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Network Rail

Oxford Corridor Phase 2 Capacity Improvement Scheme

Environmental Impact Assessment – Environmental Statement: Chapter 14 – Water Resources and Flood Risk

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14. WATER RESOURCES AND FLOOD RISK

14.1 Introduction

14.1.1 This chapter of the Environmental Statement reports the potential effects resulting from the construction and operation of the Scheme on water resources and flood risk. The assessment has taken the following approach:

- identification of baseline conditions;
- details of relevant mitigation embedded within the Scheme and construction management measures;
- assessment of potential effects on water resources and flood risk from the Scheme;
- proposals for appropriate additional mitigation measures if required; and
- conclusions on the likely significant residual effects of the Scheme on water resources and flood risk.

14.1.2 A full description of the Scheme is given in Chapter 2 – Description of the Scheme.

14.1.3 The water resources and flood risk assessment consider the following:

- flood risk and surface water drainage;
- water quality; and
- groundwater.

14.1.4 This chapter is supported by figures within Volume 3 and two appendices within Volume 4 of this Environmental Statement. The figures within Volume 3 are (those figures denoted with an 'A' relate to Appendix 14.1 Flood Risk Assessment):

- Figure 14.1 – Environmental Constraints; Biodiversity, Surface Water and Groundwater;
- Figure 14.2 – Surface Water Features;
- Figure A14.1 – Reservoir Failure
- Figure A14.2 - Environment Agency Flood Zones;
- Figure A14.3 – Historic Flooding;
- Figure A14.4 – Baseline Fluvial Modelling - 5% AEP;
- Figure A14.5 – Baseline Fluvial Modelling - 1% AEP;
- Figure A14.6 – Baseline Fluvial Modelling - 1% AEP + 35% Allowance for Climate Change;

- Figure A14.7 – Baseline Fluvial Modelling - 1% AEP + 70% Allowance for Climate Change;
- Figure A14.8 – With-Scheme Modelling - 5% AEP;
- Figure A14.9 – With-Scheme Modelling - 1% AEP;
- Figure A14.10 – With-Scheme Modelling - 1% + 35% Allowance for Climate Change;
- Figure A14.11 – With-Scheme Modelling - 1% + 70% Allowance for Climate Change;
- Figure A14.12 – Baseline Surface Water Flood Risk;
- Figure A14.13 – Flood Depth Difference – 1% AEP; and
- Figure A14.14 - Flood Depth Difference – 1% AEP% + 70% Allowance for Climate Change.

14.1.5 The appendices within Volume 4 are:

- Appendix 14.1 – Flood Risk Assessment; and
- Appendix 14.2 – Preliminary Water Environment Regulations Compliance Assessment.

14.1.6 This chapter provides an assessment of the potential effects on water resources and flood risk caused by the construction and operation of the Scheme.

14.1.7 The assessment of the potential effects has been undertaken based on the guidance provided within Design Manual for Roads and Bridges (DMRB) LA113 Road Drainage and the Water Environment (Highways England et al., March 2020; hereafter referred to as DMRB LA113) and DMRB LA104 (Highways England et al., July 2019; hereafter referred to as DMRB LA104).

14.2 Legislation, Policy and Guidance

14.2.1 The following section outlines the relevant national legislation, regional and local planning policies, and guidance relevant to this assessment.

14.2.2 Table 14.1 sets out the relevant legislation, Table 14.2 sets out relevant planning policy and Table 14.3 provides a summary of relevant guidance for this water resources and flood risk assessment.

14.2.3 The legislation, policies and guidance listed have been considered in the assessment of the likely significant effects on water resources and flood risk as a result of the Scheme. It has also been referred to during the development of appropriate mitigation measures.

Table 14.1: Legislation relevant to Water Resources and Flood Risk

Legislation	Description in relation to Water Resources and Flood Risk	Relevance to the Scheme
Flood Risk		
Environmental Protection Act 1990	The Environmental Protection Act (1990) defines the structure and authority of waste management and control of emissions into the environment within England, Wales and Scotland.	The Scheme incorporates control of waste and water within its design and mitigation measures.
Land Drainage Act 1991 and 1994	The Land Drainage Act outlines the responsibilities of various bodies that deal with local (land) drainage including local authorities, internal drainage boards and riparian owners.	The Scheme may have impacts on surface water and would incorporate a new drainage design.
Environment Act 1995	The Environment Act (1995) created a number of new agencies including the Environment Agency and requires the Environment Agency to supervise all matters relating to flood risk management in England and Wales.	The Scheme would be located within all Flood Zones: 1, 2, 3a and 3b and therefore is at risk of flooding. Works within Flood Zone 2 and 3 and that impact on fluvial flood risk would require agreement with the Environment Agency.
Flood and Water Management Act 2010	The Flood and Water Management Act (2010) defines the responsibilities of various flood risk management authorities. The Act gives the Environment Agency strategic overview for national flood risk management in England and gives unitary and county councils responsibility for local flood risk management. The Act also requires new developments to have sustainable urban drainage systems.	The Scheme would be located within all Flood Zones: 1, 2, 3a and 3b and therefore is at risk of flooding. Works within Flood Zone 2 and 3 and that impact on fluvial flood risk would require agreement with the Environment Agency. The Scheme may have impacts on surface water and would incorporate new drainage design such as soakaways. The Lead Local Flood Authority will be consulted.
Flood Risk (England and Wales) Regulations 2016	The Flood Risk Regulations transposed the EU Floods Directive into law in England and Wales. The EU Floods Directive aims to provide a consistent approach to flood risk management across Europe.	The Scheme would be located within all Flood Zones: 1, 2, 3a and 3b and therefore is at risk of flooding. The development may also impact flood risk elsewhere and have impacts on existing flood risk management strategies.
Water Quality		
Water Resources Act 1991	The Water Resources Act (1991) defines the duties of the Environment Agency on flood defences and other areas relating to water management and quality.	Relevant to potential interaction of the Scheme with flood defences and groundwater.

Legislation	Description in relation to Water Resources and Flood Risk	Relevance to the Scheme
Control of Pollution (Oil Storage) (England) Regulations 2001	The Control of Pollution (Oil Storage) Regulations 2001 outlines the requirements in which oil should be stored to reduce the risk of a pollution incident.	Relevant to all surface water and ground waters. Construction sites and activities likely to include the use of and storage of oil.
Environmental Permitting (England and Wales) Regulations 2016 (as amended)	These regulations provide for the regulation of specified installations and controls over emissions to the environment such as via discharges to the water environment and flood risk activities.	Predominantly during construction where environmental permits may be required for discharges to the water environment and flood risk activities.
The Water Environment (Water Framework Directive) (England and Wales) Regulations 2017	The Water Environment Regulations requires measures to be put in place to prevent deterioration and ensure support for environmental objectives to be achieved for all water bodies.	Sheepwash Channel and surrounding watercourses form sections of the Thames Water Framework Directive (WFD) waterbody.
Groundwater		
Water Act 2003	Parliamentary Act amending the Water Resources Act 1991, Reservoirs Act 1975 and the Water Industry Act 1991. Makes provision in connection with land drainage and flood defence; contaminated land so far as it relates to the pollution of controlled waters.	Contamination from activities relating to site works could impact groundwater and potentially contaminated water could be discharged to the ground.
Water Supply (Water Quality) Regulations 2016	The Water Supply (Water Quality) Regulations 2016 consolidates legislation concerning the quality of water supplies for human consumption in England. .	The Scheme overlies a Secondary A superficial aquifer which has the potential to be a supply of drinking water.

Table 14.2: Planning policy relevant to Water Resources and Flood Risk

Policy Document	Description in relation to Water Resources and Flood Risk	Relevance to the Scheme
Flood Risk		
National Planning Policy Framework (NPPF) (2019)	The NPPF sets out the Government's planning policies for England and sets tests to protect people and property from flooding which all Local Planning Authorities are expected to follow. Where these tests are not met, NPPF makes clear that new development should not be allowed. Where there are more suitable sites in terms of flood risk, or a proposed development cannot be made safe, it should not be permitted.	The Scheme would be located within all Flood Zones: 1, 2, 3a and 3b and therefore is at risk of flooding. Works within Flood Zone 2 and 3 and that impact on fluvial flood risk would require agreement with the Environment Agency. A flood risk assessment (FRA) has been carried out to

Policy Document	Description in relation to Water Resources and Flood Risk	Relevance to the Scheme
		investigate flood risk and can be found in Volume 4 – Appendix 14.1.
National Planning Policy Guidance (NPPG) (2019)	Provides further guidance to local planning authorities to ensure effective implementation of planning policy set out in the NPPF on development in areas at risk of flooding, including requirements for a site-specific FRA. An FRA should demonstrate to the decision-maker how flood risk will be managed now and over the development's lifetime, taking climate change into account, and with regards to the vulnerability of its users. Conditions which should be established by the FRA are detailed in Appendix 14.1 – Flood Risk Assessment.	The Scheme area is greater than one hectare and is within Flood Zone 2 and 3. Therefore, according to Footnote 50 of NPPG, a site-specific FRA is required for the Scheme.
Water Quality		
Water supply, wastewater and water quality Planning Practice Guidance (PPG)	Advises on how planning can ensure water quality throughout the development. Provides guidance on how to help protect and enhance local surface waters and groundwaters by safeguarding and improvement measures as part of new developments.	Adherence to the measures outlined in the CoCP would ensure measures and good practice are adopted throughout the Scheme. Surface watercourses within proximity to the Scheme are known to receive flow from the local drainage networks. Proposed discharges may also have an impact on local watercourses.
Groundwater		
Policy Statement for National Networks (NNNPS)	The NNNPS sets out government planning policies to prevent new and existing developments from contributing to unacceptable levels of water pollution or land instability. The development should, wherever possible, help to improve local environmental conditions such as water quality.	Contamination from activities relating to site work and water discharge could contribute to the deterioration of groundwater quality and other impacts to groundwater resources.

Table 14.3: Guidance relevant to Water Resources and Flood Risk

Guidance Document	Description in relation to Water Resources and Flood Risk
Non-Statutory Technical Standards for Sustainable Drainage Systems (SuDS) (Defra, 2015)	The ministerial statement on SuDS (Department for Communities and Local Government, 2014) details that as of the 6th April 2015 all major developments should include provision for SuDS for management of run-off. The Non-Statutory Technical Standards for SuDS set a basic minimum for SuDS design in terms of runoff rates and volume (requirements detailed in Appendix 14.1 – Flood Risk Assessment).

Guidance Document	Description in relation to Water Resources and Flood Risk
Oxford City Council Level 1 Strategic Flood Risk Assessment (SFRA) (Wallingford HydroSolution Limited 2017)	SFRAs provide an overall understanding of the flood risk within the District taking into account all potential sources.
Oxford Local Plan 2016 – 2036 (Oxford City Council 2020)	The Oxford Local Plan brings together all major planning policy for the district into a single document and forms part of the statutory development plan. Oxford City Council Local Plan policies pertaining to flood risk and drainage and relevant to the Scheme are detailed and addressed in Appendix 14.1 – Flood Risk Assessment.
Local Standards and Guidance for Surface Water Drainage on Major Development in Oxfordshire (Oxfordshire County Council, 2018)	The Oxfordshire County Council Local Standards and Guidance for Surface Water Drainage on Major Development in Oxfordshire is intended to assist developers in the design of surface water drainage systems. This document sets out standards that are applied by Oxfordshire County Council as the Lead Local Flood Authority (LLFA) for new development proposals in Oxfordshire with area greater than one hectare, which reflect the National Non-Statutory Technical Standards for SuDS. The guide provides Oxfordshire-specific information on the planning, design and delivery of surface water drainage, designed to reduce the risk of flooding and maximise environmental gain. It also aims to ensure that all new developments and redevelopments in the county are designed to mitigate and adapt to the effects of climate change.
Network Rail Business Process Environment and Social Minimum Requirements for Projects – Design and Construction (Network Rail, 2019)	The Network Rail Design and Construction guidance includes design requirements regarding weather resilience and climate change adaption. Guidance detailed in Appendix 14.1 – Flood Risk Assessment.
Network Rail Drainage Systems Manual NR/L2/CIV/005 (Network Rail, 2018)	Provides guidance for all works including design, inspection and maintenance to coordinate the management of railway drainage design. Part 2 of the Manual specifies requirements for railway drainage which are detailed in Appendix 14.1 – Flood Risk Assessment.
Guidance on climate change allowances (Environment Agency, 2020)	This guidance details the climate change allowances required to assess the impacts of climate change on flooding for new developments, this is dependent on the location, design life and vulnerability classification of the development (as detailed in Table 2 of the National Planning Practice Guidance (PPG) (MHCLG, 2018)). Guidance detailed within Appendix 14.1 – Flood Risk Assessment.
Discharges to surface water and groundwater: environmental permits (Environment Agency and Department for Environment, Food and Rural Affairs, 2016a)	This guidance provides details about when an environmental permit to discharge liquid effluent or waste to surface water or onto the ground is necessary and type of permit required which is relevant as the discharge of water to ground via a soakaway is proposed.

Guidance Document	Description in relation to Water Resources and Flood Risk
Groundwater risk assessment for your environmental permit (Environment Agency and Department for Environment, Food and Rural Affairs, 2016b)	This guidance sets out how a groundwater risk assessment should be undertaken as part of an application for an environmental permit.
Water discharge and groundwater activity environmental permits (Environmental Agency, 2018)	Guidance on how the Environment Agency sets and assesses compliance for surface water discharge activity and groundwater activity permits for waste water or trade discharges which is relevant as the discharge of water to ground via a soakaway is proposed.
Environmental permitting guidance: groundwater activities (Department for Environment, Food and Rural Affairs, 2011)	Guidance on how the European Directives and other legislation relating to groundwater activities should be applied and how particular terms should be interpreted in England and Wales.
The Environment Agency's approach to groundwater protection (Environment Agency, 2018a)	Position statements which provide information about the Environment Agency's approach to managing and protecting groundwater. They detail how the Environment Agency delivers government policy for groundwater and adopts a risk-based approach where legislation allows.

14.3 Methodology

Introduction

14.3.1 This section reports the consultation undertaken, defines the study area, temporal scope, the sources of baseline data, and the methodology and significance criteria. The limitations and assumptions of the study are also described.

Consultation

14.3.2 Oxford City Council issued a Scoping Opinion in response to the Scoping Report (Network Rail, 2020) in January 2021. The Scoping Opinion included a requirement for water resources and flood risk to be included in the Environmental Impact Assessment (EIA) and further direction on the content of the assessment.

14.3.3 An overview of consultation undertaken on the Scheme is summarised in Chapter 4 – Approach to Environmental Assessment. In relation to the water resources and flood risk assessment there has been additional engagement with Oxford City Council.

14.3.4 Table 14.4 summarises the consultation responses that were received regarding the scope and methodology to be applied in the EIA. The methodology for this assessment has considered the feedback received and where appropriate the scope and methodology have been revised.

Table 14.4: Summary of EIA Scoping Report consultation responses for water resources and flood risk scope and methodology

Consultee	Issues raised in response to the Scoping Report	Summary of the response to issues raised
Oxford County Council	It is queried that the impact of the development on water quality for groundwater, should be scoped in given the potential for spillages (either during construction or built phase of development).	The impacts to groundwater quality for both the construction and operational phases have been considered. Refer to the Section 14.5 - assessment of water resources and flood risk.
Environment Agency	The site lies within Flood Zone 3b (functional floodplain), 2 and 1. Flood Zone 3b is defined as “land where water has to flow or be stored in times of flood”	Fluvial flood risk has been identified at the proposed areas of construction: Sheepwash Bridge and Botley Road. A flood risk assessment (FRA) and sequential test have been completed. Refer to Appendix 14.1 – Flood Risk Assessment

Study Area

14.3.5 The study area for the flood risk and groundwater assessment is 2km from the Scheme's red line boundary, and 500m for the surface water assessment.

Temporal Scope

14.3.6 Baseline conditions are described using available data sources, including consideration of how this baseline may change from present day to the year of construction (i.e. the future baseline in the absence of the Scheme). This EIA has been prepared during the 2020/2021 global COVID-19 coronavirus pandemic. As a result of the pandemic it is considered that 2020 would not be a true baseline for this topic. This is due to a significant reduction in train frequency as a result of national lockdown restrictions. Fewer trains would likely result in lower levels of pollutants entering receiving watercourses. Therefore, the year 2019 has been used as a more representative year.

14.3.7 The temporal scope of this assessment was:

- Baseline year: 2019
- Future baseline year (first year construction): 2022;
- Future baseline year (first year operation): 2025

Baseline Data

14.3.8 The water resources and flood risk baseline has been established using the following sources of information:

- Oxford City Council Level 1 Strategic Flood Risk Assessment (SFRA) (Wallingford HydroSolutions Limited, 2017);
- Oxford City Council Local Plan (Oxford City Council, 2020);
- Oxfordshire County Council Preliminary Flood Risk Assessment (JBA Consulting, 2017)
- Oxford Flood Alleviation Scheme model 2018. (Environment Agency, 2018b)
- Statutory Main River Map (Environment Agency, 2020)
- British Geological Survey data (BGS, 2021).
- Canals dataset (Canal & River Trust, 2021);
- Environment Agency Risk of Flooding from Reservoirs (Environment Agency, 2021)
- Environment Agency Catchment Data Explorer (Environment Agency, 2021b)

- Environment Agency Flood Map for Planning (Environment Agency, 2021)
- Environment Agency Long Term Flood Risk Information Mapping (Environment Agency, 2021)
- Environment Agency Recorded Flood Outlines (Environment Agency, 2021)
- Environment Agency Risk of Flooding from Surface Water Extents: 0.1, 1 and 3.3 percent annual chance (Environment Agency, 2021) datasets
- Environment Agency Water Quality Archive (WIMS, 2021);
- Multi Agency Geographic Information for the Countryside (MAGIC) (Defra, 2021);
- National River Flow Archive (NRFA, 2021); and
- A historical Phase 1 and Phase 2 Ground Investigation (THJV, 2014a), conducted seven years ago for the Oxford Corridor Capacity Improvement Scheme. This includes groundwater level monitoring data and local geological information in proximity to Oxford Station.

Assessment Methodology

14.3.9 The assessment follows the general methodology outlined in the Scoping Report (Network Rail, 2020) and described in Chapter 4 – Approach to Environmental Assessment in that it considers whether potential effects are likely to be significant based on the importance of the receptors and the magnitude of the impact.

Assessment of Construction Impacts

14.3.10 The assessment criteria adopted are largely derived from the environmental assessment approach presented in Highways England's DMRB. Although the guidance applies to appraisal of road transport schemes, the concepts adopted are applicable for other large transport developments. LA113 covers environmental assessment for Road Drainage and the Water Environment.

Assessment of Operational Impacts

14.3.11 The assessment of operational impacts was undertaken adopting the criteria from LA113 and WebTAG which specifically covers water environment appraisal under A3.10. The criteria provided in the guidance to undertake a qualitative assessment were applied to the Scheme, as the quantitative assessment criteria provided in this guidance is only relevant to road schemes.

Use of Significance Criteria

14.3.12 The determination of effect significance follows the approach set out in DMRB LA104 Environmental Assessment and Monitoring. It is determined by combining the importance of a receptor (Table 14.5) and the magnitude of an impact (Table 14.6) to determine the overall significance of effect (Table 14.7). The water resources and flood risk receptors are identified through the application of DMRB LA113 and are assigned a value/importance based on criteria set in Table 3.70 of LA113.

Magnitude of Impact

14.3.13 The magnitude of potential impacts may be beneficial or adverse. The criteria for estimating the magnitude of impacts is presented in Table 14.6. This is based on criteria provided in LA113 Table 3.71.

Table 14.5: Criteria for determining the value/importance of receptors for water resources and flood risk (adapted from Table 3.70 in LA113)

Value/Importance	Road Drainage and the Water Environment (RDWE) matter	Criteria
Very High	Flood risk	Essential infrastructure or highly vulnerable development[1].
	Surface water quality	Watercourse having a WFD Classification shown in a River Basin Management Plan and Q95 ≥ 1.0 m3/s. Site protected/designated under EC or UK legislation (Ramsar sites, Special Areas of Conservation (SACs), Special Protection Areas (SPAs), Sites of Special Scientific Interest (SSSIs) and salmonoid water) / Species protected by EU legislation.
	Groundwater	Principal bedrock and superficial aquifers. Groundwater flow and yield associated with licensed groundwater abstractions. Groundwater quality associated with SPZ1 (Source Protection Zone 1) (Inner Protection Zone) associated with licensed abstractions. Buildings of regional or national importance, such as Grade I and II* listed buildings, Scheduled Monuments, hospitals, power stations and large industrial sites. Water feeding Groundwater Dependent Terrestrial Ecosystems (GWDTEs) with a high or moderate groundwater dependence with a high environmental importance and international or national value, such as Ramsar site, SAC, SPA, SSSI.
High	Flood risk	More vulnerable development[1].
	Surface water quality	Watercourse having a WFD Classification shown in a River Basin Management Plan and Q95 < 1.0 m3/s. Species protected under EC or UK legislation (as detailed in LA108)
	Groundwater	Secondary A aquifers. Groundwater flow and yield and quality associated with extensive non-licensed private water abstractions (i.e. feeding ten or more properties or supplying large farming / animal estates). Groundwater quality associated with SPZ2 (Outer Protection Zone) associated with licensed abstractions. Residential and commercial properties and Grade II listed buildings. Water feeding GWDTEs of low groundwater dependence with a high environmental importance and international or national value, such as Ramsar sites, SACs, SPAs and SSSIs; or water feeding highly or moderately GWDTE with a national non-statutory UK Biodiversity Action Plan priority.
Medium	Flood risk	Less vulnerable development[1].

Value/Importance	Road Drainage and the Water Environment (RDWE) matter	Criteria
	Surface water quality	Watercourse not having a WFD Classification shown in a River Basin Management Plan and Q95 > 0.001 m3/s.
	Groundwater	Secondary B and Secondary Undifferentiated aquifers. Groundwater flow and yield and quality associated with small scale private water abstractions (i.e. feeding fewer than ten properties). Groundwater quality associated with SPZ3 (Source Catchment Protection Zone) associated with licensed abstractions and with licensed abstractions for which no Source Protection Zone (SPZ) is defined. Unoccupied residential and commercial properties and buildings. Water feeding GWDTEs of low groundwater dependence with a national non-statutory UK Biodiversity Action Plan priority; or water feeding highly or moderately groundwater dependent GWDTE sites with no conservation designation.
Low	Flood risk	Water compatible development[1].
	Surface water quality	Watercourse not having a WFD Classification shown in a River Basin Management Plan and Q95 < 0.001 m3/s.
	Groundwater	Unproductive aquifers. Very poor groundwater quality and / or very low permeability make exploitation of groundwater unfeasible. No active groundwater supply. Industrial buildings that are currently not utilised, all derelict buildings and infrastructure that serves a single dwelling. Water feeding GWDTEs of low groundwater dependence with no designation or groundwater that supports a wetland not classified as a GWDTE, although may receive some minor contribution from groundwater.
[1]Essential Infrastructure, highly vulnerable development, more vulnerable development, less vulnerable development and water compatible development are defined in the NPPF. These values are also used for the consideration of groundwater dewatering impacts which could lead to subsidence.		

Table 14.6: Assessment criteria for determining the magnitude of the impact for water resources and flood risk receptors (adapted from Table 3.71 in LA113)

Magnitude of Change	RDWE Element	Criteria
Adverse		
High	Flood risk	Increase in peak flood level (> 100mm).
	Surface water quality	Results in loss of the attribute and/or quality and integrity of the attribute.
	Groundwater	Major or irreversible change to groundwater aquifer(s) flow, water level, quality or available yield which endangers the resources currently available. Groundwater resource use / abstraction is irreparably impacted upon, with a major or total loss of an existing supply or supplies. Changes to water table level or quality would result in a major or total change in, or loss of, a groundwater dependent area, where the value of a site would be severely affected. Changes to groundwater aquifer(s) flow, water level and quality would result in major changes to groundwater baseflow contributions to surface water and / or alterations in surface water quality, resulting in a major shift away from baseline conditions. Dewatering effects create significant differential settlement effects on existing infrastructure and buildings.
Medium	Flood Risk	Increase in peak flood level (> 50mm).
	Surface water quality	Results in an effect on the integrity of the attribute, or loss of part of the attribute
	Groundwater	Moderate long term or temporary significant changes to groundwater aquifer(s) flow, water level, quality or available yield which results in moderate long term or temporarily significant decrease in resource availability. Groundwater resource use / abstraction is impacted slightly, but existing supplies remain sustainable. Changes to water table level or groundwater quality would result in partial change in or loss of a groundwater dependent area, where the value of the site would be affected, but not to a major degree. Changes to groundwater aquifer(s) flow, water level and quality would result in moderate changes to groundwater baseflow contributions to surface water and / or alterations in surface water quality, resulting in a moderate shift from baseline conditions. Dewatering effects create moderate differential settlement effects on existing infrastructure and buildings.
Low	Flood Risk	Increase in peak flood level (> 10mm)
	Surface water quality	Results in some measurable changes in the quality or vulnerability of the attribute
	Groundwater	Minor changes to groundwater aquifer(s) flow, water level, quality or available yield leading to a noticeable change, confined largely to the development area. Changes to water table level, groundwater quality and yield result in little discernible change to existing resource use. Changes to water table level or groundwater quality would result in minor change to groundwater

Magnitude of Change	RDWE Element	Criteria
		dependent areas, but where the value of the site would not be affected. Changes to groundwater aquifer(s) flow, water level and quality would result in minor changes to groundwater baseflow contributions to surface water and / or alterations in surface water quality, resulting in a minor shift from baseline conditions. Dewatering effects create minor differential settlement effects on existing infrastructure and buildings.
Negligible	Flood Risk	Negligible change to peak flood level (≤ +/- 10mm).
	Surface water quality	Results in an effect on the attribute, but of insufficient magnitude to affect the use or integrity of that attribute
	Groundwater	Very slight change from groundwater baseline conditions approximating to a 'no change' situation. Dewatering effects create no or no noticeable differential settlement effects on existing infrastructure and buildings.
Beneficial		
Low	Flood Risk	Decrease in peak flood level (> 10mm).
	Surface water quality	Results in some beneficial effect on the attribute or a reduced risk of a negative effect occurring.
	Groundwater	Minor reduction in spillage risk. Reduction of groundwater hazards to existing structures. Reductions in waterlogging and groundwater flooding.
Medium	Flood Risk	Creation of flood storage and decrease in peak flood level (> 50mm).
	Surface water quality	Results in a moderate improvement of attribute quality.
	Groundwater	Moderate reduction in spillage risk. Contribution to improvement in water body WFD classification. Improvement in water body Catchment Abstraction Management Strategy (or equivalent) classification. Support to significant improvements in damaged GWDTE.
High	Flood Risk	Creation of flood storage and decrease in peak flood level (> 100mm).
	Surface water quality	Results in a major improvement of attribute quality.
	Groundwater	Removal of existing polluting discharge to an aquifer or removing the likelihood of polluting discharges occurring. Recharge of an aquifer. Improvement in water body WFD classification.
No Change		No loss or alteration of characteristics, features or elements; no observable impact in either direction.

Significance of Effects

14.3.14 The significance of effects is based on the combination of the value (or importance) of the receptor and the magnitude of impact as outlined in Chapter 4. Potential effects can be neutral, beneficial or adverse.

Table 14.7: Factors in the assessment of significance of effect

Magnitude	Value				
	Very Low	Low	Medium	High	Very High
High	Minor	Moderate (Significant)	Moderate / Major (Significant)	Major (Significant)	Major/Very Substantial (Significant)
Medium	Negligible / Minor	Minor	Moderate (Significant)	Moderate / Major (Significant)	Major (Significant)
Low	Negligible	Negligible / Minor	Minor	Minor / Moderate	Moderate (Significant)
Negligible	None/ Negligible	Negligible	Negligible	Negligible / Minor	Minor
None	Neutral	Neutral	Neutral	Neutral	Neutral

14.3.15 For the purpose of this water resources and flood risk assessment, effects of moderate significance or greater have been considered to be significant. This aligns with the assessment methodology outlined in Chapter 4. It should be noted that based on NPPF, any increase in flood risk could be considered unacceptable and require mitigation. This is addressed within Appendix 14.1 – Flood Risk Assessment within Volume 4.

Matters Scoped Out of the Assessment

14.3.16 The matters that have been scoped out of this topic assessment, in accordance with the Scoping Opinion (Appendix 1.1):

- Flood Risk as a result of Reservoir Breach. As works at Sheepwash Bridge within maximum extent of reservoir breech flood risk, would not alter the existing risk of this occurring;
- Flood Risk as a result of Canal Breach. Only the works at Sheepwash Bridge would be within the likely extent of a canal breach. The works here would not alter the existing risk;
- Flood Risk as a result of Tidal Flooding Tidal/Coastal Flooding as the Scheme is not located within an area that is influenced by tidal activity (as confirmed by the Oxford City Council SFRA (2017)), therefore the Scheme area is not under threat of flooding from tidal/coastal sources;

- Flooding from Failure of Flood Defence Infrastructure as the Scheme is not located within (or in proximity to) any areas shown on the Environment Agency Flood Map for Planning as benefitting from flood defences. As such, it is considered that the Scheme area is not under threat of flooding as a result of failure of flood defence infrastructure;

- For surface water quality, Oxford Canal, Wareham Stream and Castle Mill Stream are not considered further due to being located a sufficient distance away from the Scheme. It is also likely, that any silt laden runoff generated would be captured within the local drainage network and discharged to either the local sewer network or to another surface watercourse. This also applies to Bulstake Stream and is therefore not considered further.
- Impacts to groundwater in the bedrock as the bedrock is classified as an unproductive aquifer of low value.
- Geomorphology due to the distance downstream to any surface watercourses and because surface water would discharge to the existing highways drainage network.

14.3.17 These matters have been scoped out on the basis that they would not be likely to result in a significant effect on water resources and flood risk.

Limitations and Assumptions

14.3.18 Limitations and assumptions for water resources and flood risk comprise the following matters:

Flood Risk

14.3.19 Topographic surveys have been undertaken to inform hydraulic modelling, but no site walkover surveys have been completed to date to inform the assessment of impact.

14.3.20 Where hydraulic modelling has been undertaken there are uncertainties and limitations associated with the modelling (e.g. where topographical survey of ground elevation is not currently available, lower resolution LiDAR data have been used) (refer to Appendix 14.1- Flood Risk Assessment for additional details of model assumptions and limitations).

14.3.21 It is assumed in the assessment that all SuDS and drainage networks would be fully maintained and managed as per standard guidance and practice.

14.3.22 Environment Agency mapping for surface water flood risk does not account for climate change allowances. To approximate the risk of flooding in a 1% (1 in 100) Annual Exceedance Probability (AEP) considering climate change the 0.1% (1 in 1000) AEP has been used as an approximation

14.3.23 Little information is available on the existing sewer and water supply infrastructure. It has been assumed that the risk of flooding from these sources is low.

Groundwater

14.3.24 Baseline information gathered is from desk-based sources and available ground investigation information at the time of writing.

14.3.25 The exact excavation depths associated with the Scheme are not available at this stage. Other works may require excavations such as the sub-way construction, however the depths are expected to be limited and dewatering impacts are assumed as very localised.

Surface Water

14.3.26 Drainage for Rodger Dunham Way, Cripley Road and Botley Road have been provided. However, drainage information for the wider network is not known. Therefore, it has been assumed that any existing road drainage is likely to drain to the public surface water drainage network and does not discharge directly to the nearest surface watercourse.

14.4 Baseline Conditions

Characterisation of the Environmental Baseline

14.4.1 To the north, the Scheme crosses the Sheepwash Channel which connects the River Thames to the west and the Castle Mill Stream next to the Oxford Canal to the east. The Scheme is also within close proximity to Wareham Stream and Bulstake Stream. Surface water bodies which could be impacted by the Scheme are summarised in Table 14.8 (see Volume 3 – Figure 14.2).

Table 14.8: Surface waterbodies within (or in close proximity to) the study area

Watercourse	Description	Receptor Value
River Thames (Main River)	Flows north to south approximately 150m to the west of Oxford Station.	Very High
Sheepwash Channel (Main River)	Flows from west to east and connects the River Thames to the west and the Castle Mill Stream to the east (within the Scheme's red line boundary).	Very High
Fiddler's Stream (Main River)	Flows north to south to the north-west of the north western extent of the Scheme, and joining Sheepwash Channel to the west of the Scheme. At this location Sheepwash Bridge accommodates the existing railway, Roger Dudman Way and a footbridge.	Medium

Flood Risk

14.4.2 For a detailed description of baseline flood risk associated with the Scheme please see Appendix 14.1 – Flood Risk Assessment, summarised below:

Fluvial Flood Risk

14.4.3 The Environment Agency's Recorded Flood Outlines dataset (Environment Agency, 2020) contains all the Environment Agency's records of historic flooding from rivers, the sea, groundwater and surface water (and contains information about the recorded flood). The Oxford City Council SFRA (2017) also contains details of historic flood events. A review of these information sources identifies that a number of historic flooding events have occurred within (or in close proximity to) the Scheme. All of these recorded historic flood events were attributed to Main River fluvial flooding.

14.4.4 According to the Environment Agency flood map (Environment Agency, 2020), the majority of the Scheme is within Environment Agency Flood Zone 1 (low probability of fluvial flooding). However, this mapping shows that areas of the Scheme, particularly in proximity to Sheepwash Channel, fall within Environment Agency Flood Zones 2 and 3 (medium and high probability of flooding, respectively) (See Volume 3 – Figure A14.2 for Environment Agency Flood Zones 2 and 3).

14.4.5 The Environment Agency River Thames hydraulic model is considered a more accurate indication of fluvial flood risk than Environment Agency flood zone mapping. This has therefore been used to assess fluvial flood risk across the Scheme area (See Volume 3 – Figures A14.4-A14.7 for baseline hydraulic fluvial modelling outputs). A review of outputs from the Environment Agency River Thames hydraulic model for the 1% (1 in 100) AEP and above, (including climate change allowance) indicates that the western side of the Scheme is at risk of flooding for such an event. The Scheme elements at high risk of fluvial flooding are Cripley Road, Botley Road, where the road passes under Botley Road Bridge, and the western entrance. Flooding in the vicinity of Sheepwash Channel is shown to be within the watercourse and would not impact the level of the bridge works proposed.

Surface Water Flood Risk

14.4.6 A Critical Drainage Area is an area that has critical drainage problems and which has been notified to the local planning authority as such by the Environment Agency in line with the NPPF. According to the Oxford City Council SFRA (2017), Oxford City Council and the Environment Agency "have confirmed that there are no designated Critical Drainage Areas within the Oxford City Council administrative boundary".

14.4.7 A review of the Environment Agency's Risk of Flooding from Surface Water mapping (see Volume 3 – Figure A14.12) identifies that the majority of the Scheme site is within an area of very low: less than 0.1% (1 in 1000) AEP flood risk. There are however areas of medium: 1% (1 in 100) to 3.33% (1 in 30) AEP and low 0.1% (1 in 1000) to 1% (1 in 100) AEP probability of surface water flooding. These are predominantly located on roads or the railway and within modelled fluvial 1% (1 in 100) AEP plus climate change flood extent areas.

14.4.8 Botley Road is at high risk of surface water flooding to an area extending approximately 15m either side of the Botley Road Bridge. The risk reduces as the road's elevation increases either side of the bridge.

Groundwater Flood Risk

14.4.9 The Environment Agency's Areas Susceptible to Groundwater Flooding dataset (included within the Oxfordshire County Council preliminary flood risk assessment (2017)) details that the Scheme lies within an area of high susceptibility to groundwater emergence (greater than or equal to 75% risk of groundwater emergence, based on a 1km square grid). This is broadly aligned with the River Thames. This does not mean that this area would necessarily be impacted by flooding, but that geological conditions mean groundwater flooding here is possible. The Oxford City Council SFRA (2017) uses the Environment Agency's Groundwater Flooding Register to quantify the risk of groundwater flooding. Appendix 6 of the Oxford City Council SFRA, shows that none of these Groundwater Register Locations are located in proximity to the Scheme area.

14.4.10 There is evidence however, that the existing infrastructure is affected by groundwater flooding and an active pumping system is in place at Botley Road. From the Highway Drainage Design Report (THJV, 2016), the pumping system is understood to manage groundwater using two pumps. There is evidence that groundwater is pumped even in dry weather conditions, suggesting a daily abstraction of groundwater, at variable abstraction rates depending on the conditions. This suggests that groundwater levels in this area are artificially lowered roughly to the threshold of 370mm above the base of the existing pumping station sump at 51.87m AOD. The dewatering zone of influence is not clear.

14.4.11 Groundwater level information is also available for nine groundwater monitoring boreholes provided by the Phase 1 and Phase 2 Ground Investigation (THJV, 2014). Groundwater levels, typically encountered in River Terrace Deposits, were found to be between 2.4 and 3.7 metres below ground level (mbgl) which is between 56.4 and 55.7m AOD at an average of

3.1 mbgl (55.7m AOD). Data presented within the Oxford Corridor Capacity Improvement – Phase 1 and Phase 2: Ground Investigation Report (THJV, 2014a) also show that the groundwater below the Scheme is in direct connectivity to the adjacent River Thames, as expected for the Oxford area (Macdonald et.al., no date).

14.4.12 Groundwater flood risk in the area is considered to be medium. However, groundwater flooding is considered unlikely to occur independently of fluvial flooding as groundwater levels in this area are closely associated with water levels on the River Thames.

Flooding Associated with Sewerage and Water Supply Infrastructure

14.4.13 There are a number of clean water and sewer networks within the Scheme area. The Oxford City Council SFRA (2017) details that the flood risk from the surface water sewer network within Oxford (as reported the sewerage undertaker for Oxford, Thames Water) is low. There is a residual risk of flooding from local sewer networks and water supply infrastructure however this is also likely to be low.

Water Quality

14.4.14 The Scheme crosses one surface waterbody classified under the WFD: the Sheepwash Channel. The Sheepwash Channel falls under the Thames (Evenlode to Thame) surface water body and is currently classified as having an overall water quality status of Moderate. The ecological quality suffers due to phosphate concentrations and impacts upon invertebrates. The chemical quality is impacted by tributyltin compounds. River Thames and Sheepwash Channel fall under the Thames (Evenlode to Thame) WFD water body.

14.4.15 There is a water quality monitoring station located on the River Thames approximately 0.5km downstream from where the Castle Mill Stream and River Thames converge (Thames at Folly Bridge, Oxford - SP 51364 05527) Further details regarding the latest water quality measurements can be found within Appendix 14.2. The data are presented in Table 14.9.

Table 14.9: December 2019 Water quality monitoring data on The River Thames (EA WIMS dataset, accessed 2021)

Determinant	Units	Measurement
pH	-	8.25
Temperature of Water	°C	5.4
Conductivity at 25 C	µs/cm	625
Ammoniacal Nitrogen as N	mg/l	0.037
Alkalinity to pH 4.5 as CaCO3	mg/l	240

Existing Drainage

14.4.16 Rodger Dudman Way primarily flows into the drainage system of Botley Road. However, existing drainage provision north of Sheepwash Bridge discharges to Fiddler's Stream. Cripley Road is served by gullies within the carriageway and ultimately discharges to the River Thames via a surface water sewer. Botley Road is currently served by roadside gullies which lead to a pumping station which ultimately discharges to a sewer east of the Scheme. It is currently unknown whether any of the remaining watercourses mentioned in Table 14.8 receive surface water.

Groundwater

14.4.17 The Oxford Clay and West Walton Formation which forms the bedrock below the Scheme is classified as unproductive strata. The superficial deposits comprise Alluvium and River Terrace Deposits both classed as Secondary A aquifers. Data presented within the Phase 2 ground investigation report (THJV, 2014a) show localised areas of made ground have been located within the top 4m of the ground surface.

14.4.18 Groundwater vulnerability for the superficial deposit aquifers is defined as medium-low (Defra, 2021).

14.4.19 As discussed for flood risk, groundwater levels provided by the Phase 1 and Phase 2 Ground Investigation (THJV, 2014a), typically encountered in River Terrace Deposits, were found to be between 2.4 and 3.7 mbgl which is between 56.4 and 55.7m AOD at an average of 3.1 mbgl (55.7m AOD). Groundwater encountered during drilling is recorded for 24 boreholes. Average groundwater strikes were found to be 3.4mbgl or 55.6m AOD.

14.4.20 The groundwater level data presented within the Phase 2 ground investigation report (THJV, 2014a) show in some locations that the River Terrace Deposits aquifer is unconfined. At other boreholes the groundwater level in the deposits is above the base of the overlying alluvial deposits, indicating that the River Terrace Gravel aquifer has a degree of confinement in places. As discussed for flood risk, the groundwater below the Scheme is in direct connectivity with the adjacent River Thames (THJV, 2014a).

14.4.21 However, as stated in the flood risk section, a pumping station is already in operation at Botley Road to protect existing infrastructure (THJV, 2017). There is evidence that groundwater is pumped even in dry weather conditions, suggesting a daily abstraction of groundwater, at variable abstraction rates depending on the conditions. This suggests that groundwater levels in this area are artificially lowered roughly to the threshold

of 370mm above the base of the existing pumping station sump at 51.87m AOD. The dewatering zone of influence is unclear.

14.4.22 Results from permeability tests undertaken for 47 samples of the River Terrace Deposits strata are provided by the Phase 1 and Phase 2 Ground Investigation (THJV, 2014a). As shown in the report, the average permeabilities generated using the Hazen's formula and also the Kozeny-Carmen method are 1.73 $x10^{-3}$ m/s and 8.16 $x10^{-3}$ m/s respectively. Information on groundwater quality is captured in Chapter 7 - Geology & Soils.

14.4.23 Approximately 500m northeast of the site, at the former Eagle Iron Works, two groundwater abstraction points used for drinking water, process water and non-evaporative cooling were identified in 2014 (THJV, 2014b). Historical BGS borehole logs (BGS, 2021) show that there are two shallow wells at this point and the abstraction is derived from the River Terrace Deposits. It is unlikely the abstraction still exists as the site has been redeveloped (see Chapter 8 - Geology and Soils). However, for the purpose of the assessment, the abstraction shall be considered as a potential groundwater receptor. The location of the abstraction sourced from the BGS borehole logs is presented in Volume 3 – Figure 14.1.

14.4.24 As indicated by the Environment Agency (Environment Agency, 2021f), a designated site with a GWDTE component has been identified within the groundwater study area as Port Meadow with Wolvercote Common and Green SSSI. It is located 500m north of the site (Figure 14.1). The site consists of a series of neutral grasslands situated in the Thames floodplain. The grassland has developed on calcareous gravels deposited on the Oxford Clay during the late Pleistocene, which are in turn partly overlain by alluvium. The site is free draining, the water-table rising and falling with the height of the river. A constant flow of ground water aerates the soil and prevents the acidification often associated with waterlogging. The GWDTE is also a Special Area of Conservation (SAC) under the European Habitats Directive (Oxford City Council, 2021b).

14.4.25 A UK HAB Habitat mapping survey has been undertaken by the ecology team and is presented in Appendix 4.1 – Preliminary Ecological Appraisal. Within 1 km of the Scheme, two priority habitats have the potential to be GWDTEs: a wet woodland approximately 25m northwest of Sheepwash Bridge and Cripley Island and Fiddler's Island also containing a wet woodland, approximately 250m northwest of Sheepwash Bridge. The location of these sites is shown on Figure 14.1 in Volume 3.

Future Baseline

14.4.26 Over the anticipated lifetime of the Scheme (100 years) changes to the baseline as a consequence of climate change would likely occur, including a likely increase in the frequency and magnitude of flood events.

14.4.27 The future baseline accounting for climate change has been assessed in line with the latest Environment Agency guidance for increases in fluvial flows and rainfall intensity that is based on UKCP09. Please see Appendix 14.1 – Flood Risk Assessment for further details of how future climate change has been considered in the assessment of flood risk.

14.4.28 In terms of future hydromorphological baselines, increased river flooding could cause erosion, specifically where it may already flood. However, given the stable nature of most of the watercourses within the study area, extensive changes to baseline conditions would be unlikely.

14.4.29 Average summer river flows may decrease as a result of a warming climate, leading to a reduction in dilution capacity resulting in lower river quality and increased pollution levels. However, extensive changes to baseline conditions up until the first operational year (2025) would be unlikely.

14.4.30 The direct effect of climate change on groundwater resources depends primarily upon the change in the volume and distribution of groundwater recharge. The effects of climate change on groundwater in the UK therefore may include:

- a long-term decline in groundwater storage;
- an increased frequency and severity of groundwater droughts;
- an increased frequency and severity of groundwater-related floods; and
- mobilisation of pollutants due to seasonally high water tables.

14.4.31 With respect to the Scheme and surrounding area, these effects could result in locally significant impacts on the river flows that are sustained in part by groundwater flow. In addition, a reduction in groundwater levels during prolonged dry periods could affect groundwater abstractions. It could also affect GWDTEs that are sustained by shallow groundwater flows and potentially increase the risk of settlement effects to nearby infrastructure and buildings. If seasonally high groundwater levels are encountered, due to increased winter rainfall, then groundwater levels could rise into the areas of made ground that are currently not in contact with groundwater. This could lead to groundwater contamination or groundwater flooding.

Identification of Sensitive Receptors

14.4.32 The following water resources and flood risk sensitive receptors have been identified:

- local properties and infrastructure at potential risk of flooding;
- Sheepwash Channel and associated floodplain;
- River Thames and associated floodplain;
- Fiddler's Stream;
- Secondary A superficial aquifers (Alluvium and River Terrace Deposits);
- a licensed groundwater abstraction for industrial use (it is unlikely that the abstraction still exists but for the purposes of this assessment, it has been considered);
- nearby buildings potentially at risk of subsidence due to dewatering; and
- groundwater inputs to the Port Meadow with Wolvercote Common & Green SAC and SSSI.

14.5 Design and Best Practice Measures

Design

14.5.1 The Scheme has been designed, as far as possible, to avoid and reduce impacts and effects on water resources and flood risk through the process of design-development, considering good design principles. Embedded mitigation is defined within DMRB as '*Design measures which are integrated into a project for the purpose of minimising environmental effects.'*

14.5.2 The assessment of whether significant effects would be likely to occur has been based on the Scheme as described in Chapter 2 – Description of the Scheme and taken account of measures embedded within the design.

14.5.3 The relevant measures embedded in the design of the Scheme for this water resources and flood risk assessment are listed in Table 14.10. The adoption of these embedded mitigation measures would reduce the potential environmental effects on water resources and flood risk.

Table 14.10: Summary of design measures for this water resources and flood risk assessment

Measure	Outcome / Benefit
The Sheepwash Bridge has been designed so that there is no permanent impact on the Sheepwash Channel, navigation or towpath headroom. Temporary impacts have also been reduced by using short duration closures only.	Removes permanent impacts to the Sheepwash Channel, navigation and towpath. Limits potential flood risk from the watercourse. Construction effects of short duration.
The Scheme has been designed to require no excavation into the water table for provision of the western retaining wall.	Limits potential impacts on the water environment and the need for dewatering. Reduces the risk of groundwater flooding during construction.
Installation of permanent low permeability cut-off walls for dewatering at Botley Road by use of a grout curtain and sheet piling.	Limits potential impacts on groundwater and the need for extensive dewatering. Reduces the volume of potentially contaminated water to discharge. Reduces the risk of groundwater flooding during construction.
A pre-existing long-term groundwater management system is currently in place at Botley Road. As Botley Road would be lowered further, a new pump would be put in place to continue to manage local groundwater conditions.	Reduces the risk of groundwater flooding during operation phase.
Highway design finessed significantly to reduce dig into the water table.	Limits potential impacts on the water environment and the need for dewatering. Reduces the risk of groundwater flooding during construction and operation.
Before track run-off water is discharged it would undergo treatment via oil interceptors/ silt traps.	Provides treatment of track run-off prior to drainage. Limits the potential impact on the water environment.

Construction Management Measures

14.5.4 The Scheme would be constructed in accordance with a Code of Construction Practice (CoCP), which can be found in Appendix 2.1. The CoCP sets out the principles for environmental mitigation, which would then be used as the basis for the Construction Environmental Management Plan (CEMP).

14.5.5 The CEMP would outline measures to be put in place to ensure that water quality does not deteriorate and flood risk is not increased as far as reasonably practicable during the construction phase of the Scheme. In particular, the CEMP would detail pollution prevention and control measures, as well as contingency plans to deal with an accidental spillage or other potentially polluting incidents.

14.5.6 This water resources and flood risk assessment has identified management measures, to be included within the CEMP, which would be required to control water resources and flood risk effects during the construction phase. These measures are included in Table 14.11.

Table 14.11: Summary of construction management measures relevant to this water resources and flood risk assessment

Measure	Outcome / Benefit
The management of activities within floodplains and overland surface water flow paths (i.e. kept to a minimum) with construction works and storage areas to be located out of the floodplain as far as reasonably practicable or allowances made for floodplain control measures and contingency actions	Locating activities outside the floodplain reduces risk of flooding to construction areas which could result in injury to workers or loss of materials/plant. This also reduces the risk of construction activities interacting with flow paths and increasing the risk of flooding elsewhere. Locating activities outside the floodplain/surface water flow routes reduces risk of contamination to surface water.
Where necessary, implementation of measures to mitigate for any flood waters displaced during temporary construction works (provision of temporary compensation areas if required)	Reduces impacts of loss of floodplain during construction works.
Incorporating sustainable drainage mitigation for construction work with drainage implications (e.g. increasing surface water flood risk as a result of increased impermeable area)	Providing temporary SuDs reduces the risk of surface water flooding to the site or increase in flood risk elsewhere. No increase in impermeable area is currently anticipated so this measure may not be required.
Adopting the Environment Agency flood warning system during construction and developing a suitable plan which would ensure effective and safe evacuation of personnel and plant from areas at risk on receipt of a flood warning	Adopting the Environment Agency flood warning system allows for emergency plans and flood prevention measures to be implemented in time to reduce impacts of flooding such as injury and loss of materials/plant
Managing the risk from groundwater flooding (during excavation) through appropriate working practices and with adequate plans and equipment in place for dewatering to ensure safe dry working environments. Management of the water removed by dewatering activities before discharge.	Managing risk of groundwater flooding would reduce the likelihood of groundwater flooding which could lead to injury and loss of materials/plant.
Environmental Incident Control and Emergency Preparedness Plan to be prepared. To include: • Control risk of pollution • Pollution prevention measures (PPG21) • Pro-active management practices • Criteria for implementing relevant measures	To limit risk of environmental pollution incidents as a result of events such as diesel spillage etc.
Specific measures to control silt would be implemented, with silt laden surface water runoff at the construction sites (specifically the Sheepwash	To reduce contaminants such as sediment being released to surface waters

Measure	Outcome / Benefit
Channel) being managed to prevent flowing into any surface water receptors (drawing on CIRIA532)	
If a discharge to a watercourse or groundwater is necessary, the water should be treated and controlled in accordance with any legislative requirements and environmental permits.	To reduce the levels of contaminants including suspended solids being released to surface waters
Environmental permits for any temporary or permanent dewatering of excavations would be obtained by the Contractor from the Environment Agency prior to undertaking any dewatering activities.	To comply with government legislation and control volumes abstracted through dewatering to reduce any adverse effects to the groundwater environment.
CIRIA guidance would be adopted as standard mitigation as appropriate from the following publications: • Environmental Handbook for Building and Civil Engineering Projects (3 Parts: C512, C528 and C529) (Venables, 2000) • Control of water pollution from construction sites. Guidance for consultants and contractors (C532) (Masters-Williams et al, 2001) • Control of water pollution from linear construction projects. Site guide (C649) (Murnane et al, 2006) • Groundwater control: design and practice, second edition (C750) (Preene et al, 2016) • Environmental good practice on site guide (fourth edition) (C741) (Charles et al, 2015)	To reduce the contamination of soils, groundwater and surface water

14.6 Assessment of Water Resources and Flood Risk Effects

Construction Phase

14.6.1 With adoption of the design measures and the construction management measures described within Tables 14.10 and 14.11, the potential for likely significant effects on water resources and flood risk during construction of the Scheme could arise from the following.

Flood Risk

14.6.2 With the good practice measures contained within the CoCP, there are no significant flood risk effects expected during the construction phase.

Surface Water Quality

14.6.3 The surface water quality could be affected through runoff of contaminants (including silts) into surface waters and accidental spillages of contaminating substances such as fuel, concrete and cement. As part of the Scheme the construction works pose a risk of runoff (with associated contaminants) occurring, particularly at the Sheepwash Bridge, western entrance building, Botley Road interim footbridge and Botley Road works. The impact is likely to be greatest in areas where works are to take place within 10m of a watercourse, therefore the Sheepwash Channel is considered to be most at-risk during construction. The potential for impact on water quality would be reduced through adhering to the measures identified within the CoCP. Once these mitigation measures are taken into account however no significant effects have been identified.

14.6.4 The construction of the grout curtain on Botley Road has a high risk of introducing highly polluting constituents of grout (e.g pulverised ash) to the local drainage network. If left untreated it could cause serious harm to receiving watercourses. The drainage network at Botley Road leads to a pumping station which discharges to a sewer away from the Scheme. It is not currently known where this sewer discharges to. However, it is possible that it may discharge to a surface watercourse either directly, or through a combined sewer overflow. However, once the CoCP mitigation measures are followed no significant effects are anticipated.

Groundwater

14.6.5 Water runoff from the railway tracks is likely to be contaminated with hydrocarbons and possibly other hazardous substances. An initial drainage strategy suggests a discharge to the ground, with the possibility of recharging directly to groundwater below a confined geological horizon. There are

currently uncertainties on the geological and hydrogeological conditions present on site, and for this reason no detailed risk assessment could be undertaken. Despite the embedded treatment measures (oil interceptor and silt trap), there is a risk that this could result in a deterioration of groundwater quality in superficial deposits (high importance). The current discharge strategy does not align with current Environment Agency guidance looking at avoiding direct discharges to groundwater. A new discharge to ground, depending on the volumes, could also alter groundwater flow directions and create new flooding issues downgradient of the recharge area. These potential impacts on groundwater (both quality and flow) would be categorised as a medium adverse magnitude of impact, resulting in a moderate significance of effect.

14.6.6 Where works are required for the lowering of Botley Road, the proposed grout curtain cut-off wall would be expected to limit the effects of dewatering in the surrounding area. As a result, significant impacts outside of the grout curtain are unlikely. The details on the grout curtain thickness and permeability remain to be confirmed however, and as a result, potential impacts on immediate receptors, such as settlement effects on surrounding infrastructure and buildings (high importance), cannot be ruled out. This could result in a potential low magnitude of impact, resulting in a potential moderate significance of effect. No other groundwater related receptor is expected to be impacted.

14.6.7 Other proposed works including the construction of the subway and lift shafts may require dewatering but are not anticipated to cause a significant dewatering effect.

<u>Operational Phase</u>

14.6.8 The assessment of potential Water Resources and Flood Risk effects taking account of the design measures and the best practice measures described within Tables 14.10 and 14.11, has identified that there would be the potential for likely significant effects as a result of the operation of the Scheme on the following.

Flood Risk

14.6.9 The Scheme is not considered to significantly increase the fluvial flood risk in the 1% (1 in 100) AEP. However, baseline fluvial flood risk remains high for the western entrance and down Botley Road.

14.6.10 In the 1% (1 in 100) AEP + 70% (expected increase due to climate change) event, fluvial flood depths of 1.15m and 3.8m are predicted in the western entrance and the Botley Road underpass respectively which is an increase

from the baseline scenario for this event. This would have a potential high adverse impact resulting in a potential major significance of effect on essential highway and railway infrastructure including the proposed scheme.

14.6.11 The Scheme is not considered to increase the surface water runoff. However, Environment Agency mapping indicates flooding in the 3.3%, 1% and 0.1% annual chance event. The current drainage strategy has been designed to prevent flooding in up to a 3.33% (1 in 30) AEP event and the drainage system's capacity in events greater than this would therefore be exceeded. As the Scheme alters catchment areas and lowers ground levels, there is therefore a risk that surface water flood depths on Botley Road would be increased. This would potentially result in high adverse impacts resulting in a potential major significance of effect on essential infrastructure.

14.6.12 The installation of the grout curtain around Botley Road could cause a build-up of groundwater within the superficial aquifer (high importance) on the up-hydraulic gradient side of the structure. In addition, the existing pump at Botley Road may currently artificially maintain groundwater levels lower than they would naturally be, beyond Botley Road. The new long-term groundwater management system for Botley Road would sit within the grout curtain, significantly reducing the drawdown effect outside the grout curtain. It is therefore possible that groundwater outside the grout curtain would naturally rebound and become shallower. As a result, there is a risk that groundwater flooding could be enhanced immediately outside of the grout curtain around Botley Road, particularly on the up-hydraulic gradient side of the structure. This would cause a medium magnitude impact, resulting in a moderate significance of effect.

Surface Water Quality

14.6.13 As outlined in Section 2, the Scheme would increase rail capacity within the station through the implementation of a new track. The surface water generated from this track would soak through the ballast to a soakaway located on Rodger Dudman Way. Given the permeable nature of the superficial deposits and the distance from Fiddler's Stream, there may be potential for some groundwater reaching this watercourse. As the soakaway acts as a form of filtration, some treatment of the track drainage is likely to occur and therefore, impacts on Fiddler's stream are considered negligible resulting in a negligible significance of effect. Groundwater impacts as a result of this are discussed separately.

Groundwater

14.6.14 Given that the new track drainage discharge to groundwater would be in place permanently, the impacts discussed in the construction phase apply for the operational phase. This would be categorised as a medium adverse magnitude impact, resulting in a moderate significance of effect.

14.7 Additional Mitigation Measures

14.7.1 The following additional mitigation measures have been identified as a result of this assessment in addition to the measures included in Section 14.5.

Flood Risk

14.7.2 As a result of high fluvial flood risk, a long-term emergency plan for flood events would be designed and implemented. This would be for both the western entrance to the station and Botley Road. This would include signing up to the Environment Agency's Floodline flood alert and flood warning system and potential road and facility closures to mitigate the risk associated with flooding i.e. a continuation of the flood risk measures within the CoCP.

14.7.3 Various options will be explored during detailed design to mitigate flooding to the Scheme and prevent increase in flood risk to the Scheme and surrounding areas. Options could involve providing flood resilience measures to reduce risk to the Scheme without increasing flood risk elsewhere.

14.7.4 Surface water flooding is also considered to be a risk in the Botley Road area. Whilst drainage has been proposed here that should provide betterment from existing, this has currently been designed to prevent flooding for a 30-year event. Environment Agency mapping has indicated that the area may be at risk of surface water flooding in extreme events. Design of the drainage system to withstand the 1% (1 in 100) AEP plus 40% allowance for climate change would be required to mitigate the risk of surface water flooding. Site constraints mean this is unlikely to be practicable.

14.7.5 The potential to increase discharge rates into the existing sewer network to 60l/s will be explored at detailed design, however the capacity of the existing sewer network may mean this cannot be achieved. More details on these measures can be found in Appendix 14.1 – Flood Risk Assessment. These measures have the potential to reduce the change in surface water flood risk to negligible or minor levels, resulting in a negligible or minor significance of effect to Botley Road.

Groundwater

14.7.6 A site-specific ground investigation would be required to refine the characterisation of ground and groundwater conditions at the site. This would particularly target the Botley Road area and the location for the proposed soakaway discharge. The ground investigation would be to confirm groundwater levels and quality and would also include permeability tests at Botley Road and percolation tests at the proposed soakaway location. The network of boreholes around Botley Road would be designed to support an analysis of groundwater levels and potential rebound / long term variation immediately outside the grouting curtain.

14.7.7 The output of the ground investigation should support the detailed design phase, including finalising embedded measures such as the detailed design of the grout curtain. It would also confirm whether dewatering would be required in other areas of the Scheme. This would include determining the volume and quality of groundwater that would be abstracted.

14.7.8 Verification of ground and groundwater conditions would also support the review of the track run-off discharge strategy and the strategy should be amended as necessary. Depending on the revised strategy, a detailed groundwater risk assessment may be required. The revised strategy and associated requirements would be discussed with the Environment Agency if required.

14.7.9 Following completion of the ground investigation and finalisation of the grout curtain design details, a settlement risk assessment may be required for the existing infrastructure and buildings located in proximity of Botley Road. The settlement risk assessment would be designed to identify whether additional mitigation measures would be required, such as monitoring of groundwater levels during construction and / or re-enforcement of structures with a residual risk.

14.7.10 The groundwater monitoring network around the grout curtain at Botley Road should assist with the prediction of long-term changes to groundwater around the grout curtain. Should any groundwater flood risks be identified outside the Botley Road grout curtain, an additional drainage strategy may be required to manage shallow groundwater levels and avoid groundwater reaching the sub-surface.

14.7.11 For areas across the Scheme with uncertainty as to whether dewatering would take place such as the subway, a detailed dewatering assessment would be undertaken (during detailed design) where groundwater is confirmed as being intercepted. This would include an assessment of the risk

of subsidence effects on nearby buildings. If significant effects are predicted, further mitigation such as a cut-off wall (sheet piling or a grout curtain) may be required to limit drawdown of groundwater outside the cut-off.

14.7.12 With these additional mitigation measures, all impacts on groundwater and associated receptors would be of negligible magnitude, resulting in a minor significance of effect.

14.8 Summary of Residual Water Resources and Flood Risk Effects

14.8.1 The additional mitigation measures outlined would further reduce the potential effects reported in Section 14.6. Table 14.12 summarises the residual likely effects of the Scheme for Water Resources and Flood Risk.

Table 14.12: Residual effects for Water Resources and Flood Risk

Potential Effect	Receptor(s)	Likely effect without additional mitigation	Additional Mitigation Measure(s)	Residual Effects
Construction				
Deterioration of groundwater quality from the discharge of wastewater to the ground	Superficial aquifer (High value)	Moderate effect - significant	Undertake a ground investigation and confirm conditions. Revisit the discharge strategy. Undertake a risk assessment if a soakaway option is confirmed to ensure that the treatment proposed is sufficient to prevent the deterioration of groundwater quality. Sufficient treatment in place would reduce the magnitude to negligible. Approval from Environment Agency required.	Minor - not significant
Settlement risks resulting from residual dewatering effects around Botley Road	Buildings surrounding the works (High value)	Moderate effect - significant	Undertake a ground investigation and confirm conditions Finalise detailed design for the grout curtain and undertake settlement analysis. If required put in place additional mitigation measures such as groundwater level monitoring and / or building works re-enforcement.	Minor - not significant
Operation				
Fluvial Flooding to Development	Botley Road and western entrance	Major effect - significant	A long-term emergency plan is required for flood events. This is required for both the western entrance to the station and Botley Road. This would include signing up to the Environment Agency's Floodline flood alert and flood warning system and potential road and facility closures. Alternative measures should also be explored to mitigate flooding to the Scheme. Options could involve providing flood resilience measures	Major – significant Flooding would still occur to the Scheme, but impacts would be reduced.
Surface Water Flooding to the Development	Botley Road and western entrance	Major effect - significant	The potential for 60l/s discharge to existing sewers should be explored, however the capacity of the existing sewer network may prevent this from being a viable option. Drainage to be designed for the 1% (1 in 100) AEP event plus 40% allowance for climate change and to	Minor - not significant (if drainage can be designed to 1% (1 in 100) AEP plus climate change event.)

Potential Effect	Receptor(s)	Likely effect without additional mitigation	Additional Mitigation Measure(s)	Residual Effects
			prevent surface water flooding in this location. If this cannot be achieved additional mitigation measures such as road closure should be implemented.	Major – significant (if it cannot).
Deterioration of groundwater quality from the discharge of wastewater to the ground	Superficial aquifer (High value)	Moderate effect - significant	Undertake a ground investigation and confirm conditions. Revisit the discharge strategy. Undertake a risk assessment if a soakaway option is confirmed to ensure that the treatment proposed is sufficient to prevent the deterioration of groundwater quality. Sufficient treatment in place would reduce the magnitude to negligible. Approval from Environment Agency required.	Minor - not significant
Groundwater build-up at the cut-off wall (grout curtain)	Superficial aquifer (High value)	Moderate effect - significant	Where risks are identified after the characterisation of ground conditions from a ground investigation, an additional drainage external to the grout curtain may be required. With this mitigation in place, the magnitude of impact would be reduced to negligible.	Minor - not significant

14.9 Conclusions

14.9.1 This chapter reports the effects on Water Resources and Flood Risk as a result of the Scheme.

14.9.2 Through the implementation of design and construction management measures, this has resulted in the reduction or avoidance of impacts on water resources and flood risk as detailed here.

- Most Scheme elements are not located within areas at risk of flooding and do not impact flood risk elsewhere. Adherence of good practice measures would reduce potential impacts of flooding during the construction period particularly where construction areas are located in areas likely to flood.
- Through adherence of good practice measures set out in the CoCP and the treatment provided by oil interceptors and silt traps, impacts on surface water and groundwater quality would be significantly reduced.
- Measures put in place to limit groundwater dewatering and good practice measures set out by the CoCP, prevent significant impacts to groundwater availability.

14.9.3 Following the assessment of water resources and flood risk effects for the Scheme, additional mitigation measures described in Table 14.12 would be incorporated into the Scheme to manage or reduce potential effects.

14.9.4 As a result of these additional mitigation measures, the only residual significant environmental effects for water resources and flood risk would be:

- Major significant increase in risk of fluvial flooding to the site of the western entrance and Botley Road as a result of the increased flood depths in high magnitude flood events.
- Major significant increase in surface water flood risk on Botley Road as a result of potential increases in flood depth in high magnitude rainfall events.

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