Preliminary-Flood-Risk-Assessment-2016/pdf/PreliminaryFloodRisk_AssessmentReport2016.pdf?m=636735630447370000 [accessed 3 September 2021]

[16] Environment Agency (2009) Tees Catchment Flood Management Plan, available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/289194/River_Tees_Catchment_Flood_Management_Plan.pdf [accessed 3 September 2021]

- North Yorkshire County Council - SuDS Design Guidance (North Yorkshire County Council, 2018)[17]
- North Yorkshire County Council, City of York Council, and the North York Moors National Park Authority - Strategic Flood Risk Assessment (Level 1), 2017[18]
- North Yorkshire County Council Preliminary Flood Risk Assessment, (North Yorkshire County Council, 2011)[19]
- North Yorkshire County Council - Preliminary Flood Risk Assessment (addendum), (North Yorkshire County Council, 2017)[20]
- The Richmondshire Local Plan (2012 – 2028) (Richmondshire District Council, 2014)[21]
- Wear CFMP (Environment Agency, 2009)[22]
- North West Yorkshire Level 1 Strategic Flood Risk Assessment Update, (JBA, 2010)[23]
- North Pennines Area of Outstanding Natural Beauty (AONB) Management Plan 2019-24 (North Pennines AONB Partners, 2018)[24]

Standards and guidance

- Planning practice guidance (Ministry of housing, communities and local government, 2018)[25]
- *DMRB LA 104*
- *DMRB LA 113*

[17] North Yorkshire County Council (2018) SuDS Design Guidance 2018 Update, available at: https://www.northyorks.gov.uk/sites/default/files/fileroot/Environment%20and%20waste/Flooding/NYCC%20SuDS%20Design%20Guidance%202018%20Update.pdf [accessed 3 September 2021]
[18] North Yorkshire County Council, City of York Council and the North York Moors National Park Authority (2017) Strategic Flood Risk Assessment (Level 1), available at: https://www.northyorkmoors.org.uk/planning/framework/evidence-base/FINAL-NYM-SFRA-NOV-20171.pdf [accessed 3 September 2021]
[19] North Yorkshire County Council (2011) Preliminary Flood Risk Assessment, available at: https://webarchive.nationalarchives.gov.uk/ukgwa/20140328094437/http:/www.environment-agency.gov.uk/research/planning/135526.aspx [accessed 3 September 2021]
[20] North Yorkshire County Council (2017) Preliminary Flood Risk Assessment (addendum), available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/698270/PFRA_North_Yorkshire_County_Council__2017.pdf [accessed 3 September 2021]
[21] Richmondshire District Council (2014) Richmondshire Local Plan 2012-2028: Core Strategy, available at: https://www.richmondshire.gov.uk/media/9616/core-strategy-2012-28.pdf [accessed 3 September 2021]
[22] Environment Agency (2009) Wear Catchment Flood Management Plan, available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/289186/River_Wear_Catchment_Flood_Management_Plan.pdf [accessed 3 September 2021]
[23] JBA Consulting (2010) North West Yorkshire Level 1 Strategic Flood Risk Assessment Update, available at: https://www.richmondshire.gov.uk/media/8255/north-west-yorkshire-level-1-sfra-update.pdf [accessed 3 September 2021]
[24] North Pennines AONB Partners (2018) North Pennines Area of Outstanding Natural Beauty Management Plan 2019-24, available at: https://www.northpennines.org.uk/wp-content/uploads/2019/06/MPlan-220719-webres.pdf [acessed 3 September 2021]
[25] Ministry of Housing, Communities and Local Government (2018) Planning practice guidance, available at: https://www.gov.uk/government/collections/planning-practice-guidance [accessed 3 September 2021]

- Cycle 2 river basin management plans (RBMPs) 2015-2021 - The project spans the boundary between three River Basin Districts (RBDs), the Solway Tweed, the Northumbria, and the Humber.
- Flood risk management plans (FRMPs) 2015-2021

14.3 Assessment Methodology

14.3.1 The assessment within the ES will follow the requirements of *DMRB LA 104* and *DMRB LA 113*. These provide a methodology and criteria for assessing the impact of a proposed road scheme on the water environment.

14.3.2 The methodology for assessing effects is based on the principle that the environmental effects of the scheme, in relation to surface water and groundwater receptors, should be determined by the following steps:

- Definition of a study area (as defined in section 14.5).
- Identification of potential receptors within the study area to form baseline conditions, as per Table 3.69 of *DMRB LA 113*.
- Assessment of the potential importance (referred to as value within *DMRB LA 104* and importance within this report) and sensitivity of each of these receptors, as per Table 3.70 of *DMRB LA 113.* Further information and preliminary importance values are presented in in Appendix 14.1: Preliminary Assessment of Receptor Importance.
- Assessment of the potential magnitude of any construction or operation impact on the receptor, as per Table 3.71 of *DMRB LA 113*.
- Assessment of the overall significance of any effects on receptors due to impacts, as per Table 3.8.1 of *DMRB LA 104*. The significance of effect is determined by a combination of the identified importance/sensitivity of the receptor with the estimated magnitude of the effect, considering embedded and essential mitigation. For the purpose of this assessment, values of moderate and above will be defined as likely significant effects.

Construction impacts

14.3.3 *DMRB LA 113* recommends that an assessment of construction impacts should use the advice given in Construction Industry Research and Information Association (CIRIA) Report C648 *Control of Water Pollution from Linear Construction Projects*[26] on potential impacts arising during the construction phase and the assessment and mitigation of these risks.

14.3.4 The potential impacts of construction on surface water or sediment runoff, water quality, flood risk and groundwater quality or level have been assessed based on the proposed construction methods and sequencing. Where construction methods have not been available, standard construction practices have been assumed. Cumulative impacts as a result of construction phasing have also been assessed.

14.3.5 Outline measures to reduce construction impacts will be included in the Environmental Management Plan (EMP). An outline of what will be included in the EMP is presented in Appendix 4.1: Outline of Environmental Management Plan. These measures will be secured by the DCO application through the imposition of a requirement and these measures are therefore relied on for the purposes of this assessment. For the purposes of the impact assessment it is assumed that they will be implemented correctly. These measures will also be reported in the Register of

[26] CIRIA (2006) Control of Water Pollution from Linear Construction Projects (C648)

Environmental Actions and Commitments (REAC) in the EMP, to be submitted with the ES as part of the DCO application.The potential impacts of construction on hydrogeology will be evaluated as part of a Hydrogeological Impact Assessment (HIA), by consideration of the proposed construction activities in the context of a baseline conceptual model of the hydrogeological regime. The HIA will be prepared as an appendix to the Road Drainage and the Water Environment ES chapter and will be submitted as part of the DCO application.

Operational impacts

14.3.6 The assessment of potential impacts during operation will cover the following key aspects of the water environment:

- Surface water quality and routine runoff using Highways England Water Risk Assessment Tool (HEWRAT)
- Groundwater levels and flow (Appendix A of *DMRB LA 113*)
- Groundwater dependant terrestrial ecosystems (Appendix B of *DMRB LA 113*)
- Groundwater quality and run off (Appendix C of *DMRB LA 113*)
- Spillage assessment (Appendix D of *DMRB LA 113*)
- Hydro-morphological assessment (Appendix E of *DMRB LA 113*)

14.3.7 The project has the potential to result in potential direct adverse effects on surface water and groundwater bodies classified under the WFD. Therefore, a WFD assessment will be undertaken to the appropriate level, in accordance with Environment Agency guidance (Environment Agency, 2017)[27] to determine whether the risk is acceptable. The WFD assessment will be informed by the additional assessments outlined in *DMRB LA 113*.

14.3.8 Flood risk is assessed in the PEI Report using the Environment Agency flood risk maps, details are given in Section 14.6.2, enabling sensitive areas to be identified across the schemes.

14.3.9 A standalone FRA will be prepared to support the Environmental Impact assessment (EIA). It will assess potential impacts to the project and to people and property elsewhere associated with flood risk from pluvial, fluvial, and groundwater flooding in accordance with NPPF. The FRA will include a quantitative assessment of flood risk for the scheme, including hydraulic modelling. The FRA will be informed by consultation with the Environment Agency, relevant Lead Local Flood Authorities (LLFAs) and available published flood data. It will use the latest available climate change data.

14.3.10 Detailed assessment of the geomorphology of the watercourses within the Temple Sowerby to Appleby and Appleby to Brough schemes and their associated floodplains is planned to inform the Habitats Regulations Assessment (to be submitted with the DCO application), Hydromorphology Assessment and the WFD Compliance Assessment (both to be presented as an appendices to the Road drainage and the water environment ES Chapter). This is due to both schemes directly interacting with the River Eden Special Area of Conservation (SAC) or functionally linked habitat associated with the receptor.

Consultation

[27] Environment Agency (2017) Water Framework Directive assessment for a flood risk activity, available at: https://www.gov.uk/government/publications/water-framework-directive-how-to-assess-the-risk-of-your-activity [accessed 3 September 2021]

14.3.11 Stakeholder consultation is a key part of the assessment process. Key stakeholders for the water environment, including the Environment Agency, Natural England and the various Local Authorities (LA) have been consulted throughout the project development process. During the current preliminary design and environmental assessment phase, a water environment focussed Technical Working Group (TWG) has been established involving these organisations, through which baseline evidence, the emerging design, assessment methodology and initial assessment findings have been shared, discussed and feedback received. Other stakeholders have also been engaged through the project Focus Groups and via the scoping opinion process.

14.3.12 In addition to the TWG, Focus Groups and scoping opinion, a number of stakeholders have been consulted to gather baseline data and inform the assessment.

14.3.13 Stakeholder engagement is ongoing and will continue to the DCO application submission. This will include the TWG and Focus Groups, along with specific consultation with regulatory bodies, LLFA and water companies.

14.4 Assessment Assumptions and Limitations

14.4.1 For the assessment of construction impacts, where construction methods and sequencing are not available, current standard construction practices are assumed. For the assessment of operational impacts, the assessment is based on the design as it currently stands – aspects that are still evolving (such as drainage design) will be assessed in full within the ES.

14.4.2 Ongoing data collection will enhance understanding of current and future conditions within the study area, this will be encorporated into the ES. Every effort has been made to ensure that the existing data used for the PEI Report present an accurate interpretation of the water environmental baseline and the interactions between surface water and groundwater.

14.4.3 Assessment of the groundwater aspects of the project is being carried out in accordance with the *DMRB LA 113* standard and Environment Agency guidance for dewatering abstractions (*SC040020/SR1*) and groundwater abstractions (*SC040020/SR2*).

14.4.4 The final environmental design may be amended during detailed design prior to construction. However, the assessment of potential effects has taken account of the 'worst case' scenarios, i.e. one that is precautionary, but it is reasonable to assume could occur, rather than an extreme scenario that is unlikely, and mitigation measures are included within the project design for this preliminary assessment accordingly.

14.4.5 The findings presented in this chapter represent those available at the time of writing and data collected to that point. This will be fully updated in the ES.

14.4.6 Further topic-specific limitations and assumptions associated with the project are discussed in the following sections.

Surface water

14.4.7 The baseline conditions have been derived from both desk-based and field studies. Additional data collection is ongoing.

14.4.8 Approximate Q^{95} value ranges have been assumed based on the nearest available flow monitoring points on the National River Flow Archive for the PEI Report. It is assumed that for small and unnamed tributaries, where flow monitoring data is not

available, Q^{95} ranges are assumed to be ≤0.001m^3/s. These values will be updated using LowFlows data within the ES and it's appendices.

14.4.9 The Environment Agency has provided a hydraulic model of the Hayber Beck and Moor Beck to the north of Warcop which includes several tributaries of the River Eden. The model will be further developed to assess the scheme and results will be reported within the ES Chapter.

Groundwater

14.4.10 The understanding of the hydrogeological regime of the project and its study area is currently limited to desk study data and initial water features surveys (undertaken in October 2020 and March 2021). Additional water feature surveys are to be conducted and GI information is not yet available. As additional information is received the conceptual models and assessment will be refined and tailored based on ground conditions encountered and existing information.

14.4.11 Analytical and two-dimensional conceptual models will be developed for key assessment areas, which will be tailored for structural and geotechnical design assessments, following the standard set out in Appendix A *Groundwater levels and flow* of *DMRB LA 113*.

14.4.12 The *DMRB LA 113 Appendix C Groundwater quality and run off* assessments shall be undertaken as part of the ES process and shall be completed following the PEI Report stage.

Existing road drainage and outfalls

14.4.13 Highways England's *Drainage Data Management System (HADDMS)* (Highways England, 2021)[28] information has been used to inform baseline drainage information relating to existing assets. Information within HADDMS is known to be incomplete across the schemes. For this chapter, this information is assumed to be complete as it is the only data set currently available as these features have not yet been verified. Efforts will be made to identify and verify existing assets to inform the ES.

14.5 Study Area

14.5.1 The study area will include surface water and groundwater features within a 1km radius of the draft DCO boundary and is based on the 'source-pathway-receptor' pollutant linkage principle. The 1km buffer was selected based on professional judgement of the potential impacts posed by the project and is in line with assessments for other highways schemes.

14.5.2 Extension of the study area beyond the 1km buffer may be necessary to capture potential impacts to receptors beyond the standard study area. This may be important where the project is likely to impact surface water receptors upstream and downstream of the study area or groundwater receptors where there is hydraulic connectivity. A risk-based approach will be taken to the extension of the study area based on assessment of impact pathways and this will be kept under review as understanding of interactions evolves.

14.5.3 For surface waters, the study area includes the geographical extent of the full scope of the works for each scheme alignment option and all surface water features, including main rivers and their tributaries, ordinary watercourses, surface water

[28] Highways England (2021) Highways England's Drainage Data Management System, available at: http://haddms.com/ [accessed 3 September 2021]

abstractions and flood zones within 1km of these options, where features have hydrological connectivity to the project.

14.5.4 For groundwater, the study area includes the geographical extent of the full scope of the works for each scheme of works and all groundwater features which include underlying aquifers, source protection zones, springs, groundwater abstractions and groundwater dependant terrestrial ecosystems (GWDTEs) within 1km of the project.

14.5.5 The alternative alignment sections for Appleby to Brough and the alternative junction arrangements for Cross Lanes to Rokeby (as described in Chaper 2: The Project) have been assessed as additional alternative alignments for the respective schemes. For these schemes, the study area comprises a combined study area of 1km from the furthest extent of all draft DCO boundaries. Figure 14.1: Surface Water Features, shows the study area for Appleby to Brough and Cross Lanes to Rokeby as a singular study area for the respective scheme that encompases all alternative alignment variants.

14.6 Baseline Conditions

Current baseline

Baseline methodology

14.6.1 The baseline describes the existing condition of surface waters, groundwater and flood risk within the study area. The value of each water feature identified has been determined based on the attributes and indicators of quality listed in Table 3.69 of *DMRB LA 113*, and is detailed in Appendix 14.1: Preliminary Assessment of Receptor Importance

14.6.2 The following data sources were used to compile the baseline conditions:

- Observations from site walkover surveys
- Environment Agency Catchment Data Explorer (Environment Agency, 2019a)[29]
- River Basin Management Plans
- Existing highway drainage plans
- National River Flow Archive (Centre for Ecology and Hydrology, 2019)[30]
- Natural England, Multi-Agency Geographic Information for the Countryside (MAGIC) (Department for Environment, Food and Rural Affairs, 2019)[31]
- Ordnance Survey (OS) mapping (including topography)
- British Geological Survey (BGS) mapping (Bristish Geological Survey, 2019)[32]
- Environment Agency *Pluvial flood risk mapping* (Gov.uk, 2019a)[33]
- Environment Agency *Fluvial flood risk mapping* (Gov.uk, 2019b)[34]

[29] Environment Agency (2019a) Catchment Data Explorer, available at: http://environment.data.gov.uk/catchment-planning/ [accessed 3 September 2021]
[30] Centre for Ecology and Hydrology (2019) National River Flow Archive, available at: http://nrfa.ceh.ac.uk/data/station/meanflow/64001 [accessed 3 September 2021]
[31] Department for Environment, Food and Rural Affairs (2019). MAGIC, Interactive mapping at your fingertips, available at: http://www.magic.gov.uk/ [accessed 3 September 2021]
[32] British Geological Survey (2019) Geology of Britain viewer, available at: http://mapapps.bgs.ac.uk/geologyofbritain/home.html [accessed 3 September 2021]
[33] GOV.uk (2019a) Flood map for planning, available at: https://flood-warning-information.service.gov.uk/long-term-flood-risk/map?easting=379438&northing=514304&map=SurfaceWater [accessed 3 September 2021]
[34] GOV.uk (2019b) Flood map for planning, available at: https://flood-warning-information.service.gov.uk/long-term-flood-risk/map?easting=379438&northing=514304&map=RiversOrSea [accessed 3 September 2021]

- Environment Agency *Historic Flood Map* (Gov.uk, 2021)[35]
- Environment Agency *Water Quality Archive* (Environment Aency, 2019b)[36]
- Highways England's *Drainage Data Management System (HADDMS)* (Highways England, 2021)[37]

Site investigations and surveys

Walkover surveys

14.6.3 Walkover surveys of the study area were undertaken between 19 October 2020 and 22 October 2020 and between 14 June 2021 to 18 June 2021. The visits focused on building knowledge of surface water, spring and groundwater features to gain a good overall understanding of the hydrological and hydrogeological regime of the study area. Further site walkover surveys will be conducted to inform the ES and relevant appendices.

14.6.4 The weather conditions for the visits varied and different conditions in the water environment were evident, with days with low levels of precipitation having low flows and levels in watercourses, and days with higher levels of precipitation resulting in watercourses having higher levels and flows.

14.6.5 Site investigations are included as part of the ground investigation programme, which is due to commence in autumn 2021. The ground investigation includes exploratory boreholes with completion as stand pipes and piezometers as well as surface geophysics. Following the ground investigation groundwater levels will be monitored for a minimum period of 12 months.

14.6.6 In order to determine risk to small private water wells the conceptual model developed for each scheme shall be used to determine the groundwater regime. On the basis of each conceptual model those areas hydraulically down gradient of the road shall be considered at risk from potential construction water quality impacts. Those areas where drawdown of groundwater levels is anticipated shall be identified as areas where there is risk of groundwater lowering. It will assumed that every property in these areas has a private water supply.

Route wide

Designated sites

14.6.7 The following statutory designated sites identified within within the route wide study area:

- River Eden SAC (Natural England, 2019a)[38]
- The North Pennine Moors SAC (Joint Nature Conservation Committee, 2021)[39]

[35] GOV.uk (2021) Historic Flood Map data download, available at: https://data.gov.uk/dataset/76292bec-7d8b-43e8-9c98-02734fd89c81/historic-flood-map [accessed 3 September 2021]
[36] Environment Agency (2019b) Water Quality Archive, available at: https://environment.data.gov.uk/water-quality/view/sampling-point/TH-PUTE0282 [accessed 3 September 2021]
[37] Highways England (2021) Highways England's Drainage Data Management System, available at: http://haddms.com/ [accessed 3 September 2021]
[38] Natural England (2019) River Eden Special Area of Conservation (SAC) Site Code: UK0012643, available at: http://publications.naturalengland.org.uk/file/6608403158007808 [accessed 3 September 2021]
[39] Joint Nature Conservation Committee (2021) North Pennine Moors, available at: https://sac.jncc.gov.uk/site/UK0030033 [sccessed 3 September 2021]

- The North Pennine Moors Special Protection Area (SPA) (Natural England, 1997)[40]
- River Eden and Tributaries Site of Special Scientific Interest (SSSI) (Natural England, 1997b)[41].
- Temple Sowerby Moss SSSI (Natural England, 1985)[42].
- Bowes Moor SSSI (Natural England)[43]
- Kilmond Scar SSSI (Natural England)[44]

14.6.8 Proximity to designated and non-designated sites is provided and further details of the designated features relating to respective designated sites are provided within Chapter 6: Biodiversity.

Surface water

14.6.9 The project crosses between three surface water management catchments, the Solway Tweed to the west of the Penines and the Tees to the east, and the eastern section crosses into Swale Ure Nidd and Ouse Upper.

14.6.10 In addition to the watercourses described in the following sections, a number of smaller drains are present across the study areas, which drain into the watercourses.

Groundwater

14.6.11 The hydrogeology in the route wide study area comprises of superficial deposits that overlie bedrock. Full details of geological stratigraphy in the study area are presented in Chapter 9: Geology and Soils.

14.6.12 Regional aspects of the hydrogeology that underly the schemes, including the aquifer units and WFD groundwater bodies, are described here as route wide. Those site specific features, such as groundwater surface water interactions (surface water baseflow contribution, springs, sinks and GWDTE) as well as licensed abstractions, are described below for each individual scheme. For small private abstractions (less than 20m^3/d), it is assumed route wide that each property may have an existing supply. Those properties potentiqally at risk from construction (hydraulically downgradient of the schemes or 200m upgradient) will be identified at ES stage and at that stage risk assessd on a scheme by scheme basis.

Superficial aquifers

14.6.13 The stratigraphy of the Till superficial deposits may be complex, with interdigitations of sand, gravel, silt and clay which may each develop their own piezometric level, resulting in perched water tables. Till is designated as a Secondary undifferentiated aquifer.

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[40] Natural England (2019) North Pennine Moors Special Protection Area (SPA) Site code: UK9006272, available at: http://publications.naturalengland.org.uk/file/4804702013489152 [accessed 3 September 2021]
[41] Natural England (1997) River Eden and Tributaries SSSI, available at: https://designatedsites.naturalengland.org.uk/PDFsForWeb/Citation/2000215.pdf [accessed 3 September 2021]
[42] Natural England (1985). Temple Sowerby Moss SSSI, available at https://designatedsites.naturalengland.org.uk/PDFsForWeb/Citation/1002571.pdf [accessed 3 September 2021]
[43] Natural England (undated) Designated Sites: Bowes Moor, available at: https://designatedsites.naturalengland.org.uk/PDFsForWeb/Citation/1001397.pdf [accessed 3 September 2021]
[44] Natural England (undated) Designated Sites: Kilmond Scar, available at: https://designatedsites.naturalengland.org.uk/PDFsForWeb/Citation/1000376.pdf [accessed 3 September 2021]

14.6.14 Alluvium and River Terrace deposits associated are present route wide, associated with main rivers. These deposits both comprise a mixture of sand, silt and clay. Glaciofluvial deposits, comprising sand and gravel, are present in discrete areas mostly on the northern side of the River Eamont alluvium and are all designated as Secondary A aquifers.

14.6.15 Groundwater flow through the superficial deposit aquifer is dominated by intergranular flow. The variable nature of the material may allow for perching of groundwater within coarse grained zones above the local groundwater table. The superficial deposits are unconfined however clays may cause some local confinement of water bearing, coarse grained lenses.

14.6.16 Locally the superficial deposits may confine the underlying bedrock aquifer and lead reduce the quantity of recharge that may occur.

Bedrock aquifers

14.6.17 The bedrock geology comprises of Carboniferous age sandstones, siltstones, mudstones, limestones and some coals west of Penrith and from Brough to the A1. The main western section from Penrith to Brough comprises of Permian aged, sandstones and shales.

14.6.18 The Carboniferous strata comprises of the Stainmore Formation (mudstone, siltstone and sandstone), the Great Limestone Member (limestone), the Alston Formation (limestone, sandstone, siltstone and mudstone) and Four Fathom Limestone Member (limestone). These carboniferous strata are designated by the Environment Agency as being Secondary A aquifers. Locally, the limestone members include karst landforms and can include dissolutionlly enhanced groundwater pathways, including, fracture flow, conduits and caves.

14.6.19 Groundwater flow through the limestones is dominated by secondary (fracture) porosity pathways and tertiary (karstic) porosity features, so the aquifer may locally have a high permeability but overall have low storage capacity. Fracture flow through rock defects like joints and bedding planes is expected to be the main way groundwater will flow within sandstone units. Compared to the limestone, sandstone is likely to have a lower hydraulic conductivity, but greater storage capacity.

14.6.20 Limestones which are thicker and more fractured (Great Limestone Member) are expected to have higher hydraulic conductivity in comparison to thinner and less fractured units (Four Fathom Limestone Member). The density and size of fractures often decreases rapidly the deeper into the aquifer, these effects can be observered at depths of 50m to 80m and deeper.

14.6.21 Borehole yields are highly variable, within Carboniferous Limestones in the Northern Pennines, a range from 240m^3/d to 1,920m^3/d have been observed. There are also cases of dry boreholes with no yield. It is expected the hydraulic conductivity of the aquifer in the study area is also highly variable.

14.6.22 The Permian strata comprises of the Penrith Sandstone Formation and the Eden Shales Formation, which is designated as a Principal Aquifer. The Penrith Sandstone Formation is designated as a Principle aquifer, whilst the Eden Shale Formation is designated as Secondary B aquifer. Parts of the Eden Shale Formation have gypsum and anhydrite beds, which are designated as unproductive.

14.6.23 The Penrith Sandstone Formation is highly permeable with high intergranular flow occuring except in areas where significant silica cementation has occurred. Silicified layers occur within the Penrith Sandstone Formation throughout the study area. These areas of silification planes are in the form of join infillings or bedding-paralelle

horizons. These may act as barriers to flow The Penrith Sandstone aquifer is regionally significant and is widely used for industry, public supply and small farms. Large quantities of groundwater for public supply are obtained from the aquifer.

14.6.24 The Penrith Sandstone Formation exhibits a dual permeability comprising of intergranular matrix flow as well as fracture flow. Allen *et al* 1997 presents hydraulic conductivity of the Penrith Sandstone to the range from $3x10^{-4}$m/s to $4x10^{-10}$m/s, based on a compilation of laboratory testing of intergranular permeability and insitu pumping and packer tests. Allen refers to the importance of both grain size and cementation in relation to the variation in intergranular permeability. Established large diameter boreholes within the Penrith Sandstone in the Vale of Eden typically yield up to 3,000m^3/d.

Groundwater WFD catchments

14.6.25 The superficial deposit aquifers are not specifically designated as WFD groundwater bodies. However, it is anticipated they are hydraulically connected to the relevant underlying designated bedrock aquifer WFD groundwater bodies, and as such they are inherantly included with the underlying bedrock groundwater bodies.

14.6.26 The route wide study area is located within the Solway Tweed river basin district, the Northumbria river basin district and the Humber river basin district.

14.6.27 The Solway Tweed river basin district includes two WFD groundwater bodies within the study area: the Eden and Esk Lower Palaeozoic and Carboniferous Aquifer and the Eden Valley and Carlise Permo-Triassic ssandstone Aquifers. The boundary between the WFD groundwater bodies runs in a north-west to south-east direction between the M6 and the A6, generally following the geological divide between the Permo-Triassic bedrock to the east and the Carboniferous bedrock to the west. These Groundwater bodies have ‘Good’ quantitative status but ‘Poor’ current chemical status. The ‘current overal status (2019)’ of these groundwater bodies is ‘Poor’.

14.6.28 The Northumbria river basin district inludes one WFD groundwater body: the Tees Carb Limestone and Millstone Grit. The current overall status (2019) for the Tees Carb Limestone and Millstone Grit is ‘poor’, due to achieving ‘good’ Quantitative but ‘poor’ Chemical WFD status.

14.6.29 The Humber river basin district includes one WFD groundwater body: the SUNO Millstone Grit and Carboniferous Limestone. The current overall status (2019) for the SUNO Millstone Grit and Carboniferous Limestone is ‘poor’, due to achieving ‘good’ Quantitative but ‘poor’ Chemical WFD status.

Groundwater levels

14.6.30 Groundwater monitoring levels are not available within the route wide study area. Monitoring data from the ground investigation programme will be included in the ES.

14.6.31 Groundwater flow will drain towards the the main river, which will receive groundwater contribution as baseflow. Groundwater levels will fluctuate seasonally being highest between January and March and lowest between June and September.

14.6.32 Groundwater contained in alluvium deposits will be hydraulically connected with river and the underlying bedrock geology, this is particularly the case with the Penrith Sandstone Formation, which is assumed to have complete continutinity between bedrock, superficials and river.

Abstractions

14.6.33 There are likely to be a number of small private domestic and agricultural supplies within the route wide study area. These wells are assumed to abstract less than

20m^3/d and as such be under the daily abstraction rate by which a licence is required. It is assumed that each property has the potential to include a small private groundwater supply.

Flood risk

Fluvial flooding

14.6.34 Sections within the route wide study area are indicated on Environment Agency mapping to be at risk of fluvial flooding (from rivers or the sea). Due to the difference in elevation between the study area and the coast, flood risk in the study area is not considered to be from the sea.

Pluvial flooding

14.6.35 Sections within the route wide study area are indicated on Environment Agency mapping to be at risk of pluvial flooding (from rainfall and surface water sources). The mapping does not distinguish between areas at risk of flooding purely from surface water runoff (specifically during heavy rainfall events) and areas at risk from small watercourses that are too small to be included on fluvial flood risk mapping.

Groundwater flooding

14.6.36 The BGS Groundwater Flooding map indicates there is the potential for clearwater flooding and flooding from superficial deposits within the route wide study area. Clearwater groundwater flooding refers to groundwater levels rising in an unconfined bedrock aquifer in response to recharge higher in the catchment.

Existing road drainage and outfalls

14.6.37 HADDMS identifies a number of exisiting assests within the route wide study area. Information within HADDMS is known to be incomplete and the status of these is currently undertermined. Efforts will be made to identify and verify existing assets to inform the ES.

M6 Junction 40 to Kemplay Bank

Designated sites

14.6.38 The River Eamont, a tributary to the River Eden, is located within the study area, and flows parallel to the existing A66. The River Eamont is designated within the River Eden SAC and River Eden and Tributaries SSSI.

Surface water

14.6.39 A number of watercourses flow through the study area. All eventually flow into the River Eamont to the south west of the existing A66.

14.6.40 Most of the watercourses in the study area drain from agricultural lands north and west of Penrith and flow through urban landscapes with modification such as culverts in place. Exceptions are the River Eamont, that drains from Ullswater situated south west of the study area, and the River Lowther which drains from the south west of Shap, outside of the study area.

14.6.41 The watercourses designated as Main Rivers by the Environment Agency within the study area include the River Lowther and River Eamont. Table 14-2: Watercourses within M6 Junction 40 to Kemplay Bank study area, gives a brief description of the watercourses within the study area (from west to east) and they are displayed on Figure 14.1: Surface Water Features.

Table 14-2: Watercourses within M6 Junction 40 to Kemplay Bank study area

Watercourse	Description
Carlsike Beck	Flows south into the River Eamont, crossed by the existing A66/A592 roundabout, in the west of the study area.
Myers Beck	Flows east into Dog Beck, crossed by the existing M6, and then culverted under the railway and housing within Penrith, in the north west of the study area.
Dog Beck	Flows east into Thacka Beck, culverted through Penrith beneath Victoria road, in the north of the study area.
Thacka Beck	Flows south into the River Eamont, through Penrith and is crossed by the existing A66 and then culverted beneath Carlton Hall, in the centre of the study area
Unnamed Tributary of River Eamont 3.2	Flows east into the River Eamont, straightened channel through Frenchfield sports centre, in the east of the study area
River Eamont	Flows east, crossed by the existing M6, and flows parallel, to the south of the existing A66. Joins the River Lowther to the east of the study area, then joins the River Eden approximately 7km further downstream.
River Lowther	Flows east, located parallel, to the south of the River Eamont. Joins the River Eamont at Brougham Castle 250m upstream of the existing A66 crossing.

Surface water WFD catchments

14.6.42 River Eamont Upper (GB102076071020) WFD surface waterbody catchment underlies the majority of the study area. This waterbody is associated with a ‘Good’ Ecological and ‘Fail’ Chemical WFD status, resulting in a ‘Moderate’ overall status in 2019. The Environment Agency do not give a Reason for Not Achieving Good (RNAG) for this catchment.

14.6.43 The Lowther (Lower) (GB102076071010) WFD catchment, to the south of the study area is associated with a ‘Moderate’ ecological and ‘Fail’ chemical WFD status, resulting in a ‘Moderate’ overall status in 2019. The river is classified as ‘Heavily Modifed’ which impacts on its ability to achieve ‘Good’ status, with physical modification for flood protection recorded as reason for not achieving 'Good’ status for Trout Beck.

Groundwater

14.6.44 Regional aspects of the hydrogeology that underly the schemes, including the aquifer units and WFD groundwater bodies, are described in the route wide baseline section. Those site specific features, such as groundwater surface water interactions (springs and sinks) and abstractions are described in the folloiwng sections.

Groundwater-surface water interactions

14.6.45 No springs and seepages are mapped within the study area. Springs and seepages are likely to be present particuarly in the banks and below the river level of the River Eamont and River Lowther.

14.6.46 The River Eamont and River Lowther will receive groundwater baseflow from the bedrock formations and superficial deposits.

Abstractions

14.6.47 The eastern end of the study area lies within an SPZ3 associated with abstractions to the north and the north west of the scheme.

14.6.48 There are two licensed wells in the scheme study area, these are:

- Abstraction well 2776004056/R01 at Penrith Industrial Estate - Permo-Triassic Sandstone
- Abstraction well 277600644 at Penrith and District Farmers Auction Mart - Permo-Triassic Sandstone

Flood risk

Fluvial flooding

14.6.49 The existing A66 within the study area does not have a flood risk greater than Fluvial Flood Zone 1. Enviroment Agency mapping shows areas within Fluvial Flood Zone 2 and 3 which are associated with:

- Dog Beck to the north west of the study area, within the Penrith Industrial Estate
- Thacka Beck to the north east of the study area.
- Unnamed Tributary of River Eamont 3.2 within the Frenchfield sports fields in the east of the study area
- The River Eamont in the south of the study area from Red Hills to Eamont Bridge.

Pluvial flooding

14.6.50 There are areas of ‘High’ pluvial water flood risk associated with Dog Beck and Thacka Beck within Penrith, in the north east of the study area located within industral estates, along residential roads, the A6 road through the town centre, the existing A66, adjacent parkland to Thacka Beck and a small area of the A686.

14.6.51 In the north of the study area, adjacent to the existing A66, Wetheriggs Country Park has areas of ‘High’ pluvial water flood risk and this also impacts on Clifford Road. Parkland in the east of the study area. Frenchfield has areas of ‘High’ flood risk that continue north towards the existing A686 and Charleton residential areas.

14.6.52 Small sections of ‘High’ pluvial flood risk are displayed adjacent to the River Eamont at Skirsgill and Eamont Park. This is liklely to be a result of localised depressions in the topography and may be inlfuenced by the watercourse. Areas of ‘High’ pluvial flood risk within the Brougham area in the south of the study area impact agricultural and recreational land uses.

Historic flooding

14.6.53 Environment Agency data shows historic flooding events associated with Thacka Beck within Penrith in 2002 and 2005. Historic flooding associated with the River Eamont has also occurred south of the existing A66 around the area of Skirsgill in 1995, 1997, 2005 and 2015. A further area of flooding occurred in 2005 associated with the River Eamont and River Lowther in the east of the study area, around Brougham.

Consented discharges

14.6.54 Four consented discharges have been identified in Environment Agency data within the study area. As shown in Table 14-3: Consented discharge licences within the M6 Junction 40 to Kemplay Bank study area, these include discharges associated with storm tanks, combined sewage overflows (CSO) and a pumping station.

Table 14-3: Consented discharge licences within the M6 Junction 40 to Kemplay Bank study area

Site Name	Licence Status	Description
Penrith Grammar School	Active	Storm Tank/CSO on Sewerage Network (water company)
Castle Hill Drive	Active	Storm Tank/CSO on Sewerage Network (water company)
Carleton Hall Templebank CSO	Active	Storm Tank/CSO on Sewerage Network (water company)
Brougham Pumping Station	Active	Pumping Station on Sewerage Network (water company)

Existing road drainage

14.6.55 HADDMS identifies four outfalls within the study area. One of these was classed as moderate priority (category C status), two as low priority (category D status) and one as risk addressed. No culverts, soakaways or flooding hotspots[45] were identified within the study area on HADDMS.

Penrith to Temple Sowerby

Designated sites

14.6.56 The River Eamont and the Light Water; both tributaries to the River Eden, are within the study area, with the existing A66 crossing the River Eamont at Brougham Castle and the Light Water 900m west of this. Both watercourses are designated within the River Eden SAC and River Eden and Tributaries SSSI.

Surface water

14.6.57 Watercourses within the study area drain into the River Eden via a number of tributaries. Minor watercourses which are tributaries of these named rivers and the River Eden have also been included in the assessment and grouped where required.

14.6.58 All watercourses within the study area flow through agricultural rural landscapes. The River Eamont drains from Ullswater situated south west of the study area, and the River Lowther which drains from the south west of Shap, outside of the study area.

14.6.59 The watercourses designated as Main Rivers by the Environment Agency within the study area include the River Lowther and River Eamont. Table 14-4: Watercourses within the Penrith to Temple Sowerby study area, gives a brief description of the watercourses in the study area (from west to east) and they are displayed on Figure 14.1: Surface Water Features.

Table 14-4: Watercourses within the Penrith to Temple Sowerby study area

Watercourse	Description
River Eamont	Flows east, joined by the River Lowther and crossed by the existing M6 in the west of the study area, flows north east and joins the River Eden 2.3km directly north of the existing A66.
River Lowther	Flows east, located parallel, to the south of the River Eamont. Joins the River Eamont at Brougham Castle 250m upstream of the existing A66 crossing, in the west of the study area.

[45] Flooding hotspot is defined as “An extent of carriageway at risk of repeated flooding”. – Highways England (2020) CD 535: Drainage asset data and risk management, Revision 1.

Watercourse	Description
Unnamed Tributary of River Eamont 3.2	Flows east into the River Eamont, straightened channel through Frenchfield sports centre, in the west of the study area
Unnamed Tributary of Light Water 3.1	Flows north into the Light Water in the west of the study area, crossed by the existing A66.
Light Water	Flows north into the Eamont, crossed by the existing A66, and joins the River Eamont 780m downstream of the crossing point, in the western extent of the study area.
Unnamed Tributary of River Eamont 3.3	Flows north into the River Eamont, in close proximity to Whinfell Park, crossed by the existing A66 and joins the River Eamont 350m downstream.
Unnamed Tributary of River Eamont 3.5	Flows north into the River Eamont, crossed by the existing A66 in line with the meander in the River Eamont in the centre of the study area.
Swine Gill	Flows north into the River Eden, crossed by the existing A66, to the west of Whinfell. Joins the River Eden 1.7km downstream of the crossing point.
Unnamed tributary of River Eden 4.5	Flows north into the River Eden, at existing A66 and B412 junction in the east of the study area.

Surface water WFD catchments

14.6.60 Eamont (Lower) (GB102076070990) WFD surface waterbody catchment underlies the majority of the study area. This waterbody is associated with ‘Good’ Ecological and ‘Fail’ Chemical status’ in 2019, resulting in a ‘Moderate’ overall status. The status for the supporting element hydromorphology is ‘Good’ and the physico-chemical quality elements have a status of ‘High’. The Enviroment Agency do not give a RNAG for this catchment.

14.6.61 The Lowther (Lower) (GB102076071010) WFD catchment, situated in the south west of the study area, is associated with ‘Moderate’ Ecological and ‘Fail’ Chemical status’, resulting in a ‘Moderate’ overall status. The watercourse is classified as ‘Heavily Modifed’ which impacts on its ability to achieve ‘Good’ status. The Enviroment Agency do not give a RNAG for this catchment.

14.6.62 Eden Lyvennet to Eamont (GB102076070980) WFD catchment, in the east of the study area, is associated with ‘Good’ Ecological and ‘Fail’ Chemical status’ , resulting in a ‘Moderate’ overall status. The hydromorphology status is ‘‘Supports Good’’ and the physico-chemical status is ‘High’. Sediment from unknown sources recorded as reason for not achieving 'Good’ status for Trout Beck.

Groundwater

14.6.63 Regional aspects of the hydrogeology that underly the schemes, including the aquifer units and WFD groundwater bodies, are described in the route wide baseline section. Those site specific features, such as groundwater surface water interactions (springs and sinks) and abstractions are described in the folloiwng sections.

Groundwater-surface water interactions

14.6.64 Review of available data, including aerial photography and mapping, has identified one spring (S29) in this study area.

14.6.65 The River Eamont and River Lowther will receive groundwater baseflow from the bedrock formations and superficial deposits.

Abstractions

14.6.66 The western end of the study area lies within an SPZ3 associated with abstractions to the north and the north west of the scheme.

14.6.67 An SPZ1, 2 and 3 located 2km south at the eastern end of the alignment. This SPZ is associated with a supply well near Center Parcs Whinfell Forest.

14.6.68 There are no licensed wells in the scheme study area.

Flood risk

Fluvial flooding

14.6.69 The western section of the study area contains an area within Fluvial Flood Zones 2 and 3, associated with the River Eamont and River Lowther and their floodplains which occurs on both sides of the existing A66.

14.6.70 In the centre of the study area adjacent to Barrackbank Wood there is a floodplain 124m north of the existing A66, designated as Fluvial Flood Zone 3. This floodplain is associated with the River Eamont.

Pluvial flooding

14.6.71 There are areas of 'Medium' pluvial water flood risk displayed adjacent to the River Eamont along the existing A66 and Moor Lane.

14.6.72 There are areas of 'Low' pluvial water flood risk displayed adjacent to the Light Water at Light Water Bridge on along the existing A66 and the land adjacent to the south, likely to be a result of localised depressions in the topography. Similarly, there are areas of 'Low' pluvial water flood risk influenced by the Unnamed Tributary of River Eamont 3.3 on the existing A66.

Historic flooding

14.6.73 Environment Agency data shows historic flooding events associated with River Eamont in 2005, 2009 and 2015. Historic flooding associated with the study area is indicated on Environment Agency mapping to be at risk of fluvial flooding (from rivers or the sea).

14.6.74 Consultation response received from Cumbria Council LLFA stated that "Flooding has been experienced in the vicinity of the Karma Llama Kafé due to a watercourse culvert underneath the A66."

Consented discharges

14.6.75 Seven consented discharges have been identified in Environment Agency data within the study area for this scheme. As shown in Table 14-5: Consented discharge licences within the Penrith to Temple Sowerby study area, these include discharges associated with sewage treatment works, pumping stations, quarrying and hospitality.

Table 14-5: Consented discharge licences within the Penrith to Temple Sowerby study area

Site Name	License status	Description
1 - 4 Swinegill Cottages	Active	Domestic property (multiple) (including farmhouses)
Winderwath Cottages	Active	Domestic property (multiple) (including farmhouses)

Site Name	License status	Description
Fremington	Active	WwTW (not water co) (not STP at a private premises)
C.Hall CSO	Active	Storm Tank/CSO on Sewerage Network (water company)
Penrith outfall	Active	Storm Tank/CSO on Sewerage Network (water company)
Sceugh Farm	Active	WwTW (not water company) (not STP at a private premises)
Penrith Wastewater Treatment Works (WwTW)	Active	WwTW/Sewage Treatment Works (water company)

Existing road drainage and outfalls

14.6.76 HADDMS identifies ten outfalls within the study area. Six classed as moderate priority (category C status) and four as low priority (category D status). No culverts, soakaways or flooding hotspots were identified within the study area on HADDMS.

Temple Sowerby to Appleby

14.6.77 Unless specified, the following baseline applies to the Blue Red and Orange alternative study areas. These are shown on Figure 14.1: Surface Water Features.

Designated sites

14.6.78 The River Eden and Trout Beck; a tributary to the River Eden, are located within the study areas. Both watercourses are designated within the River Eden SAC and River Eden and Tributaries SSSI.

14.6.79 River Habitat Survey (RHS) and River Corridor Survey (RCS) have confirmed that Trout Beck supports habitats and species included in the River Eden SAC designation. Further details of the designated features relating to the River Eden SAC are provided within Chapter 6: Biodiversity.

14.6.80 Located to the east of Temple Sowerby and 350m north of the existing A66, within the study area, is the Temple Sowerby Moss SSSI. This site is within a slight depression in the glacial drift over an area of Penrith Sandstone and is notable for the development of its fen communities.

Surface water

14.6.81 Watercourses within the study areas drain into the River Eden via a number of tributaries.

14.6.82 The watercourses in the north and west of the study areas drain from the fells to the north, inlcudings Knock Pike and Dufton Pike, and flow through agricultural fields and small villages, including Long Marton. In the south of the study areas the watercourses flow north from the the Howgill Fells through largely agricultural land.

14.6.83 Both Trout Beck and the River Eden are designated by the Environment Agency as Main Rivers. Table 14-6: Watercourses within the Temple Sowerby to Appleby study areas, gives a brief description of the watercourses in the study area (from west to east) and they are displayed on Figure 14.1: Surface Water Features.

Table 14-6: Watercourses within the Temple Sowerby to Appleby study areas

Watercourse	Description
Birk Sike	Flows west into the River Eden, parallel to the north of the existing A66 in the north of the study areas. Joins the River Eden to the west of the study areas.
River Eden	Flows northwest, parallel to the south of the existing A66. Joined by several tributaries to the south of the study area and joins River Lyvennet in the south east of the study areas.
River Lyvennet	Flows north, joins the River Eden 520m to the south of the existing A66.
Unnamed Tributary of Birk Sike 4.2	Situated northwest of Kirkby Thore, flows northeast through agricultural land into Birke Sike.
Unnamed Tributary of Birk Sike 4.3	Situated northeast of Kirkby Thore, flows northwest through agricultural land into Birk Sike, adjacent to British Gypsum factory.
Unnamed Tributary of Trout Beck 4.1	Situated 440m south of existing A66, flows south-west into the River Eden in west of study areas.
Trout Beck	Flows north west into the River Eden, from Long Marton, crossed by the existing A66 to the south of Kirkby Thore.
Unnamed Tributary of Keld Sike 4.1	Partially subterranean artificially straightened field drainage channel situated 200m north of Sleastonhow Lane, to the east of Kirkby Thore. Flows southeast into Keld Sike.
Keld Sike (1)	Flows south into Trout Beck where it becomes a straightened channel to the west of Long Marton.
Unnamed Tributary of Trout Beck 4.2	Flows north from Crackenthorpe, parallel to the existing A66. Data received from the Environment Agency indicates a culvert linking this watercourse to the watercourse along the field boundary to the south of Powis House, flowing via another culvert into Trout Beck.
Unnamed Tributary of Trout Beck 4.3	Flows north into Trout Beck, located within the area of low ground adjacent to the Roman Road and flows along Castrigg Lane and past Broad Lea House.
Unnamed Tributary of Trout Beck 4.6	Flows west with areas of artificially straightened channel and into Trout Beck 100m north of the existing A66.
Keld Sike (2)	Flows from Castrigg Lane at the railway line north past Broom House Farm and joining Trout Beck 200m to the south of Long Marton, parallel to the north of the Roman Road.
Unnamed Tributary of River Eden 4.2	Flows from Castrigg Lane at the railway line north past Broom House Farm and joining Trout Beck 200m to the south of Long Marton, parallel to the north of the Roman Road.
Unnamed Tributary of River Eden 4.3	Situated north west of Appleby, flows south from existing A66 for 60m into the River Eden.

Surface water WFD catchments

14.6.84 The Eden - Scandal Beck to Lyvennet (GB102076070880), Crowdundle Beck – Lower (GB102076070950) and Trout Beck (GB102076070930) are all associated with 'Good' Ecological and 'Fail' Chemical WFD status', resulting in 'Moderate' overall status' in 2019. The EA do not give a RNAG for The Eden - Scandal Beck to Lyvennet (GB102076070880), or Crowdundle Beck – Lower (GB102076070950). Pollution from agricultural land management is recorded as reason for not achieving 'Good' status for Trout Beck. At the existing A66 and Trout Beck crossing, the channel has historically been realigned and meanders have been removed in the past century, thus reducing the wet channel length significantly.

Groundwater

14.6.85 Regional aspects of the hydrogeology that underly the schemes, including the aquifer units and WFD groundwater bodies, are described in the route wide baseline section. Those site specific features, such as groundwater surface water interactions (springs and sinks) and abstractions are described in the folloiwng sections.

14.6.86 The River Eden, Birk Sike and Trout Beck will receive groundwater baseflow from the bedrock formations and superficial deposits.

Groundwater-surface water interactions

14.6.87 There are three surface water groundwater interactions within the study areas. Springs S24 and S26 occur in Glacial Till with bedrock near surface. At spring S24 bedrock is visible in the stream bed. Whilst at S26, the flow seeps from Glacial Till.

14.6.88 The River Eden will receive groundwater baseflow from the bedrock formations and superficial deposits.

Abstractions

14.6.89 An SPZ1, 2 and 3 located 2km south in the western sections of the study areas. This SPZ is associated with a supply well near Center Parcs Whinfell Forest.

14.6.90 There are six licensed wells in the scheme study area, these are:

- Agricultural abstraction well (Licence number: 2776003013) at Spittals Farm - Permo-triassic Sandstone
- Agricultural abstraction well (Licence number: 2776003012/R01) in Kirkby Thore - Permo-Triassic Sandstone
- Two Industrial abstraction wells (Licence number: 277600311) in Kirkby Thore - Permo-Triassic Sandstone
- One industrial abstraction well (Licence number: 2776003009) in Kirkby Thore - Permo-Triassic Shale
- One agricultural abstraction well (License number: 2776001134/R01) west of Appleby-in-Westmorland.

Flood risk

Fluvial flooding

14.6.91 Areas of Fluvial Flood Zone 2 and 3 shown within Enviroment Agency mapping include areas associated with:

- Birk Sike and its floodplain in the western section of the study areas.
- Trout Beck and its floodplain, to the north west of the existing A66 between Kirkby Thore and Long Marton.
- The River Eden and its floodplain, parallel and to the south-west of the existing A66. Within the eastern section of the study areas the extent of Fluvial Flood

Zone 3 associated with the River Eden are separated from the existing A66 by a steep embankment.

Pluvial flooding

14.6.92 There are areas of 'High' pluvial water flood risk influenced by tributaries of Trout Beck within Kirkby Thore along a number of residential roads as well as at the junction of Piper Lane and the exisitng A66. At west Crackenthorpe there are areas of 'High' and 'Medium' pluvial flood risk along the side road adjacent to the existing A66 and in the vicinity of Powis Cottages associated with depressions in the topography. There are also areas of 'High' pluvial flood risk associated with the River Eden along several residential roads within Appleby, including Drawbiggs Lane and the B6542.

14.6.93 There are areas of pluvial flood risk adjacent to and within the wider floodplain of both Trout Beck and the River Eden. These are likely to indicate historic flow paths for the respective channels, particularly downstream of the historically realigned section of Trout Beck (to the west of Powis House), where there are areas of 'High' pluvial flood risk parallel to the north of the existing channel.

Historic flooding

14.6.94 Environment Agency data shows historic flooding events associated with Trout Beck within Kirkby Thore in 2004, 2005 and 2015. Historic flooding associated with the River Eden has also occurred in Bolton in 2005, 2009 and 2015 and on seven occations within Appleby between 1990 and 2015.

Consented discharges

14.6.95 12 consented discharges have been identified in Environment Agency data within the study areas. As shown in Table 14-7: Consented discharge licences within the Temple Sowerby to Appleby study area, these include dischages associated with sewage treatment works, pumping stations, quarrying and hospitality.

Table 14-7: Consented discharge licences within the Temple Sowerby to Appleby study area

Site Name	Licence Status	Description
Kirkby Thore STW	Active	WwTW/Sewage Treatment Works (water company)
Kirkby Thore PS	Active	Pumping Station on Sewerage Network (water company)
Bolton Mill Caravan Park	Active	Holiday Accom/Camp Site/Caravan Site/Hotel/Hostel
Stamphill Mine	Active	Mineral/Gravel Extraction/Quarrying
Stamphill Mine	Active	Mining of Coal + Lignite
The Stackyard	Active	Food + Beverage Services/Cafe/Restaurant/Pub
Hall Farmhouse	Active	WwTW (not water company) (not STP at a private premises)
Long Marton West STW	Active	WwTW/Sewage Treatment Works (water company)
Appleby WwTW	Active	WwTW/Sewage Treatment Works (water company)
Appleby CSO	Active	Storm Tank/CSO on Sewerage Network (water company)
Roman Road Campsite	Active	Holiday Accom/Camp Site/Caravan Site/Hotel/Hostel

Site Name	Licence Status	Description
Butts Car Park	Active	Storm Tank/CSO on Sewerage Network (water company)

Existing road drainage and outfalls

14.6.96 *HADDMS* identifies 13 outfalls within the study areas. 12 of these were classed as moderate priority (category C status) and one as low priority (category D status). Two culverts were also identified within the study area from HADDMS, in addition to two flooding hotspots, both of which were classed as 'risk addressed'. No soakaways were identified within the study areas on *HADDMS*.

Appleby to Brough

14.6.97 The following baseline applies to the combined study area, which comprises of a 1km buffer of the furthest extent of all draft DCO boundaries for the Black-black-black route and the Blue (central) and Orange (eastern) alternatives. The alignments, associated DCO boundaries, and combined study area are shown on Figure 14.1: Surface Water Features.

Designated sites

14.6.98 The River Eden and a number of tributaries are within the study area, with the extent of the River Eden and a large number of tributaries are designated as the River Eden SAC and River Eden and Tributaries SSSI.

14.6.99 The scheme is located on the southern boundary of the North Pennines AONB, with the following designations relating to the water environment falling into the eastern extent of the study area:

- The North Pennine Moors SPA
- The North Pennine Moors SAC
- Bowes Moor SSSI.

Surface water

14.6.100 A number of watercourses flow through the study area. All eventually flow into the River Eden.

14.6.101 All watercourses in the study area, with the exception of the River Eden, drain from fells to the north of the study area and flow through predominately agricultural land and some small settlements, including Warcop and Sandford.

14.6.102 The watercourses designated as Main Rivers by the Environment Agency within the study area include Coupland Beck, River Eden, Mire Sike, Moor Beck, Hayber Beck, Crooks Beck, Lowgill Beck and Swindale Beck. Table 14-8: Watercourses within Appleby to Brough study area, gives a brief description of the watercourses in the study area (from west to east). Figure 14.1: Surface Water Features, displays the watercourses identified in the study area.

Table 14-8: Watercourses within Appleby to Brough study area

Watercourse	Description
Hilton Beck	Flows south in the north west of the study area. Discharges into the Coupland Beck.
George Gill	Flows west into Coupland Beck, to the south of Brackenber, in the north west of the study area.

Watercourse	Description
Coupland Beck	Flows south into the River Eden, to the south of Coupland in the north west of the study area and drains George Gill and Hilton Beck.
Lycum Beck	Flows south into the George Gill, in the west of the study area.
River Eden	Flows northwest, south of the existing A66, Warcop and Sandford in the north west of the study area.
Unnamed Tributary of Mire Sike 6.1	Drain flows east from Middle Bank End, before flowing south and into Mire Sike to the south of Far Bank End.
Unnamed Tributary of Mire Sike 6.4	Flows west parallel to the existing A66 before joining Unnamed Tributary of Mire Sike 6.1 to the north of Far Bank End.
Unnamed Tributary of Mire Sike 6.8	Flows south through Sandford Mire, three small drains discharge into it as it flows through the mire before discharging into Mire Sike.
Unnamed Tributary of Mire Sike 6.12	Flows south and crosses existing A66 to the west of Dike Nook, in the northwest of the study area. Watercourse flows into Mire Sike.
Mire Sike	Crossed by the existing A66 to the south of Wheat Sheaf Farm in the centre of the study area. Watercourse flows north west into the River Eden at the confluence to the west of Far Bank End.
Unnamed Tributary of Cringle Beck 6.1	Flows south from Moor House and Hilton Road, passing adjacent east to Wheat Sheaf Farm, culverted under Eden Valley Railway before discharging into Cringle Beck.
Cringle Beck	Flows south then west into Mire Sike, crossing the existing A66 adjacent to the east of Wheat Sheaf Farm in the centre of the study area. It is also culverted under the Eden Valley Railway.
Hayber Beck	Crossed by the existing A66 and flows south through the centre of the study area into before meeting Eastfield Sike at a confluence and becoming Crooks Beck, to the east of Warcop.
Moor Beck	Flows south from Hayber Beck into Crooks Beck in the centre of the study area.
Eastfield Sike	Crossed by the existing A66 and flows southwest through the centre of the study area. Meets Hayber Beck at a confluence and becomes Crooks Beck, to the east of Warcop.
Crooks Beck	Flows west though Warcop into the River Eden in the centre of the study area. Watercourse drains Hayber Beck, Eastfield Sike and Lowgill Beck.
Lowgill Beck	Flows under the existing A66 in the east of the study area. Flows west and drains into Crooks Beck.
Unnamed Tributary of Lowgill Beck 6.1	Unnamed watercourses from Bale Hill and Brough Hill join and flow under the existing A66 into Lowgill Beck, towards the east of the study area.
Woodend Sike	Located in the east of the study area, the watercourse flows south before the confluence with Yosgill Sike (to the north of the existing A66) and becoming Lowgill Beck.

Watercourse	Description
Yosgill Sike	Located in the east of the study area, the watercourse flows south before the confluence with Woodend Sike (to the north of the existing A66) and becoming Lowgill Beck.
Unnamed Tributary of Lowgill Beck 6.7	Located in the east of the study area, the watercourse flows south, crossed by the existing A66 before becoming feeding into Unnamed Tributary of Lowgill Beck 6.3.
Unnamed Tributary of Lowgill Beck 6.3	Located in the south east of the study area, the watercourse flows west and joins the Lowgill Beck just south of Broom Rigg.
Swindale Beck	Located in the east of the study area, the watercourse flows south crossed by the existing A66. Joins the River Eden approximately 2.8km downstream.
Augill Beck	Located in the east of the study area, the watercourse flows south crossed by the existing A66. Discharges into the Swindale Beck south west of Brough Primary School.

Surface water WFD catchments

14.6.103 The following surface water WFD catchments are located within the study area:

- Hilton Beck (ID: GB102076070770)
- Eden - Scandal Beck to Lyvennet (ID: GB102076070880)
- Low Gill (Crooks Beck) (ID: GB102076070750).

14.6.104 Hilton Beck is associated with ‘Good’ ecological and ‘Fail’ chemical WFD status, resulting in a ‘Moderate’ overall status in 2019. Diffuce pollution of heavy metals from mining activity is recorded as reason for not achieving 'Good’ status.

14.6.105 The Eden - Scandal Beck to Lyvennet is associated with ‘Good’ ecological and ‘Fail’ chemical WFD status’, resulting in a ‘Moderate’ overall status in 2019. The Enviroment Agency do not give a RNAG for this catchment.

14.6.106 Low Gill (Crooks Beck) is associated with ‘Poor’ ecological and ‘Fail’ chemical WFD status, resulting in a ‘Poor’ overall status in 2016. The Environment Agency lists diffuse pollution from poor nutrient management from agriculture (livestock) and sediment from agriculture and rural land management on fish as reasons for not achieving 'Good’ status for Low Gill (Crooks Beck).

Groundwater

14.6.107 Regional aspects of the hydrogeology that underly the study area, including the aquifer units and WFD groundwater bodies, are described in route wide baseline conditions section. Those site specific features, such as groundwater surface water interactions (springs and sinks) and abstractions, are described below for the study area.

Groundwater-surface water interactions

14.6.108 There are two surface water groundwater interactions within the study area; S23 and S50 (as shown on Figure 14.6: Hydrogeological Study Areas and FeaturesM6 Junction 40 to Kemplay Bank).

14.6.109 The study area cross the Pennine fault, which separates the Penrith Sandstone Formation and the Stainmore Formation. Spring S23 is in a steep sided valley that lies in the northeast of the study area. The groundwater flow that feeds this study area likely to be from limestones of the Alston Formation.

14.6.110 The River Eden will receive groundwater baseflow from the bedrock formations and superficial deposits.

Abstractions

14.6.111 There are no designated groundwater SPZs within the study area.

There are two licensed groundwater abstractions within the study area:

- Eastfield Farm (Licence Number: NW/076/0001/009) – Permo-Triassic Sandstone
- Borehole at West View Brough, Kirkby Stephen (Licence number: 2776001135/R01) – Permo-Triassic Sandstone.

Flood risk

Fluvial flooding

14.6.112 Areas of Fluvial Flood Zone 2 and 3 shown within Enviroment Agency mapping include areas associated with:

- Coupland Beck and its floodplain in the north west of the study area.
- River Eden and Mire Sike between Warcop and Ormside.
- Hayber Beck, the confluence and floodplain of Hayber Beck, Moor Beck and Eastfield Sike in the centre of the study area.
- The wide floodplain of Crooks Beck and the lower reaches of Lowgill Beck within Warcop.
- Lowgill Beck at Flitholme and Flitholme Bridge.
- Lowgill Beck where it is crossed by the existing A66 which extends to Woodend Sike, upstream of its confluence with Yosgill Sike.
- Swindale Beck and Augill beck, through Brough in the east of the Orange alternative study area.

Pluvial flooding

14.6.113 In the northern sections of the study area there are areas of ‘High’ and ‘Medium’ pluvial water flood risk associated with Coupland Beck and its tributaries upstream and adjacent to the exisiting A66.

14.6.114 Downstream of the exisiting A66 there are areas of ‘High’ and ‘Medium’ pluvial water flood risk associated with small areas of wetland and field drains to the north and east of both Far Bank End and Middle Bank End. Additionally, to the south of the railway line, are areas of ‘Medium’ pluvial water flood risk associated with Sandford Mire and Mire Sike.

14.6.115 In the central sections of the study area there are areas of ‘High’ and ‘Medium’ pluvial water flood risk adjacent to Cringle Beck and an extensive area to the east of Cringle Beck’s confluence with Mire Sike. This is considred to be a result of a number of small tributaries and the railway line. There are also large areas to the north, east and south of Warcop, associated with depressions in the land around existing A66 watercourse crossings and the large valley bottom immediately upstream and downstream of the railway embankment, to the north west and east of Warcop. To the east of Warcop, there are areas of ‘High’ and ‘Medium’ pluvial water flood risk around Eastfield Sike and upstream of the exisiting A66 crossing at Toddygill Bridge and upstream.

14.6.116 In the eastern sections of the study area, there are areas of ‘High’ and ‘Medium’ pluvial water flood risk along the extent of Lowgill Beck, with a large area to the north of Flitholme, and areas adjacent to large reaches of Woodend Sike and Yosgill Sike and their confluence north of the exisiting A66 crossing.

14.6.117 Thoughout the study area there are areas of 'High' and 'Medium' pluvial water flood risk associated with the River Eden and its floodplain, including some areas of minor unnamed tributaries.

14.6.118 The east of the study area has areas of 'High' and 'Medium' pluvial water flood risk associated with the Swindale Beck and Augill Beck, affecting sections of the existing A66 junction.

Historic flooding

14.6.119 Environment Agency data shows historic flooding events associated with the following events in the study area:

- Coupland Beck at Coupland in 2000, 2002, 2005 and 2015
- The River Eden at Ormside in 2005 and 2015 and Sandford in 2015
- Moor Beck at Warcop in 2015
- Swindale Beck within Brough town centre.

Consented discharges

14.6.120 Five consented discharges (three active consents) have been identified in Environment Agency data within the study area. As shown in Table 14-9: Consented discharge licences within the Appleby to Brough study area, these include discharges associated with sewage treatment works, pumping stations and hospitality.

Table 14-9: Consented discharge licences within the Appleby to Brough study area

Site Name	Licence Status	Description
Hayber Gill Centre	Inactive	Sport, recreation/Golf/Gym/Theme Pk/Spa
Warcop Village PS	Active	Pumping station on sewerage network (water company – UU)
Syphon CSO	Active	Storm tank/CSO on sewerage network (water company – UU)
Warcop Camp STW	Active	WwTW/Sewage Treatment Works (water company – UU)
Crooks Beck	Inactive	WwTW/Sewage Treatment Works (water company – UU)
Swindale Beck STW	Inactive	WwTW/Sewage Treatment Works (water company)
Brough WWTW	Active	WwTW/Sewage Treatment Works (water company)

Existing road drainage and outfalls

14.6.121 HADDMS identifies 27 outfalls within the study area, 20 classed as moderate priority (category C status) and seven as low priority (category D status). Six culverts were also identified within the study areas from *HADDMS*. No soakaways or flooding hotspots were identified within the study area on *HADDMS*.

Bowes Bypass

Designated sites

14.6.122 The scheme is located on the southern boundary of the North Pennines AONB, with the following designations relating to the water environment falling into the eastern extent of the study area:

- The North Pennine Moors SPA
- The North Pennine Moors SAC
- Bowes Moor SSSI
- Kilmond Scar SSSI.

Surface water

14.6.123 The majority of watercourses within the study area drain into the River Greta via a number of tributaruies that converge at a low point to the north east of the A66 and A67 junction

14.6.124 The River Greta is designated by the Environment Agency as a Main River. Table 14-10: Watercourses within the Bowes Bypass study area, gives a brief descitption of the watercourses in the study area (from west to east). Figure 14.1: Surface Water Features displays the watercourses identified in the study area.

Table 14-10: Watercourses within the Bowes Bypass study area

Watercourse	Description
Bessy Sike	Flows east and then north in the north west of the study area.
Unnamed Tributary of River Greta 7.7	Flows south into the River Greta in the west of the study area.
Unnamed Tributary of River Greta 7.1	Flows south from the existing A66 into the River Greta, south west of Ivy Hall Farm.
Unnamed Tributary of River Greta 7.3	Flows south, crossed by Clint Lane in the north of the study area. Converges multiple field drains into one culvert which flows under the existing A66 and emerges to the south of the existing A66 at Stone Bridge Farm. Watercourse then flows south into the River Greta.
Chert Gill	Flows north into the River Greta in the south of the study area, culverted under Long Close Lane.
How Low Gill	Flows north into the River Greta in the south of the study area, culverted at Whorlands.
Unnamed Tributary of River Greta 7.5	Watercourse flows south into the River Greta from the Stone Bridge Farm, in the east of the study area.
Unnamed Tributary of River Greta 7.6	Flows east into the River Greta, starting south of Low Broats in the south west of the study area.
River Greta	Flows east, parallel to the south of the existing A66 and Bowes. Flows into the River Tees 9.5km downstream of the study area.
Thorsgill Beck	Flows east in the north west of the study area, discharges into the River Tees approximately 5km downstream of the study area.

Surface water WFD catchments

14.6.125 The majority of the study area is within the Greta from Sleightholme Beck to Eller Beck (GB103025072140) WFD catchment. This waterbody is associated with ‘Moderate’ ecological and ‘Fail’ chemical WFD status’, resulting in a ‘Moderate’ overall status in 2019. Barriers of both natural and phyisical modification origins are recorded as reasons for not achieving 'Good’ status.

14.6.126 In the northern extent of the study area, Deepdale Beck from Source to River Tees (GB103025072170) and Tees from Percy Beck to River Greta (GB103025072512) both are associated with ‘Good’ ecological and ‘Fail’ chemical WFD status’, resulting in a ‘Moderate’ overall status in 2019. The Enviroment Agency do not give a RNAG for either catchments.

14.6.1 Components resulting in the failing chemical status for each of the waterbodies were Polybrominated diphenyl ethers (PBDE) and Mercury and its compounds, which are not known to be associated with road run-off.

Groundwater

14.6.2 Regional aspects of the hydrogeology that underly the schemes, including the aquifer units and WFD groundwater bodies, are described in the route wide baseline section. Those site specific features, such as groundwater surface water interactions (springs and sinks) and abstractions are described in the folloiwng sections.

Groundwater and surface water interactions

14.6.3 All of the limestone formations within the study area have the potential to form karstic features, such as enclosed depressions, caves and springs.

14.6.4 Bowes includes two caves (K2 and K4) within 1km of the study area. There are also six karst landforms (surface depressions) with study area, 17 groundwater to surface water interactions (springs) and one surface water to groundwater contribution (sink). Refer to Figure 14.6: Hydrogeological Study Areas and FeaturesM6 Junction 40 to Kemplay Bank for location of receptor.

14.6.5 The Great Limestone Member includes a number of significant karst features in the area, including caves. The other limestone units has the potential for dissolution but those karst features in the area are generally small scale.

14.6.6 The River Greta will receive groundwater baseflow from the bedrock formations and superficial deposits.

Abstractions

14.6.7 There are no designated groundwater Source Protection Zones (SPZ) within the scheme or withn the 1km study area.

14.6.8 There are no Environment Agency licensed abstractions within 1km of the study area.

Flood risk

Fluvial flooding

14.6.9 There is an area of Fluvial Flood Zone 2 and 3 associated with the River Greta, along the southern extent of the study area. This is relatively confined to the extents of the watercourse due to the surrounding topography. Bowes itself, the existing road and northern tributaries to the River Greta are within Fluvial Flood Zone 1, and therefore are of low potential of flooding from rivers.

Pluvial flooding

14.6.10 There are areas of 'High' pluvial flood risk associated with tributaries of the River Greta along a number of roads within the study area including at the A66 and A67 junction and along sections of The Street, to the west of Bowes. Pluvial flood risk is mostly confined to roads, field drains and within close proximity to existing watercourses, with the majority of the properties within Bowes located within areas of 'Low' risk.

Historic flooding

14.6.11 No historic flood outlines within the study area are shown within Environment Agency data.

Consented discharges

14.6.12 Two consented discharges have been identified in Environment Agency data within the study area for this scheme. As shown in Table 14-11: Consented discharge licences within the Bowes Bypass study area, this includes one discharge linked to a sewage treatment works and one to a quarry.

Table 14-11: Consented discharge licences within the Bowes Bypass study area

Site Name	License status	Description
Bowes Sewage Treatment Works	Active	WwTW/Sewage Treatment Works (water company)
Hulands Quarry	Active	Mineral/Gravel Extraction/Quarrying

Existing road drainage and outfalls

14.6.13 HADDMS identifies two culverts and four flooding hotspots within the study area. Of the four flooding hotspots one was classed as very high priority (category A status), two as high priority (category B status) and one as moderate priority (category C status). No outfalls or soakaways were identified within the study area on HADDMS.

Cross Lanes to Rokeby

14.6.14 The following baseline applies to the combined study area, which comprises of a 1km buffer of the furthest extent of all draft DCO boundaries for the Black route (evolved version of the Preferred Route announced in Spring 2020) and the Blue (Cross Lanes) and Red (Rokeby) alternative junctions. The alignments, associated DCO boundary, and combined study area are shown on Figure 14.1: Surface Water Features.

Designated sites

14.6.15 There are no designated sites associated with the water environment within the study area for this scheme.

Surface water

14.6.16 Watercourses within the study area drain into the River Tees via a number of tributaries.

14.6.17 Within the study area the River Greta is the only watercourse designated by the Environment Agency as a Main River. Table 14-12: Watercourses within the Cross Lanes to Rokeby study area, gives a brief description of the watercourses in the study area (from west to east) and they are displayed on Figure 14.1: Surface Water Features

Table 14-12: Watercourses within the Cross Lanes to Rokeby study area

Watercourse	Description
Thorsgill Beck	Flows east in the north west of the study area, discharging into the River Tees.
Punder Gill	Flows east parallel to the south of the existing A66, crossed by the Moorhouse Lane in the west of the study area, flowing into Tutta Beck.
Unnamed Tributary of Punder Gill 8.1	Flows east into Punder Gill, crossing the existing A66 in the west of the study area.
Unnamed Tributary of Tutta Beck 8.1	Flows north into Tutta Beck, parallel to Moorhouse Lane in the west of the study area.
Tutta Beck	Flows east, parallel to the south of the existing A66. Crossed by the existing A66 and joins the River great in the east of the study area.
New Cut	Flows south in the south west of the study area, discharges into the River Greta.
Unnamed Tributary of Tutta Beck 8.2	Flows north along agricultural field boundaries into Tutta Beck, to the west of Birk House, in the east of the study area.
Unnamed Tributary of Tutta Beck 8.3	Flows north into Tutta Beck, to the east of Birk House in the west of the study area.
Partridge Gill	Flows east in the south of the study area, flows into the Wellfield Strand at Jack Wood.
Wellfield Strand	Flows north in the south of the study area, flows into the Tutta Beck near Ewbank farm.
Manyfold Beck	Flows east into the River Tees, parallel to the north of the existing A66, joins the River Tees on the east of the study area, downstream of the Abbey Road bridge crossing.
Unnamed Tributary of Manyfold Beck 8.3	Flows east into Manyfold Beck from Princess Charlotte Wood, culverted beneath B6277.
Unnamed Tributary of Manyfold Beck 8.1	Flows east into Manyfold Beck from Smithy Cottage, culverted beneath B6277.
River Greta	Flows north into the River Tees, crossed by the existing A66 (to the north of Greta Bridge) and joins the River Tees 1.1km downstream, in the east of the study area.
River Tees	Flows east rom Barnard Castle, to the north of the existing A66, joined by the River Greta to the north east of the study area.

Surface water WFD catchments

14.6.18 The Greta from Gill Beck to River Tees (GB103025072130) and the Tees from Percy Beck to River Greta (GB103025072512) both are associated with ‘Good’ Ecological and ‘Fail’ Chemical statuss in 2019, resulting in an overall status of ‘Moderate’. The status for the supporting element hydromorphology is ‘‘Supports Good’’ and the physico-chemical quality elements have a status of ‘High’. The Enviroment Agency do not give a RNAG for either catchments.

Groundwater

14.6.19 Regional aspects of the hydrogeology that underly the schemes, including the aquifer units and WFD groundwater bodies, are described in the route wide baseline section. Those site specific features, such as groundwater surface water interactions (springs and sinks) and abstractions are described in the folloiwng sections.

Groundwater-surface water interactions

14.6.20 All of the limestone formations within the study area have the potential to form karstic features, such as enclosed depressions, caves and springs.

14.6.21 No enclosed depressions or caves were identified within 1km of the studty area. Two springs has been identified S18 and S21, refer to Figure 14.6: Hydrogeological Study Areas and Features.

14.6.22 The Great Limestone Member includes a number of significant karst features in the area, including caves. The other limestone units has the potential for dissolution but those karst features in the area are generally small scale.

14.6.23 The River Tees will receive groundwater baseflow from the bedrock formations and superficial deposits.

Abstractions

14.6.24 There are no designated groundwater Source Protection Zones (SPZ) within the scheme or withn the 1km study area.

14.6.25 There are no Environment Agency licensed abstractions within 1km of the study area.

Flood risk

Fluvial flooding

14.6.26 Areas of Fluvial Flood Zone 2 and 3 shown within Enviroment Agency mapping include areas associated with Thorsgill Beck and its floodplain in the north west section of the study area and with Tutta Beck parallel, along the south of the study area.

Pluvial flooding

14.6.27 Areas of ‘high’ pluvial water flood risk include:

- In the south east of the study area associated with natural localised depressions and influenced by the Tutta Beck and River Greta
- In the north of the study are, associated with the Manyfold Beck and minor field drains to the north of the existing A66
- In the west of the study area in pockets of localised depressions in the fields adjacent to the existing A66.

Historic flooding

14.6.28 Environment Agency data shows a small area of historic flooding in the east of the study area at Greta Bridge Bank associated with the River Greta.

Consented discharges

14.6.29 Seven consented discharges have been identified in Environment Agency data within the study area for this scheme. As shown in Table 14-13: Consented discharge licences within the Cross Lanes to Rokeby study area, these include discharges associated with domestic properties, hospitality and wastewater treatment works.

Table 14-13: Consented discharge licences within the Cross Lanes to Rokeby study area

Site Name	Licence Status	Description
Castle Farmhouse Egglestone Abbey	Active	Domestic property (single) (inc. farmhouse)
Streetside	Inactive	WwTW (not water co) (not STP at a private premises)
Sewage treatment plant serving the Morritt Arms Hotel	Active	Food+Beverage Services/Cafe/Restaurant/Pub
The Square	Active	WwTW (not water co) (not STP at a private premises)
Greta Bridge Farm	Active	WwTW (not water co) (not STP at a private premises)
Cross Lanes Organic Farm	Active	Food + Beverage Services/Cafe/Restaurant/Pub
Cross Lanes Cottages & Farmhouse	Inactive	WwTW (not water co) (not STP at a private premises)

Existing road drainage and outfalls

14.6.30 *HADDMS* identifies one outfall within the study area of 'undetermined' status, one soakaway of 'undetermined' status and one flooding hotspot category C. No culverts were identified within the study area on HADDMS.

Stephen Bank to Carkin Moor

Designated sites

14.6.31 There are no designated sites associated with the water environment within the study area for this scheme.

Surface water

14.6.32 Watercourses within the study area drain into the River Swale via a number of tributaries.

14.6.33 None of the watercourses in the study area are designated by the Environment Agency as a Main River. Table 14-14: Watercourses within Stephen Bank to Carkin Moor study area, gives a brief description of the watercourses in the study area (from west to east). Figure 14.1: Surface Water Features, displays the watercourses identified in the study area.

Table 14-14: Watercourses within Stephen Bank to Carkin Moor study area

Watercourse	Description
Dyson Beck	Flows north into Smallways Beck, within the Aldbrough Beck catchment. Located on the west of the study area.
Smallways Beck	Flows north into Hutton Beck, within the Aldbrough Beck catchment. Crossed by the existing A66 to the west of Smallways, on the west of the study area.

Watercourse	Description
Unnamed Tributary of Smallways Beck 9.1	Flows north, culverted by existing A66 and Lanehead Lane, and discharges into Smallways Beck south east of Holm Hills.
Unnamed Tributary of Smallways Beck 9.4	Flows west and into Unnamed Tributary of Smallways Beck 9.1 in the west of the study area.
Cottonmill Beck	Flows east into Browson Beck, within the River Swale catchment. Located to the east of Newsham, within the south west of the study area.
Unnamed Tributary of Cottonmill Beck 9.3	Flows south from existing A66 through Black Plantation and into Cottonmill Beck.
Browson Beck	Flows south from Cottonmill Beck into Stalwath Beck, within the River Swale catchment. Located to the east of Newsham, within the south west of the study area.
Stalwath Beck	Flows east culverted under Dick Scot Lane and discharges into Dalton Beck south of the existing A66.
Holme Beck	Flows south west, parallel approximately 1km to the south of the existing A66, within the River Swale catchment. Located in the south east of the study area.
Unnamed Tributary of Dalton Beck 9.1	Flows east paralleled to the existing A66 and into Unnamed Tributary of Dalton Beck 9.2.
Unnamed Tributary of Holme Beck 9.3	Flows south into Holme Beck, crossed by the existing A66 slightly east of Collier Lane and culverted under Waitlands Lane, joins Holme Beck to the north of New Lane. In the centre of the study area.
Unnamed Tributary of Holme Beck 9.4	Flows south into Holme Beck, crossed by the existing A66 between Collier Lane and Moor Lane, joins Holme Beck to the north of Ravensworth. In the centre of the study area.
Unnamed Tributary of Mains Gill 9.1	Flows south through Middle Plantation in the north of the study area and discharges into Mains Gill east of Moor Lane.
Unnamed Tributary of Mains Gill 9.3	Two field drainage features flow south into Mains Gill, join to the east of Moor Lane. Located on the west of the study area.
Mains Gill	Flows south to Holme Beck along the west of Mainsgill Farm. Located in the east of the study area. Crossed by existing A66.
Unnamed Tributary of Holme Beck 9.1	Flows south west to Holme Beck, upper reach of the watercourse within Street Plantation and crossed by the existing A66. Follows field boundaries to Holme Beck, located on the east of the study area.
Unnamed Tributary of Holme Beck 9.2	Flows south to Holme Beck via Hartforth Beck, crossed by the existing A66 at the upper reach of the watercourse and follows field boundaries to the point it joins Hartforth Beck, to the west of Hartforth. Located on the east of the study area.

Watercourse	Description
Hartforth Beck	Flows south from Grange Farm, discharges into Holme Beck at culvert of Comfort Lane.

Surface water WFD catchments

14.6.34 Skeeby/Holme/Dalton Bk from Source to River Swale (GB104027069180) is associated with 'Moderate' Ecological and 'Fail' Chemical status' in 2019, resulting in an overall status of 'Moderate'. The status for the supporting element hydromorphology is 'Good' and the physico-chemical quality elements have a status of 'Good'. Pollution from agricultural land management and physical modifiction are recorded as reasons for not achieving 'Good' status.

Groundwater

14.6.35 Regional aspects of the hydrogeology that underly the schemes, including the aquifer units and WFD groundwater bodies, are described in the route wide baseline section. Those site specific features, such as groundwater surface water interactions (springs and sinks) and abstractions are described in the folloiwng sections.

Groundwater-surface water interactions

14.6.36 The Great Limestone Member includes a number of significant karst features in the area, including caves. The other limestone units has the potential for dissolution but those karst features in the area are generally small scale.

14.6.37 All of the limestone formations within the study area have the potential to form karstic features, such as enclosed depressions, caves and springs. There is one potential groundwater – surface water interaction in this scheme study area, Spring S1.

14.6.38 The River Swale will receive groundwater baseflow from the bedrock formations and superficial deposits.

Abstractions

14.6.39 There are two designated groundwater Source Protection Zones (SPZ) within the study area. These SPZ are associated with the Environment Agency licensed abstractions.

14.6.40 The Environment Agency licensed abstractions within the study area comprise of:

- Pond Dale abstraction well (license number: 2/27/23/661/R01)
- Blackhill Farm abstraction well (no licence number).

Flood risk

Fluvial flooding

14.6.41 The western section of the study area contains an area within Fluvial Flood Zones 2 and 3, associated with the Cottonmill Beck and its floodplain. At its closest point it is located 350m south of the existing A66.

Pluvial flooding

14.6.42 In the centre of the study there are areas of 'High' pluvial water flood risk displayed adjacent to the tributaries of Holme Beck located south of, and crossing under, the existing A66.

14.6.43 In the east of the study area there are areas of 'High' pluvial water flood risk associated with depressions in the topography and influenced by the Unnamed Tributary of Mains Gill 9.3 and Mainsgill that cross underneath the existing A66.

14.6.44 In the east of the study area there are areas of 'High' pluvial water flood risk adjacent to the existing A66, likely influenced by field drains.

Historic flooding

14.6.45 Environment Agency data shows no historic flooding events within the study area.

Consented discharges

14.6.46 Two consented discharges have been identified in Environment Agency data within the study area for this scheme. As shown in Table 14-15: Consented discharge licences within the Stephen Bank to Carkin Moor study area, these include waste water treatment works.

Table 14-15: Consented discharge licences within the Stephen Bank to Carkin Moor study area

Site Name	Licence Status	Description
Monks Rest Farm	Active	WwTW (not water co) (not STP at a private premises)
Foxwell Farm	Active	WwTW (not water co) (not STP at a private premises)

Existing road drainage and outfalls

14.6.47 HADDMS identifies ten outfalls within the study area. Three culverts were also identified within the study area from *HADDMS*. Three flooding hotspots were identified within the study area, two of which were classed as very high priority (category A status) and one of high priority (category B status). No soakaways were identified within the study area on *HADDMS*.

A1(M) Junction 53 Scotch Corner

Designated sites

14.6.48 There are no designated sites associated with the water environment within the study area for this scheme.

Surface water

14.6.49 The study area surrounds the Scotch Corner junction, west of Middleton Tyas. This area is characterised by a number of major roads and their associated infrastructure and agricultural land.

14.6.50 There are no main watercourses within the study area. The ordinary watercourses in the study area drain south towards the River Swale. Ludburn Beck flows south in the east of the study area towards Moulton, crossed by existing Middleton Tyas Lane, as seen on Figure 14.1: Surface Water Features.

Surface water WFD catchments

14.6.51 The Scorton Beck from Source to River Swale (GB104027069160) is associated with 'Poor' Ecological status and 'Fail' Chemical status in 2019, resulting in an overall status of 'Poor'. Pollution from the water industry and agricultural land management are recorded as reasons for not achieving 'Good' status.

Groundwater

14.6.52 Regional aspects of the hydrogeology that underly the study area, including the aquifer units and WFD groundwater bodies, are described in the route wide baseline section. Those site specific features, such as groundwater surface water interactions (springs and sinks) and abstractions are described below.

Groundwater-surface water interactions

14.6.53 There are no recorded springs or sinks in the study area.

14.6.54 The River Swale will receive groundwater baseflow from the bedrock formations and superficial deposits.

Abstractions

14.6.55 There are no designated groundwater Source Protection Zones (SPZ) within the study area.

14.6.56 There is one Environment Agency licensed abstraction within the study area:

- Abstraction well (licence reference 2/27/23/702/R01) in Middleton Tyas

Flood risk

Fluvial flooding

14.6.57 The study area is located within Fluvial Flood Zone 1 and is therefore of low flood risk from fluvial sources.

Pluvial flooding

14.6.58 Areas to in the west and north of the study area have 'Low' with small areas of 'Medium' pluvial water flood risk, associated with minor field drains and holding ponds.

14.6.59 Areas of 'High' pluvial water flood risk are concentrated in the south and south west of the study area, associated with depressions in the topography and the Ludburn Beck.

Historic flooding

14.6.60 Environment Agency data shows no historic flooding events within the study area.

Consented discharges

14.6.61 There are no consented discharges within the study area recorded in the Environment Agency data.

Existing road drainage and outfalls

14.6.62 *HADDMS* identifies one flooding hotspot within the study area, which was classed as high priority (category B status). No outfalls, culverts or soakaways were identified within the study area on HADDMS.

Future baseline

14.6.63 Consultation with the Eden Rivers Trust has revealed a proposal to reinstate a more naturalised channel for Trout Beck, closer to its original path through the floodplain. This will allow the channel to have freedom to be dynamic, healthy and follow a more natural path.

14.6.64 Otherwise, potential changes to road drainage and water environment receptors in the future will not be noticeable i.e. accidental spillage is unlikely to change and the receptor groups are unlikely to be different to those identified in the Baseline Conditions section. Therefore, the future baseline will remain the same as set out above.

14.6.65 Future climate conditions derived from the UK Climate Projections 2018 (UKCP18) indicate that the study area may undergo climatic changes including higher temperatures, increase in heat waves, reduced precipitation in summer and

increased precipitation in winter. Surface water flows are likely to become more variable, with more frequent extremes and an increase in flooding.

Assessment of Importance

14.6.66 The preliminary importance assigned to the receptors has been determined based upon current information with reference to Table 3.70 of *DMRB LA 113*, whereby importance is assigned based on the quality indicators of a receptor. Appendix 14.1: Preliminary Assessment of Receptor Importance details the receptors identified at this stage of assessment and their location relative to the draft DCO boundary. It also outlines their assigned preliminary importance and value rational.

14.7 Potential Impacts

14.7.1 Prior to the implementation of mitigation measures detailed within Section 14.7.39, the project has the potential to impact the water environment , including impacting on WFD status of connected watercourses and the condition status of the qualifying features of nearby designated sites (including the River Eden SAC/SSSI), during construction and operation.

14.7.2 The following are the potential impacts considered during the assessment, and are based on consultation with the regulators, the designers and professional judgment.

14.7.3 Potential ecological impacts associated with the following impacts are assessed in Chapter 6: Biodiversity. Potential risks posed to the water environment associated with the disturbance of contaminated land are assessed within Chapter 9: Soils and Geology

Construction

14.7.4 During construction, significant potential impacts to surface water and groundwater features and flood risk could arise from:

- Increased pollution entering the watercourses from mobilised suspended solids and spillage of fuels or other harmful substances that may migrate to surface water and groundwater receptors water quality.
- Impacts to the hydro-morphological and ecological quality of watercourses associated with works within or in close proximity to watercourses, including physical change to the watercourses and longer-term changes associated with sediment deposition.
- Changes to flood risk.
- Impacts to local land drainage structures, that may alter existing drainage patterns within catchments and provide potential pathways for pollution.
- Impacts to groundwater levels, flows and quality arising from construction activities, primarily dewatering; earthworks and intrusive investigation works creating new flow paths for groundwater.

14.7.5 Further details of construction potential impacts are provided in the following sections.

Surface water

Surface water quantity

14.7.6 The creation of surface water drainage may divert water between surface water catchments. This potential interruption and diversion of flow may lead to a reduction or loss of water supply to abstractions, springs and watercourses and potential loss of habitat (which may be permanent). The loss of water from one catchment to

another potentially affects resource availability further down-gradient in the confined aquifers.

14.7.7 Embankments and earth bunds could create a barrier for springs that feed into the surface watercourses, and redirection of flows to a different catchment could reduce catchment areas and change the flow regime within receiving surface waters. This may also have consequential effects on aquatic ecology.

Surface water quality

14.7.8 Working in, on or adjacent to watercourses may affect surface water quality through the accidental discharge of fine sediments or chemicals, including hydrocarbons. There may also be impacts to channel form through plant movements and operations.

14.7.9 Where works require groundwater control measures e.g. local groundwater level reduction or removal of the water from the excavation (dewatering), the discharge of removed groundwater into surface watercourses may affect the quality of the receiving watercourses, primarily through sediment release but also if the removed groundwater is contaminated.

14.7.10 Stockpiling of construction materials and excavated spoil may contaminate or pollute groundwaters if they are not stored correctly. These contaminants and pollutants may include fuels, oils, chemicals and concrete. Removal of topsoil or hardstanding and exposure of underlying soils to increased rainwater infiltration may result in pollutants leaching into the underlying aquifer. Drainage for construction works may also distribute contaminants and pollutants to other parts of the aquifer and create an accumulation of these substances where soakaway basins are used. This has the potential to impact the water quality of surface waters, aquifers, springs, abstractions and groundwater-dependent habitats indirectly via site runoff or directly where works are close to and within a waterbody.

Hydromorphology

14.7.11 Physical/morphological changes to watercourses and longer-term changes associated with sediment deposition and erosion (river processes) are likely to have impacts on the hydromorphological and ecological quality of watercourses.

14.7.12 The realignment or diversion of watercourse may result in the permanent loss of the respective hydromorphological features. The works may also result in the loss of geomorphological features and habitat niches within the affected channel.

Groundwater

14.7.13 Groundwater receptors may be affected through:

- Impacts to local land drainage structures, that may alter existing drainage patterns within catchments and provide potential pathways for pollution to the underlying groundwater and/or aquifer;
- Impacts on local hydrogeology and groundwater resources, through changes to groundwater levels, flows and quality arising from construction activities, primarily dewatering, construction of cuttings or shallow earthworks and intrusive investigation works creating new flow paths for groundwater. Specific activities which pose a risk to groundwater quality include:
  - Removal of topsoil or hardstanding resulting in exposure of underlying soils to increased rainwater infiltration, potentially resulting in pollutants leaching into the underlying groundwater.
  - Discharges via soakaways could lead to direct pollution of groundwater/aquifer underlying the scheme.

  - Introduction of wet concrete and grout has the potential negatively impact groundwater quality.
- Impact to the flow of springs, watercourses, groundwater abstractions (licensed and small private) and groundwater-dependent habitats resulting from construction works affecting the rate of recharge to aquifers where the water is captured relative to where it is discharged.

Flood risk

14.7.14 Flood risk may be affected during the construction phase as a result of construction works and temporary or permanent storage areas within a floodplain that may temporarily affect the floodplain function, resulting in an increase in flood risk at that location or elsewhere.

14.7.15 Any construction works on areas that drain to watercourses have the potential to increase the rate and volume of runoff and increase the risk of blockages in watercourses that could lead to flow being impeded, and a potential rise in flood risk. Changes to ground levels, temporary increases in impermeable area and vegetation clearance works may also increase the risk of surface water flooding. Finally, excavations can potentially damage existing sewers leading to flooding.

Construction decommissioning

14.7.16 Consideration will be given in the EIA to the decommissioning of the construction phase, particularly how site compounds and any dedicated haul routes will be decommissioned to avoid unwanted environmental impacts. The EMP (an outline of what will be included within the EMP is included in Appendix 4.1: Outline of Environmental Management Plan) will set out measures that need to be implement upon decomissioning of the construction phase to include mitigation measures that need to be implemented when the project moves from construction to operation. This may include construction drainage and settlement ponds that require to be infilled and removed once the operational drainage systems are in place.

Operation

14.7.17 During operation, significant potential impacts to surface water features and groundwater features and flood risk could arise from:

- Polluted surface water runoff containing sediment, hydrocarbons and soluble pollutants, such as copper and zinc, that may migrate or be discharged to surface water features or groundwater resources via the proposed highway drainage system, including from spillages.
- Permanent impact to the hydro-morphological and ecological quality of water features associated with works within or in close proximity to water features.
- Permanent impacts to catchment hydrology and hydrogeology caused by the introduction of a barrier to natural overland flow e.g. introduction of embankments and changes to natural catchment dynamics associated with the proposed highway drainage system.
- Permanent impacts to catchment hydrology and hydrogeology caused by impact to natural groundwater springs or groundwater flow associated with proposed road cuttings that could affect baseflow to watercourses and groundwater resources.
- Increased dissolution of gypsum bedrock from road drainage in the Kirkby Thore area of the Temple Sowerby to Appleby section where gypsum is present, leading to potential ground instability.

- Increased rates and volumes of surface water runoff due to an increase in impermeable area or changes to the existing drainage regime leading to a potential increase in flood risk.
- Increased flood risk to the project and to people and property elsewhere caused by crossing of watercourses thus affecting flood flow conveyance and the potential loss of floodplain storage volume.
- Change in the rate of recharge of aquifers due to change in ground surface cover and introduction of new drainage systems.
- Reduced dilution and/or dispersion of consented discharges to groundwater and treated sewage effluent due to reduced or redirected groundwater flow paths.

14.7.18 There is limited information regarding the existing road drainage arrangements and water treatment provision. The scheme may provide an opportunity to provide betterment.

14.7.19 Further details on potential impacts operational impacts are provided in the following sections.

Surface water impacts

Surface water quantity

14.7.20 Alteration of ground elevations and changes in surface water flood flow pathways may result in the overloading of drainage systems and/or surface watercourses. This may impact on flood-sensitive receptors near to overloaded systems. Wherever possible, the design will maintain existing catchments.

14.7.21 An increase in impermeable areas or changes to the existing drainage regime could result in increased rates and volumes of surface water runoff and therefore a potential increase in flood risk. This could impact properties and aquatic environments near to flood zones.

14.7.22 The introduction of a barrier to natural overland flow e.g. introduction of embankments and changes to natural catchment dynamics associated with the proposed highway drainage system may have permanent impacts on catchment hydrology and hydrogeology. This may result in a reduction or loss of water supply to downstream receptors, including abstractions, rivers and wetland, and the potential loss of aquatic habitat (which may be permanent).

Surface water quality

14.7.23 Polluted surface water runoff containing silts and hydrocarbons that may migrate or be discharged to surface water features or groundwater resources via the proposed highway drainage system, including from spillages. This has the potential to result in long-term degradation of water quality, pollution of environmental receptors and the potential loss of aquatic habitat. Water quality is particularly sensitive for schemes located within the River Eden catchment which is designated as an SAC and SSSI, and a number of qualifying species are dependent upon high water quality.

14.7.24 The pollution of surface watercourses may result in potential loss of aquatic habitat. This may, in turn, result in impacts on the amenity and economic value of surface water bodies.

14.7.25 There is currently limited information regarding the existing road drainage arrangements and water treatment provision. Details on the exisiting road drainage and treatment will be presented in the ES. The project may provide an opportunity to provide betterment within the draft DCO boundary.

Hydromorphology

14.7.26 Culverts have the potential to affect watercourses by causing local shading, reducing river habitat connectivity and inducing hydromorphological change. There is potential for a permanent impact to the hydromorphological and ecological quality of water features associated with confining the migration of watercourses and increasing the shading and interrupting processes of sediment transfer.

14.7.27 New outfall structures within a watercourse can alter local channel cross section and induce local bank or bed erosion, as well as reduce the available natural bank and riparian habitat area. This is considered highest risk for Appleby to Brough where there are a number of offline crossings of tributaries to the River Eden, posing a risk to both the WFD status and the condition status of the River Eden SAC and SSSI.

14.7.28 New outfalls will be installed to discharge carriageway runoff, which meets the quality standards required by DMRB, from the drainage system to surface watercourses. The discharges will be limited to the greenfield runoff rate, where infiltration is not possible, and will be located near to the proposed drainage basins where possible.

14.7.29 An interruption of flow in the watercourse may result in a reduction or loss of water supply to downstream receptors, including abstractions, rivers and wetlands, and the potential loss of aquatic habitat (which may be permanent).

14.7.30 Where piers within the floodplain are proposed for watercourse crossings, there is a potential to create a barrier to flow and sediment transport. This has the potential to impact the objectives of the River Eden SAC as a result of the Temple Sowerby to Appleby scheme. Detailed assessment of the hydromorphological impacts on the River Eden SAC will be provided in the ES, hydromorphological assessment, WFD compliance assessment and the HRA.

Groundwater

14.7.31 Proposed road cuttings may have permanent impacts on catchment hydrogeology in the case that permanent dewatering is required. This may result in changes to the natural groundwater regime and modify the flow at springs, reduce yield from abstraction wells or reduce baseflow contribution to water courses.

14.7.32 Structures such as piles, retaining walls and deep excavations have the potential to divert or impound groundwater flow, causing groundwater levels to rise on the upgradient side but lower on the down gradient side. Receiving water on the down gradient side my be impacted by a reduction in baseflow or alteration of the pathway to where the baseflow contribution occurs.

14.7.33 A change in the rate of recharge of aquifers due to change in ground surface cover and introduction of new drainage systems may also result in a reduction or loss of water supply to abstractions, springs, watercourses, and the potential loss of aquatic habitat (which may be permanent), and potential GWDTEs, which may be adversely impacted by changes in groundwater levels or quality.

Flood risk

14.7.34 New watercourse crossings and development within the floodplain may affect flood flow conveyance, resulting in increased flood risk to the project and to people and property elsewhere. A change in the flood flow pathway may impact on properties and aquatic environments within and associated with flood zones.

14.7.35 As well as potential effects on operational flood risk, floodplain crossings have the potential to affect natural flood flows and geomorphological processes of the

associated watercourses, which may lead to direct and indirect effects on the in-channel habitats.

Climate change

14.7.36 Future climate conditions derived from the UK Climate Projections 2018 (UKCP18) indicate that the study area may undergo climatic changes including higher temperatures, increase in heat waves, reduced precipitation in summer and increased precipitation in winter. Surface water flows are likely to become more variable, with more frequent extremes.

14.7.37 Increasing long spells of hot weather and wildfires may result in soils developing water repellence, which may reduce or temporarily impede water infiltration, leading to preferential flow and increased surface runoff.This has the potential to impact on existing and future road drainage systems and filtration mitigation.

14.7.38 These conditions are likely to reduce the amount of recharge to the groundwater. Abstractions, springs, groundwater-fed watercourses and areas of flooded ground are likely to be particularly sensitive to these impacts. Groundwater quality is also likely to be affected by a reduction in the flushing of aquifers, which may increase the residence time of groundwater within them.These impacts may cause a compound affect when in combination with potential impacts caused by the proposed scheme such as watertable drawdown.

14.7.39 While the impacts of climate change are likely to affect the water environment, embedded mitigation in the project design, such as climate change allowances in the drainage design (as defined by flood modelling) will ensure that no significant effects arise as a result of the project in combination with the effects of climate change.

14.7.40 The impact of the project on climate change, and the resilience of the project to the effects of climate change, are considered further in Chapter 8: Climate.

14.8 Design, Mitigation and Enhancement Measures

Design

14.8.1 The scheme will be designed to avoid and prevent adverse environmental effects on road drainage and the water environment through the process of design development and consideration of good design principles, and to reduce the impacts if complete avoidance is not possible. This process has been, and continues to be, influenced by the ongoing assessment of potential impacts.

14.8.2 Embedded mitigation measures for road drainage and the water environment include structures within the watercourse designed in accordance with CD 529 (Design of outfall and culvert details) and CIRIA C786 Culvert, Screen and Operation Manual guidance. In addition, embedded mitigation such as the incorporation of climate change allowances in the drainage design will be informed by ongoing flood moddeling.

14.8.3 Oportunities taken to date, and which will continue to be taken as the optioneering process continues, to avoid identified water environment constraints include the optioneering process detailed in Chapter 3: Alternatives, which has identified offline routes to minimise impacts on the floodplain (minimise crossing distance, minimise land take within floodplain, increasing distance from sensitive receptors) and hydromorphology.

Construction mitigation

14.8.4 This preliminary assessment has used a 'reasonable worst case scenario' in order to allow for additional space within the project boundary if additional mitigation may be required at a later project stage following detailed assessment (i.e. the 'mitigation boundary'). Essential mitigation to address likely significant effects will be included following completion of the detailed assessment for the ES.

14.8.5 Mitigation is outlined and secured by way of commitments within the EMP which will be provided as part of the ES. The EMP will be secured by a legal requirement in the DCO. This will include any required mitigation that would ordinarily be associated with other consents that will be disapplied by the DCO (namely flood risk activity permitting or land drainage consent).

14.8.6 The EMP will include measures that are considered standard good practice to be implemented by the construction contractor to reduce the likelihood of impacts, or their magnitude if they were to occur (including, for example, pollution prevention measures set out on GOV.UK and in the Construction Industry Research and Information Association's Guidance for Pollution Prevention). The EMP will include ground and surface water monitoring plans. Requirements for monitoring will be derived during the detailed design phase.

14.8.7 Examples of standard practice mitigation measures that will be included in the EMP include the provision of spill kits, restricting site traffic to dedicated haul roads and ensuring hard-standing areas are regularly swept and maintained.

14.8.8 Site-specific measures may include:

- A surface water management system using measures such as temporary silt fencing, cut off ditches, settlement ponds and bunds set up early in the construction period to capture all runoff and prevent ingress of sediments and contaminants into existing drainage ditches where necessary. This would be managed by the EMP in accordance with CIRIA guidelines and the Environment Agency's approach to groundwater protection (Environment Agency, 2017a)[46] and groundwater protection guidelines (Environment Agency, 2017b)[47].
- Areas of exposed sediment deemed at risk of erosion during heavy rainfall or flood inundation should be protected using either temporary measures (e.g. sheeting) or semi-permanent measures (for example coir matting) until vegetation is able to establish on these surfaces.
- Works should be suspended during out-of-bank river flows or during intense rainstorms.
- A water quality monitoring programme prior to and during construction works should be established.
- Appropriate sequencing and domaining of works to reduce impacts to surface and groundwater flows to be temporarily diverted downstream of the works area where required.
- Abstraction points should be pre-approved and permit system put in place for extraction. Attenuation ponds will be constructed and set up to facilitate

[46] Environment Agency (2017a) Protect groundwater and prevent groundwater pollution, available at: https://www.gov.uk/government/publications/protect-groundwater-and-prevent-groundwater-pollution [accessed 3 September 2021]
[47] Environment Agency (2017b) Groundwater protection technical guidance, available at: https://www.gov.uk/government/publications/groundwater-protection-technical-guidance [accessed 3 September 2021]

extraction of water for damping down during construction; locations of which will be confirmed and incorporated into the ES.

- Water with a higher risk of contamination which requires discharge, including groundwater pumped out of pilings during concrete pouring, will be contained and treated using appropriate measures such as coagulation of sediments, dewatering and pH neutralisation prior to discharge. Such discharges will be regulated via environment permits issued by the Environment Agency.
- Consideration of local groundwater catchment and flow regimes that may be affected by dewatering design and discharging the abstracted water to the same groundwater catchment and down gradient of the dewatered element.
- Discharge from dewatering activities such as earthworks, works within a floodplain or within eight metres of a watercourse should have a tailored risk assessment, alongside appropriate consents and licences from the Environment Agency. Dewatering abstractions may also require transfer licenses from the Environment Agency.
- Grouting may be required to treat voids encountered during earthworks and ground stabilisation works that may involve soil nailing or soil anchors. It is inherently difficult to prevent grout from entering fissures. Therefore, appropriate grouting methodology to be used to reduce risk to the water environment. This would include limitation of grout volumes, monitoring for pH spikes in monitoring standpipes/surface flows, and specification of polymer grouts should this be required.
- A site-specific foundation works risk assessment (FWRA) for the construction of underground structures and ground improvement works.
- Design of underground structures will require drainage provisions to relieve hydrostatic pressure. These would allow for groundwater flow around the structure.
- Review and update of groundwater conceptual model as new, site-specific information is received.
- Review and update of the hydrogeological assessment as new, site-specific information is received.

Operational mitigation

14.8.9 Discharges from the proposed drainage system, including any treatment requirements, will be compliant with relevant standards (*DMRB LA 113*, *CG 501*[48] and *CG 532*[49] as well as the HEWRAT Highways England assessment tool). As a precautionary measure at this stage in the design, all drainage systems have been designed with wet ponds as opposed to dry ponds due to water quality benefits. Water quality improvement measures will be added to the treatment train if the detailed assessment identifies the need. Further treatment may include, for example, vegetated ditches, vortex grit separators and swales (space permitting).

14.8.10 Where schemes have sections in cutting, the drainage system for each scheme, including attenuation basins, will be appropriately sized to allow for potential groundwater ingress within the cuttings. Cutting or structure drainage will maintain flow directions and existing catchment areas wherever possible. Mitigation of effects

[48] Highways England (2020c) Design Manual for Roads and Bridges: CG 501 - Design of highway drainage systems. Revision 2.
[49] Highways England (2020d) Design Manual for Roads and Bridges: CG 532 - Vegetated drainage systems for highway runoff. Revision 0.

associated with embankments to maintain existing flow regime will be detailed in the ES.

14.8.11 Where a licensed abstraction well has the potential to be impacted, a protection plan will be developed for that well. If protection is not possible, a new network connection or replacement well (designed to current guidance) will be provided.

Temple Sowerby to Appleby and Appleby to Brough

14.8.12 As described in Section 14.7, the crossing of Trout Beck and the River Eden for the Temple Sowerby to Appleby scheme and a number of watercourse crossings, including Hayber Beck, Moor Beck and Eastfield Sike, for the Appleby to Brough scheme, have the potential to affect the Main watercourses crossed and the qualifying features of the River Eden SAC designation.

14.8.13 Through consultation with the Enviornment Agency, Natural England and the Eden Rivers Trust, the following design principles have been identified that will apply to the crossing, no matter which route is selected:

- Locations of piers within the floodplain to be placed in order to minimise disturbance to flood flows, sediment transport and biodiversity. This will require an iterative design process to be informed by flood risk and geomorphological assessment.
- For the ES, specialist geomorphologist input will inform watercourse crossing and pier design including shape, alignment relative to the watercourse flow and foundation depth. This will minimise the risk of an interruption of the hydraulic processes should the piers become mid-channel structures following lateral migration of the watercourse.
- Outfall structures from road drainage into Trout Beck will be set back from the watercourse banks and an open channel used to connect the outfalls to the watercourse. This will allow lateral migration of river channel and limit damage to outfalls.

14.8.14 The above measures have been identified so that the scheme design will not prevent the SAC achieving its target of restoring natural hydrological processes.

Enhancements – route wide

14.8.15 Opportunities for enhancing the different aspects of the water environment shall be sought and reported in the ES.

14.8.16 The project will comprise a road drainage scheme that will discharge carriageway runoff, ensuring it meets the quality standards required by DMRB. This is likely to provide a betterment on the existing road drainage system and improve the water quality of receiving waterbodies in comparison to original outfalls.

14.8.17 Improvements of existing culverts may provide potential opportunity for enhancements.

14.8.18 Potential options for limiting runoff from existing road surfaces will be sought as the drainage across the existing road system is improved.

14.8.19 There may also be additional indirect enhancements from the removal and/or upgrading of existing foul drainage outfalls, to surface water and groundwaters at various properties downstream.

14.8.20 The Eden Rivers Trust are leading a potential restoration project at Sleastonhowe, which the project has the potential to interface with. The design team are, and will

continue to, work closely with the Rivers Trust, with the aim of ensuring the restoration project can successfully proceed.

14.9 Assessment of the Likely Significant Effects

14.9.1 The preliminary assessment of likely significant effects of the project on surface water and groundwater receptors is presented in the following sections. The assessment is based upon current available information and professional judgement. At this point a precautionary view has been taken. However, these effects could reduce as the EIA progresses.

14.9.2 Following a desktop review of receptor baseline information, potential source and pathways to effects, and field surveys, receptors where it is not considered to have potential for significant effects were identifed, 48 receptors do not require any further assessment. Details of the receptors not taken forward for further assessment can be found in Appendix 14.2: Receptors Scoped Out. The receptors that have been scoped out have been done so due to lack of hydrological connection to the scheme or being situated upstream/upgradient of the scheme.

14.9.3 Scheme specific potential impacts and the specific receptors likely affected are listed in Table 14-16: Route wide - likely significant effects (Road Drainage and the Water Environment) to Table 14-25: Stephen Bank to Carkin Moor - likely significant effects (Road Drainage and the Water Environment). Likely significant effects are considered following mitigation.

Route wide

14.9.4 Table 14-16: Route wide - likely significant effects (Road Drainage and the Water Environment), outlines the potential route wide impacts and design, mitigation and enhancement measures to scoped-in road drainage and water environment receptors during construction and operation within the study area of the schemes, these receptors incorporate all receptors identified in the baseline (detailed in Appendix 14.1: Preliminary Assessment of Receptor Importance) that have not been scoped out (as detailed in Appendix 14.2: Receptors Scoped Out).

Table 14-16: Route wide - likely significant effects (Road Drainage and the Water Environment)

Receptor	Potential Impacts (Construction)	Potential Impacts (Operation)	Design, Mitigation and Enhancement Measures	Likely Significant Effect Following Mitigation?
Surface waters	Degradation of surface water quality, as work near to watercourses has the potential to discharge site runoff into watercourses. In addition, there is risk of accidental spillage of pollutants (e.g. fuel leakage from the storage of plant).		Best practice construction mitigation measures and temporary construction drainage to trap and remove pollutants before reaching the receiving environment. Comprehensive runoff control installed at the start of construction to trap sediment. Regular maintenance will be conducted to maintain capacity.	No (construction)
Surface waters		Polluted surface water runoff containing sediment, hydrocarbons and soluble pollutants, such as copper and zinc, that may migrate or be discharged to surface water features or groundwater resources via the proposed highway drainage system, including from spillages.	Following *DMRB LA 113* guidance, HEWRAT assessments will be conducted to calculate the provision of sufficient contaminant treatment measures within the drainage system to ensure the water quality of the receptor. Drainage scheme will be designed and installed to trap sediment and other pollutants from the scheme.	No (operation)

Receptor	Potential Impacts (Construction)	Potential Impacts (Operation)	Design, Mitigation and Enhancement Measures	Likely Significant Effect Following Mitigation?
Surface waters	Impacts to local land drainage structures, that may alter existing drainage patterns within catchments and provide potential pathways for pollution Dewatering during earthworks altering existing drainage patterns within catchments and provide potential pathways for pollution		The contractor will adhere to pollution prevention procedures, to be outlined in the EMP and in accordance with CIRIA guidelines. Appropriate risk assessments will be completed to understand drainage patterns. Required consents will be incorporated into the DCO or obtained separately from the Environment Agency or LLFA.	No (construction)
Surface waters		Permanent impacts to catchment hydrology and hydrogeology caused by the introduction of a barrier to natural overland flow e.g. introduction of embankments and changes to natural catchment dynamics associated with the proposed highway drainage system.	Assessment of groundwater-surface water interaction for the ES will inform the cutting or structure drainage design (which will then itself be considered as part of the assessment of the Project) to help maintain flow and existing catchment areas wherever possible. Mitigation for effects associated with embankments will be detailed in the EMP to maintain existing flow regimes.	No (operation)

Receptor	Potential Impacts (Construction)	Potential Impacts (Operation)	Design, Mitigation and Enhancement Measures	Likely Significant Effect Following Mitigation?
Surface waters	Impacts to the hydro-morphological quality of watercourses associated with works within or in close proximity to watercourses.		Hydromorphology surveys will be carried out for the ES and will inform design of artificial structures and any change in channel length or width (which will then itself be considered as part of the assessment of the Project). Where possible the scheme will avoid interaction with watercourses and their floodplains. Where this is not possible, such as for structures including the use of piers within the floodplain, hydromorphology will be assessed and considered to minimise the risk of impact during construction activities.	No (construction)

Receptor	Potential Impacts (Construction)	Potential Impacts (Operation)	Design, Mitigation and Enhancement Measures	Likely Significant Effect Following Mitigation?
Surface waters		Impacts to hydromorphology and sediment regimes as a result of the introduction of artificial structures into the water environment (for example culverts and piers).	Hydromorphology surveys will be carried out for the ES and will inform design of artificial structures and any change in channel length or width (which will then itself be considered as part of the assessment of the Project). Where possible the scheme will avoid interaction with watercourses and their floodplains. Where this is not possible, such as for structures within the floodplain, hydromorphology will be assessed to ensure the design minimises any impact during operation.	Not likely but potential for residual effects on higher value receptors. (operation)

Receptor	Potential Impacts (Construction)	Potential Impacts (Operation)	Design, Mitigation and Enhancement Measures	Likely Significant Effect Following Mitigation?
Surface waters	Construction within flood zones resulting in risk of flooding of construction area, and an increased risk of pollutant transfer to watercourses.		Where possible, limited construction activities will take place within floodplains and material storage will be located outside floodplains. Mitigation measures to avoid working in flood risk areas during winter or flood events will be implemented, where possible. Construction best practice such as diversions and temporary attenuation and retention ponds will be considered where appropriate. Provision of temporary compensatory storage to accommodate temporary loss of floodplain during construction.	No (construction)
Surface waters and downstream properties		Increased rates and volumes of surface water runoff due to an increase in impermeable area or changes to the existing drainage regime leading to a potential increase in flood risk.	The FRA will inform the drainage design. The drainage will be designed to accommodate the 1 in 100-year event and the most up to date climate change factors.	No (operation)

Receptor	Potential Impacts (Construction)	Potential Impacts (Operation)	Design, Mitigation and Enhancement Measures	Likely Significant Effect Following Mitigation?
The project and downstream properties		Increased flood risk to the project and to people and property elsewhere caused by crossing of watercourses thus affecting flood flow conveyance and the potential loss of floodplain storage volume	The FRA will inform the scheme design. The scheme will be designed to accommodate a 1 in 100-year event and the most up to date climate change factors. The FRA will inform site specific design considerations. Flood storage measures will be included within the design where required, including flood compensation storage.	No (operation)
Groundwater bodies	Degradation of groundwater quality and modification of groundwater flow pathways from potential site runoff to ground. In addition, there is risk of accidental spillage of pollutants (e.g. fuel leakage from the storage of plant).		Best practice construction mitigation measures and temporary construction drainage to trap and remove pollutants before reaching the receiving environment. Comprehensive runoff control installed at the start of construction to trap sediment. Regular maintenance will be conducted to maintain capacity.	No (construction)
Groundwater bodies		Changes to groundwater flow by impoundment or damming of pathways due deep excavations or retaining walls.	In cases where deep excavations intersect the groundwater table then groundwater control measures such as drainage blankets will be incorporated to ensure that pathways are cut off and pathways interrupted.	No (operation)

Receptor	Potential Impacts (Construction)	Potential Impacts (Operation)	Design, Mitigation and Enhancement Measures	Likely Significant Effect Following Mitigation?
Small private supplies (dug wells, boreholes and springs)	Reduction in water quality		For wells and boreholes, protection by deepening existing well and sealing off upper section that may be at risk. If the existing sources does not allow protection (such as springs) or has the potential to significantly reduce yield, then a replacement source to be provided.	No (construction)

M6 Junction 40 to Kemplay Bank

14.9.5 Table 14-17: M6 Junction 40 to Kemplay Bank - likely significant effects (Road Drainage and the Water Environment) details the potential impacts during construction and operation to the receptors scoped in within the M6 Junction 40 to Kemplay Bank study area, any design, mitigation and enhancement measures and subsequent likely significant effects following mitigation.

Table 14-17: M6 Junction 40 to Kemplay Bank - likely significant effects (Road Drainage and the Water Environment)

Receptors	Potential Impacts (Construction)	Potential Impacts (Operation)	Design, Mitigation and Enhancement Measures	Likely Significant Effect Following Mitigation?
Bedrock and superficial aquifers	Degradation of groundwater quality from potential site runoff to ground. In addition, there is risk of accidental spillage of pollutants (e.g. fuel leakage from the storage of plant).		Best practice construction mitigation measures and temporary construction drainage to trap and remove pollutants before reaching the receiving environment. Comprehensive runoff control installed at the start of construction to trap sediment. Regular maintenance will be conducted to maintain capacity.	No (construction)
Abstraction well 2776004056/R01 Abstraction well 277600644	Reduction in water quality		If required - protection of wells by deepening existing well and sealing off upper section that may be at risk. If the existing well does not allow protection without reducing yield a replacement well will be required	No (construction)

Penrith to Temple Sowerby

14.9.6 Table 14-18: Penrith to Temple Sowerby - likely significant effects (Road Drainage and the Water Environment) details the potential impacts during construction and operation to the receptors scoped in within the Penrith to Temple Sowerby study area, any design, mitigation and enhancement measures and subsequent likely significant effects following mitigation.

Table 14-18: Penrith to Temple Sowerby - likely significant effects (Road Drainage and the Water Environment)

Receptor	Potential Impacts (Construction)	Potential Impacts (Operation)	Design, Mitigation and Enhancement Measures	Likely Significant Effect Following Mitigation?
Bedrock and superficial aquifers GW SPZ 3 Spring S29	Degradation of groundwater quality from potential site runoff to ground. In addition, there is risk of accidental spillage of pollutants (e.g. fuel leakage from the storage of plant).		Best practice construction mitigation measures and temporary construction drainage to trap and remove pollutants before reaching the receiving environment. Comprehensive runoff control installed at the start of construction to trap sediment. Regular maintenance will be conducted to maintain capacity.	No (construction)

Temple Sowerby to Appleby

Blue alternative

14.9.7 Table 14-19: Temple Sowerby to Appleby Blue alternative - likely significant effects (Road Drainage and the Water Environment) details the potential impacts during construction and operation to the receptors scoped in within the Temple Sowerby to Appleby Blue alternative study area, any design, mitigation and enhancement measures and subsequent likely significant effects following mitigation.

Table 14-19: Temple Sowerby to Appleby Blue alternative - likely significant effects (Road Drainage and the Water Environment)

Receptor	Potential Impacts (Construction)	Potential Impacts (Operation)	Design, Mitigation and Enhancement Measures	Likely Significant Effect Following Mitigation?
Trout Beck	Impacts to the hydro-morphological quality of watercourses associated with works within or in close proximity to watercourses.	Impacts to hydromorphology and sediment regimes as a result of the introduction of artificial structures into the water environment (for example culverts and piers).	Detailed assessment of hydromorphology will be undertaken for the ES to inform the design of the crossing, including the spacing of piers within the floodplain and the types of crossing considered (which will then itself be considered as part of the assessment of the Project). Best practice mitigation for all works within floodplains or within close proximity will be adhered to. Further location specific mitigation will be considered where necessary following assessments.	No, subject to the final design incorporating the recommendations for mitigation that are based on detailed assessment (construction and operation).

Receptor	Potential Impacts (Construction)	Potential Impacts (Operation)	Design, Mitigation and Enhancement Measures	Likely Significant Effect Following Mitigation?
Bedrock and superficial aquifers	Degradation of groundwater quality from potential site runoff to ground. In addition, there is risk of accidental spillage of pollutants (e.g. fuel leakage from the storage of plant).		Best practice construction mitigation measures and temporary construction drainage to trap and remove pollutants before reaching the receiving environment. Comprehensive runoff control installed at the start of construction to trap sediment. Regular maintenance will be conducted to maintain capacity.	No (construction)
Abstraction well 2776003013 Abstraction well 2776003012/R01	Reduction in water quality		If required - protection of wells by deepening existing well and sealing off upper section that may be at risk. If the existing well does not allow protection without reducing yield, then a replacement well will be required	No (construction)
Two Industrial abstraction wells (Licence number: 277600311) in Kirkby Thore Private small supplies	Reduction in water quality	Lowering of groundwater level and reduction in yield	If required - protection of wells by deepening existing well and sealing off upper section that may be at risk. If the existing well does not allow protection without reducing yield, then a replacement well will be required	No (construction and operation)

Red alternative

14.9.8 Table 14-20: Temple Sowerby to Appleby Red alternative - likely significant effects (Road Drainage and the Water Environment) details the potential impacts during construction and operation to the receptors scoped in within the Temple Sowerby to Appleby Red alternative study area, any design, mitigation and enhancement measures and subsequent likely significant effects following mitigation.

Table 14-20: Temple Sowerby to Appleby Red alternative - likely significant effects (Road Drainage and the Water Environment)

Receptor	Potential Impacts (Construction)	Potential Impacts (Operation)	Design, Mitigation and Enhancement Measures	Likely Significant Effect Following Mitigation?
Keld Sike (1) Trout Beck	Impacts to the hydro-morphological quality of watercourses associated with works within or in close proximity to watercourses.	Impacts to hydromorphology and sediment regimes as a result of the introduction of artificial structures into the water environment (for example culverts and piers).	Detailed assessment of hydromorphology will be undertaken for the ES to inform the design of the crossing, including the spacing of piers within the floodplain and the types of crossing considered (which will then itself be considered as part of the assessment of the Project). Best practice mitigation for all works within floodplains or within close proximity will be adhered to. Further location specific mitigation will be considered where necessary following assessments.	No, subject to the final design incorporating the recommendations for mitigation that are based on detailed assessment (construction and operation).

Receptor	Potential Impacts (Construction)	Potential Impacts (Operation)	Design, Mitigation and Enhancement Measures	Likely Significant Effect Following Mitigation?
Bedrock and superficial aquifers	Degradation of groundwater quality from potential site runoff to ground. In addition, there is risk of accidental spillage of pollutants (e.g. fuel leakage from the storage of plant).		Best practice construction mitigation measures and temporary construction drainage to trap and remove pollutants before reaching the receiving environment. Comprehensive runoff control installed at the start of construction to trap sediment. Regular maintenance will be conducted to maintain capacity.	No (construction)
Two Industrial abstraction wells (Licence number: 277600311) in Kirkby Thore	Reduction in water quality	Lowering of groundwater level and reduction in yield	If required - protection of wells by deepening existing well and sealing off upper section that may be at risk. If the existing well does not allow protection without reducing yield, then a replacement well will be required	No (construction and operation)
Abstraction well 2776003013 Abstraction well 2776003012/R01	Reduction in water quality		If required - protection of wells by deepening existing well and sealing off upper section that may be at risk. If the existing well does not allow protection without reducing yield, then a replacement well will be required	No (construction)

Orange alternative

14.9.9 Table 14-21: Temple Sowerby to Appleby Orange alternative - likely significant effects (Road Drainage and the Water Environment) details the potential impacts during construction and operation to the receptors scoped in within the Temple Sowerby to Appleby Orange alternative study area, any design, mitigation and enhancement measures and subsequent likely significant effects following mitigation.

Table 14-21: Temple Sowerby to Appleby Orange alternative - likely significant effects (Road Drainage and the Water Environment)

Receptor	Potential Impacts (Construction)	Potential Impacts (Operation)	Design, Mitigation and Enhancement Measures	Likely Significant Effect Following Mitigation?
Unnamed Tributary of Birk Sike 4.2 Trout Beck River Eden	Impacts to the hydro-morphological quality of watercourses associated with works within or in close proximity to watercourses.	Impacts to hydromorphology and sediment regimes as a result of the introduction of artificial structures into the water environment (for example culverts and piers).	Detailed assessment of hydromorphology will be undertaken for the ES to inform the design of the crossing, including the spacing of piers within the floodplain and the types of crossing considered (which will then itself be considered as part of the assessment of the Project). Best practice mitigation for all works within floodplains or within close proximity will be adhered to. Further location specific mitigation will be considered where necessary following assessments.	No, subject to the final design incorporating the recommendations for mitigation that are based on detailed assessment (construction and operation).

Receptor	Potential Impacts (Construction)	Potential Impacts (Operation)	Design, Mitigation and Enhancement Measures	Likely Significant Effect Following Mitigation?
Bedrock and superficial aquifers	Degradation of groundwater quality from potential site runoff to ground. In addition, there is risk of accidental spillage of pollutants (e.g. fuel leakage from the storage of plant).		Best practice construction mitigation measures and temporary construction drainage to trap and remove pollutants before reaching the receiving environment. Comprehensive runoff control installed at the start of construction to trap sediment. Regular maintenance will be conducted to maintain capacity.	No (construction)
Abstraction well 2776003013 Abstraction well 2776003012/R01	Reduction in water quality		If required - protection of wells by deepening existing well and sealing off upper section that may be at risk. If the existing well does not allow protection without reducing yield a replacement well will be required	No (construction)

Appleby to Brough

Black-black-black route

14.9.10 Table 14-22: Appleby to Brough Black-black-black route - likely significant effects (Road Drainage and the Water Environment) details the potential impacts during construction and operation to the receptors scoped in within the Appleby to Brough Black-black-black route study area, any design, mitigation and enhancement measures and subsequent likely significant effects following mitigation.

Table 14-22: Appleby to Brough Black-black-black route - likely significant effects (Road Drainage and the Water Environment)

Receptor	Potential Impacts (Construction)	Potential Impacts (Operation)	Design, Mitigation and Enhancement Measures	Likely Significant Effect Following Mitigation?
Hayber Beck Moor Beck Eastfield Sike Crooks Beck Lowgill Beck Unnamed Tributary of Lowgill Beck 6.1 Woodend Sike Yosgill Sike	Impacts to the hydro-morphological quality of watercourses associated with works within or in close proximity to watercourses.	Impacts to hydromorphology and sediment regimes as a result of the introduction of artificial structures into the water environment (for example culverts and piers).	Detailed assessment of hydromorphology will be undertaken for the ES to inform the design of the crossing, including the types of crossing considered (which will then itself be considered as part of the assessment of the Project). Best practice mitigation for all works within floodplains or within close proximity will be adhered to. Further location specific mitigation will be considered where necessary following assessments.	No, subject to the final design incorporating the recommendations for mitigation that are based on detailed assessment (construction and operation).
Borehole at West View Brough, Kirkby Stephen	Reduction in water quality	Lowering of groundwater level and reduction in yield	If required - protection of wells by deepening existing well and sealing off upper section that may be at risk. If the existing well does not allow protection without reducing yield, then a replacement well will be required	No (construction and operation)

Blue alternative (central section)

14.9.11 Table 14-23: Appleby to Brough Blue alternative (central section) - likely significant effects (Road Drainage and the Water Environment) details the potential impacts during construction and operation to the receptors scoped in within the Appleby to Brough Blue alternative (central section) study area, any design, mitigation and enhancement measures and subsequent likely significant effects following mitigation.

Table 14-23: Appleby to Brough Blue alternative (central section) - likely significant effects (Road Drainage and the Water Environment)

Receptor	Potential Impacts (Construction)	Potential Impacts (Operation)	Design, Mitigation and Enhancement Measures	Likely Significant Effect Following Mitigation?
River Eden Unnamed Tributary of Unnamed Tributary of Mire Sike 6.12 Mire Sike Unnamed Tributary of Cringle Beck 6.1 Cringle Beck Hayber Beck Moor Beck Eastfield Sike Crooks Beck Lowgill Beck Unnamed Tributary of Lowgill Beck 6.1 Woodend Sike Yosgill Sike Unnamed Tributary of Lowgill Beck 6.7	Impacts to the hydro-morphological quality of watercourses associated with works within or in close proximity to watercourses.	Impacts to hydromorphology and sediment regimes as a result of the introduction of artificial structures into the water environment (for example culverts and piers).	Detailed assessment of hydromorphology will be undertaken for the ES to inform the design of the crossing, including the types of crossing considered (which will then itself be considered as part of the assessment of the Project). Best practice mitigation for all works within floodplains or within close proximity will be adhered to. Further location specific mitigation will be considered where necessary following assessments.	No, subject to the final design incorporating the recommendations for mitigation that are based on detailed assessment (construction and operation).

Receptor	Potential Impacts (Construction)	Potential Impacts (Operation)	Design, Mitigation and Enhancement Measures	Likely Significant Effect Following Mitigation?
Borehole at West View Brough, Kirkby Stephen	Reduction in water quality	Lowering of groundwater level and reduction in yield	If required - protection of wells by deepening existing well and sealing off upper section that may be at risk. If the existing well does not allow protection without reducing yield, then a replacement well will be required	No (construction and operation)

Orange alternative (eastern section)

14.9.12 Table 14-24: Appleby to Brough Orange alternative (eastern section) - likely significant effects (Road Drainage and the Water Environment) details the potential impacts during construction and operation to the receptors scoped in within the Appleby to Brough Orange alternative (eastern section) study area, any design, mitigation and enhancement measures and subsequent likely significant effects following mitigation.

Table 14-24: Appleby to Brough Orange alternative (eastern section) - likely significant effects (Road Drainage and the Water Environment)

Receptor	Potential Impacts (Construction)	Potential Impacts (Operation)	Design, Mitigation and Enhancement Measures	Likely Significant Effect Following Mitigation?
Lowgill Beck Unnamed Tributary of Lowgill Beck 6.1 Woodend Sike Yosgill Sike Unnamed Tributary of Lowgill Beck 6.7	Impacts to the hydro-morphological quality of watercourses associated with works within or in close	Impacts to hydromorphology and sediment regimes as a result of the introduction of artificial structures into the water environment (for example culverts and piers).	Detailed assessment of hydromorphology will be undertaken for the ES to inform the design of the crossing, including the types of crossing considered (which will then itself be considered as part of the assessment of the Project).	No, subject to the final design incorporating the recommendations for mitigation that are based on detailed assessment

Receptor	Potential Impacts (Construction)	Potential Impacts (Operation)	Design, Mitigation and Enhancement Measures	Likely Significant Effect Following Mitigation?
Swindale Beck	proximity to watercourses.		Best practice mitigation for all works within floodplains or within close proximity will be adhered to. Further location specific mitigation will be considered where necessary following assessments.	(construction and operation).
Borehole at West View Brough, Kirkby Stephen	Reduction in water quality	Lowering of groundwater level and reduction in yield	If required - protection of wells by deepening existing well and sealing off upper section that may be at risk. If the existing well does not allow protection without reducing yield, then a replacement well will be required	No (construction and operation)

Bowes Bypass

14.9.13 There are no scheme specific impacts within the Bowes Bypass study area. Design, mitigation and enhancement measures and subsequent likely significant effects following mitigation are included in Table 14-17: M6 Junction 40 to Kemplay Bank - likely significant effects (Road Drainage and the Water Environment) of route wide likely effects.

Cross Lanes to Rokeby

Black route (evolved version of the Preferred Route announced in Spring 2020)

14.9.14 There are no scheme specific impacts within the Cross Lanes to Rokeby Black route study area, any design, mitigation and enhancement measures and subsequent likely significant effects following mitigation are included in Table 14-17: M6 Junction 40 to Kemplay Bank - likely significant effects (Road Drainage and the Water Environment) of route wide likely effects.

Blue (Cross Lanes) alternative junction

14.9.15 There are no scheme specific impacts within the Cross Lanes to Rokeby Blue (Cross Lanes) alternative junction study area. Design, mitigation and enhancement measures and subsequent likely significant effects following mitigation are included in Table 14-17: M6 Junction 40 to Kemplay Bank - likely significant effects (Road Drainage and the Water Environment) of route wide likely effects.

Red (Rokeby) alternative junction

14.9.16 There are no scheme specific impacts within the Cross Lanes to Rokeby Red (Rokeby) alternative junction study area. Design, mitigation and enhancement measures and subsequent likely significant effects following mitigation are included in Table 14-17: M6 Junction 40 to Kemplay Bank - likely significant effects (Road Drainage and the Water Environment) of route wide likely effects.

Stephen Bank to Carkin Moor

14.9.17 Table 14-25: Stephen Bank to Carkin Moor - likely significant effects (Road Drainage and the Water Environment) details the potential impacts during construction and operation to the receptors scoped in within the Stephen Bank to Carkin Moor study area, any design, mitigation and enhancement measures and subsequent likely significant effects following mitigation.

Table 14-25: Stephen Bank to Carkin Moor - likely significant effects (Road Drainage and the Water Environment)

Receptor	Potential Impacts (Construction)	Potential Impacts (Operation)	Design, Mitigation and Enhancement Measures	Likely Significant Effect Following Mitigation?
Spring S1	Degradation of groundwater quality from potential site runoff to ground. In addition, there is risk of accidental spillage of pollutants (e.g. fuel leakage from the storage of plant).		Best practice construction mitigation measures and temporary construction drainage to trap and remove pollutants before reaching the receiving environment.	No

A1(M) Junction 53 Scotch Corner

14.9.18 There are no scheme specific impacts within the A1(M) Junction 53 Scotch Corner study area. Design, mitigation and enhancement measures and subsequent likely significant effects following mitigation are included in Table 14-17: M6 Junction 40 to Kemplay Bank - likely significant effects (Road Drainage and the Water Environment) of route wide likely effects.

Summary of preliminary assessment

Preliminary construction assessment

14.9.19 Following the implementation of mitigation which will be as part of the EMP, there will be no likely significant temporary or permanent adverse effects during construction activities.

14.9.20 In relation to construction flood risk management, appropriate risk assessments will be undertaken pursuant to the EMP and detailed approvals will be obtained where necessary pursuant to the provisions of the DCO, which will disapply the need for land drainage consent or flood risk activity permits.

Preliminary operation assessment

14.9.21 Provided mitigation detailed within Section 14.8 are incorporated into the design, no likely significant effects on the water environment are anticipated during the operation of the project.

14.10 Monitoring

14.10.1 Water environment monitoring should be conducted across the project during the construction phase at appropriate locations to detect changes in the water environment from construction, and to determine locations for additional new mitigation or maintenance of existing mitigation measures, as part of the management plans that will be required by the EMP. The duration of monitoring should be programmed to provide sufficient baseline data to allow comparison between the baseline and subsequent monitoring during the construction of the project.

14.10.2 This may include the monitoring of the following groups of parameters (selected to capture construction risks) based upon WFD status and baseline pre-construction monitoring results:

- Hydrocarbons, suspended solids and heavy metals
- Physio-chemical parameters
- Groundwater levels
- Visual inspections to be conducted by an Environmental Clerk of Works (ECoW)

14.10.3 Where significant adverse environmental effects are reported for a scheme, projects shall undertake further monitoring in accordance with *DMRB LA 104*. This is considered unlikely to be needed given the preliminary assessment reported in this PEI Report.