A47 North Tuddenham to Easton Dualling

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6.1 Environmental Statement
Chapter 13 – Road drainage and the water environment

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ENVIRONMENTAL STATEMENT CHAPTER 13 ROAD DRAINAGE AND THE WATER ENVIRONMENT

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13.1. Introduction

13.1.1. Highways England (the Applicant) has submitted an application for an order to grant a development consent order (DCO) for the North Tuddenham to Easton Dualling Scheme (hereafter referred to as 'the Proposed Scheme'). The Proposed Scheme comprises the dualling of a section of the A47 between North Tuddenham and Easton, including the creation of two grade separated junctions (Wood Lane junction and Norwich Road junction), associated side road alterations and walking, cycling and horse-riding connections. This section of A47 road is currently unable to cope with the high traffic volume and there are limited opportunities to overtake slower moving vehicles on the single carriageway. This section of the A47 also has a poor safety record. The Proposed Scheme aims to reduce congestion related delay, improve safety, improve journey time reliability and increase the overall capacity of the A47. Full details of the Proposed Scheme are provided in Environmental Statement Chapter 2 (The Proposed Scheme) (**TR010038/APP/6.1**).

13.1.2. Under the Infrastructure Planning (Environmental Impact Assessment) Regulations 2017, the Proposed Scheme is an Environmental Impact Assessment (EIA) development and as such requires submission of an Environmental Statement presenting the likely significant environmental effects of the Proposed Scheme.

13.1.3. As part of the EIA process, this Environmental Statement (ES) chapter reports the potential significant effects for the road drainage and water environment topic as a result of the Proposed Scheme. This assessment includes a review of the existing baseline conditions, consideration of the potential impacts, proportionate mitigation, and enhancement and identification of residual effects.

13.1.4. The approach to this assessment follows the Scoping Report (September 2019) (**TR010038/APP/6.5**) and subsequent agreed Scoping Opinion (November 2019) for the Proposed Scheme (**TR010038/APP/6.6**). It utilises the most up to date guidance in the Design Manual for Roads an Bridges (DMRB) LA 113 Road Drainage and Water Environment (hereafter referred to as DMRB LA 113).

13.1.5. The main chapter text is supported by Figures 13.1 to 13. 8 (**TR010038/APP/6.2**) and Appendices 13.1 to 13.5 (**TR010038/APP/6.3**), which contain:

Figures

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13.2. Competent expert evidence

13.2.1. The surface water and flood risk competent expert (Ph.D., B.Sc. (Hons)) has 24 years of experience in the water sector and has successfully delivered many environmental impact assessments and supporting technical assessments for large infrastructure projects.

13.2.2. The hydrogeological competent expert (M.Sc., B.Sc. (Hons.), C.Geol.) has 17 years of experience in groundwater resources, including hydrogeological impact assessments and provision of technical support on large infrastructure projects.

13.2.3. Both competent experts have used their EIA knowledge, experience with DMRB and road infrastructure projects and professional judgement in identifying the likely significant impacts associated with the Proposed Scheme and providing technical guidance through the assessment process.

13.3. Legislative and policy framework

National legislation and policy

National Policy Statement for National Networks

13.3.1. The National Policy Statement for National Networks (NPS NN) (Department for Transport, 2014), sets out the need for, and Government's policies to deliver, development of nationally significant infrastructure projects on the national road and rail networks in England. It provides planning guidance for promoters of nationally significant infrastructure projects on the road and rail networks, and the basis for the examination by the Examining Authority and decisions by the

Secretary of State. NPS NN is used as the primary basis for making decisions on development consent applications for national networks nationally significant infrastructure projects in England.

13.3.2. Relevant to the road drainage and the water environment assessment, the NPS NN states:

- With regard to flood risk, if a[n] FRA is required to, the applicant should:
  - consider the risk of all forms of flooding arising from the project (including in adjacent parts of the United Kingdom), in addition to the risk of flooding to the project, and demonstrate how these risks will be managed and, where relevant, mitigated, so that the development remains safe throughout its lifetime
  - take the impacts of climate change into account, 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 exit
  - include the assessment of the remaining (known as 'residual') risk after risk reduction measures have been taken in to account and demonstrate that this is acceptable for the particular project;
  - consider if there is a need to remain operational during a worst case flood event over the development's lifetime
  - provide the evidence for the Secretary of State to apply the Sequential Test and Exception Test as appropriate
- The Secretary of State should be satisfied that flood risk will not be increased elsewhere and should only consider development appropriate in areas at risk of flooding where it can be demonstrated that:
  - within the site, 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; and that any residual risk can be safely managed, including by emergency planning; and that priority is given to the use of Sustainable Drainage Systems (SuDS)
- With regards to water quality the Secretary of State should be satisfied the proposal considers the River Basin Management Plans and the requirements of the Water Framework Directive (WFD) (including Article 4.7) and its daughter directives. This includes requirements on priority substances and groundwater.
- 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 its existing status and carry out impact assessments. These are included as part of the environmental statement and describe:
  - the existing quality of waters affected by the proposed project

- existing water resources affected by the proposed project and the impacts of the proposed project on water resources
- existing physical characteristics of the water environment (including quantity and dynamics of flow) affected by the proposed project, and any impact of physical modifications to these characteristics
- any impacts of the proposed project on waterbodies or protected under the Water Framework Directive and source protection zones around potable groundwater abstractions
- any cumulative effects

Water Framework Directive

13.3.3. The Water Framework Directive (WFD) establishes a framework for the management of water resources throughout the European Union (EU). The WFD was transposed into UK law through the Water Environment (Water Framework Directive) (England and Wales) Regulations 2003, which came into force in January 2004. The Water Environment (Water Framework Directive) (England and Wales) Regulations 2017 came into force in April 2017. These replace the 2003 regulations, consolidating amendments made since then, and primarily affect the management of water quality by the Environment Agency. The Water Environment (Water Framework Directive) (England and Wales) Regulations 2017 has been amended by the Floods and Water (Amendment etc.) (EU Exit) Regulations 2019/558 so as to continue to have effect now the United Kingdom has left the EU.

13.3.4. The key objectives of the WFD, provided for in the area River Basin Management Plan (RBMP), are to:

- Prevent deterioration, enhance and restore bodies of surface water, achieve good chemical and ecological status of such water and reduce pollution from discharges and emissions of hazardous substances.
- Protect, enhance and restore all bodies of groundwater, achieve good chemical and quantitative status of groundwater, prevent the pollution and deterioration of groundwater, and ensure a balance between groundwater abstraction and replenishment.
- Preserve protected areas.

The Environmental Permitting Regulations

13.3.5. The Environmental Permitting Regulations (EPR) 2016, and the 2018 amendment, aims to protect groundwater and surface waters from pollution by controlling the inputs of potentially harmful and polluting substances. The Environmental Permitting (England and Wales) Regulations 2016 have been amended by the Environmental Permitting (England and Wales) (Amendment)

(EU Exit) Regulations 2019 so as to continue to function after the United Kingdom leaves the EU.

13.3.6. The need for a Flood Risk Activity Permit now falls under the ERP regulations systems and replaces the Flood Defence Consents.

Flood and Water Management Act

13.3.7. The Flood and Water Management Act (2010) was a response to pressure to introduce legislation to address the threat of flooding and water scarcity, both of which are predicted to increase with climate change.

13.3.8. The Act requires better management of flood risk, it creates safeguards against rises in surface water drainage charges and protects water supplies for consumers. It gives responsibility to the Environment Agency for developing a National Flood and Coastal Risk Management Strategy, and gives responsibility to local authorities, as Lead Local Flood Authorities, to co-ordinate flood risk management in their area. Duties include investigating significant flooding incidents, maintaining a register of designated flood assets and provision of information.

Land Drainage Act

13.3.9. The Land Drainage Act (1991) requires that a watercourse be maintained by its owner in such a condition that the free flow of water is not impeded. The riparian owner must accept the natural flow from upstream but need not carry out work to cater for increased flows resulting from some types of works carried out upstream, for example a new housing development. The Act sets out the functions of Internal Drainage Boards and Local Authorities in relation to land drainage, giving them permissive powers under Section 25 of the act to ensure that appropriate maintenance is carried out by riparian landowners on ordinary watercourses.

The Highways Act

13.3.10. Under the Highways Act 1980 (Section 100), the Applicant has a right to discharge runoff from highways into inland and tidal waters, subject to the requirement not to pollute controlled waters. This includes groundwaters, as defined under the Water Resources Act 1991.

The Water Resources Act

13.3.11. Section 93 of the Water Resources Act (1991) provides for the establishment of groundwater protection zones. The requirements of Section 93 are implemented and set out in the Environment Agency's approach to groundwater protection (Environment Agency, 2017a) and the Environment Agency's groundwater

protection guides covering: requirements, permissions, risk assessments and controls (Environment Agency, 2017b). These replace the Environment Agency's 2013 Groundwater protection: principles and practice (GP3).

13.3.12. The Environment Agency's approach to groundwater protection includes the Environment Agency's position statements, which provide information about its 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. Many of the approaches set out in the position statements are not statutory but may be included in, or referenced by, statutory guidance and legislation.

13.3.13. Source protection zones are defined for groundwater supplies used for human consumption. The Environment Agency's position statement relating to the use of sustainable drainage systems can be found in The Environment Agency's approach to groundwater protection (Environment Agency, 2018a).

Environmental Damage (Prevention and Remediation) Regulations

13.3.14. The Environmental Damage (Prevention and Remediation) (England) Regulations 2015 only apply to damage after the Regulations come into force, and they only apply to operators of economic activities. There is a legal duty to immediately notify regulators and to prevent damage. Environmental damage is classified as damage to:

- Adverse effects on the integrity of a Site of Special Scientific Interest (SSSI) or on the conservation status of species and habitats protected by EU legislation outside SSSIs
- Adverse effects on surface water or groundwater consistent with a deterioration in the water's status (Water Framework Directive term)
- Contamination of land that results in a significant risk of adverse effects on human health

13.3.15. Remediation of damage to species, habitats or water must remove any significant risk to health. The objective is to achieve the same level of natural resources or services as would have existed if the damage had not occurred. This may involve primary remediation, complementary remediation or compensatory remediation.

The National Planning Policy Framework

13.3.16. The National Planning Policy Framework (NPPF) applies to this Scheme under Chapter 14 "Meeting the challenge of climate change, flooding and coastal change" (Ministry of Housing, Communities and Local Government, 2019). This is supported by the Planning Practice Guidance (PPG) (Ministry of Housing, Communities and Local Government, 2016), in relation to flood risk. It states that

where development is located in areas which are vulnerable to flooding, care should be taken to ensure that risks can be managed.

13.3.17. The Land Drainage Act (1991) and Flood and Water Management Act (2010) are also relevant to manage flood risk for any works within 8m of ordinary watercourses and to the discharge of surface water drainage to ordinary watercourses.

Local Policies

Joint Core Strategy for Broadland, Norwich and South Norfolk

13.3.18. The relevant policies within the strategy (Greater Norwich Development Partnership, 2014) in relation to the water environment are summarised below:

- Policy 1: addressing climate change and protecting environmental assets. Development should be located to minimise flood risk and mitigate any such risk through design and the implementation of sustainable drainage. Development should minimise water use and protect groundwater sources
- Policy 3: energy and water. This policy ensures that, amongst other things, water quality is protected and improved with no significant detriment to areas of environmental performance

The Broadland District Council Development Management Development Planning Document (DPD)

13.3.19. The relevant policies within the DPD (Broadland District Council, 2015) in relation to the water environment are summarised below:

- Policy EN4 – Pollution. Development must include an assessment of potential pollution and provide mitigation, where required. Development will only be permitted where there will be no significant impact upon amenity, human health or the natural environment.
- Policy CSU5 – Surface water drainage. Development should not increase flood risk elsewhere. Developments should not:
  - increase the vulnerability of the site, or wider catchment, to flooding from surface water runoff

13.3.20. Wherever practicable, development should have a positive impact on surface water flooding in the wider area

Breckland Council Local Plan

13.3.21. The relevant policies within the local plan adopted on November 28th, 2019 (Adoption Draft) (Breckland Council, 2019) in relation to the water environment are summarised below:

- Policy ENV 09 - Flood Risk & Surface Water Drainage. All new development will:

- be located to minimise the risk of flooding, mitigating any such risk through design and implementing sustainable drainage (SuDS) principles.
- incorporate appropriate surface water drainage mitigation measures to minimise its own risk of flooding and should not materially increase the flood risk to other areas. Particular care will be required in relation to habitats designated as being of international importance in the area and beyond which are water sensitive, as well as habitats designated of regional or local importance.

- Developers will be required to show that the proposed development would:
  - not increase green field run off rates and vulnerability of the site, or the wider catchment, to flooding from surface water runoff from existing or predicted water flows;
  - wherever practicable, have a positive impact on the risk of surface water flooding in the surrounding area adjacent to the development; and
  - address potential impact of infiltration upon groundwater Source Protection Zones and/or Critical Drainage Catchments.

Norfolk County Council

13.3.22. Norfolk County Council also provide guidance to developers on their role as Lead Local Flood Authority.

13.4. Assessment methodology

13.4.1. The proposed methodology follows DMRB LA 113 for assessing the significance of effects of proposed road schemes on the road drainage and the water environment. The procedures and the appropriate methods that must be used when assessing the potential impacts from the road projects on the water environment are described in the DMRB LA 113.

13.4.2. The following proposed methods have been adopted:

- A simple (as defined by DMRB LA113) assessment of pollution impacts from routine runoff to surface waters using Highways England Water Risk Assessment Tool (HEWRAT). The HEWRAT assessment uses updated drainage information and annual average daily traffic (AADT) data to establish potential impacts of pollutants in routine highway runoff and impacts from spillages for the Proposed Scheme upon the watercourses within the study area and the requirement for mitigation measures to adequately reduce the risk. The results of this assessment are included in Appendix 13.3 Water quality assessment (**TR010038/APP/6.3**).
- A detailed assessment of pollution impacts from routine runoff to surface waters using UKTAG Rivers and Lakes Metal Bioavailability Assessment Tool (M-BAT) (UKTAG, 2014a). The M-BAT is required when the predicted annual average concentrations of soluble pollutants exceed the environmental quality standards (EQS). This assessment effectively refines the EQS on a site-specific basis through the collection of a series of water

quality samples collected from the watercourse at the point of assessment. The results of this assessment are included in Appendix 13.3 Water quality assessment (**TR010038/APP/6.3**).

- A simple assessment of groundwater levels and flow, as described in Appendix A of DMRB LA 113. This is a qualitative assessment that identifies all potential features which are susceptible to groundwater level and flow impacts from the Proposed Scheme, based on a hydrogeological conceptualisation of the surrounding area and the regional groundwater body status. The results of this assessment are included in Appendix 13.4 Groundwater assessment (**TR010038/APP/6.3**).
- A simple assessment of groundwater dependent terrestrial ecosystems, as described in Appendix B of DMRB LA 113. This is a stepped, risk-based approach which establishes linkages between potential impacts from the Proposed Scheme on the hydrological and hydrogeological regime and any identified groundwater dependent terrestrial ecosystem (GWDTE). The results of this assessment are included in Appendix 13.4 Groundwater assessment (**TR010038/APP/6.3**).
- A detailed assessment of groundwater quality and run off, as described in Appendix C of DMRB LA 113, and using the groundwater risk assessment matrix provided in HEWRAT. The groundwater risk assessment matrix is based on the 'source-pathway-receptor' pollutant linkage principle and considers the AADT, annual average rainfall depth, drainage area ratio, and parameters of the receiving ground conditions to give a banded risk score. This method has been used to assess the risk of routine runoff to surface waters with low flows and for filter drains, where there is infiltration to ground. The results of this assessment are included in Appendix 13.4 Groundwater assessment (**TR010038/APP/6.3**).
- Assessment of pollution impacts from spillages using HEWRAT as described in Appendix D of DMRB LA 113. The method initially estimates the risk that there will be an incident causing the spillage of a potentially polluting substance somewhere on the length of road being assessed. It then calculates the risk, assuming a spillage has occurred, that the pollutant will reach and impact on the receiving watercourse or groundwater. The results of this assessment are included in Appendix 13.3 Water quality assessment (**TR010038/APP/6.3**).
- A hydromorphological assessment, as described in Appendix E of DMRB LA 113. A simple assessment, supplemented by a site survey, identifies the natural river processes that would have operated before any development had affected the river or catchment and determines whether the degree of hydromorphological change is acceptable. The results of this assessment are included in Appendix 13.5 Geomorphological assessment (**TR010038/APP/6.3**).
- A WFD assessment for both surface water and groundwater, as described in DMRB LA 113. This identifies how the Proposed Scheme has the potential to impact each of the waterbodies' quantity and quality elements and whether it could lead to non-compliance of the WFD. The WFD assessment is

incorporated into this chapter and is based on the findings of the other assessments.

13.4.3. The approach to the assessment takes into consideration comments from the Planning Inspectorate (**TR010038/APP/6.6**) in response to the Proposed Scheme's Scoping Report published in November 2019 (**TR010038/APP/6.5**).

13.4.4. The Flood Risk Assessment (FRA) (Appendix 13.1) (**TR010038/APP/6.3**) has been undertaken in accordance with the requirements of the NPPF (Ministry of Housing, Communities and Local Government, 2016; 2019), and the Environment Agency's climate change allowances (Environment Agency, 2020a). A detailed hydrological and hydraulic assessment has been undertaken as part of this assessment.

13.4.5. A Drainage Strategy (Appendix 13.2) (**TR010038/APP/6.3**) has been undertaken by the drainage designers in order to outline the proposed drainage design and mitigation measures to reduce impacts upon the water environment from the Proposed Scheme.

Update to guidance and scope of assessment

13.4.6. Following a review of changes to DMRB LA 113, the scope presented in the Scoping Report for the Proposed Scheme (2019) is still valid and no change is required.

Determination of baseline conditions

13.4.7. This chapter has been completed based on the information contained within the above reports (**TR010038/APP/6.3**), plus the following sources of information:

- British Geological Survey (BGS) 1:50,000 and 1:625,000 superficial and bedrock geological map (BGS, 2020)
- Defra's 'Magic' interactive map (Defra, 2020)
- Environment Agency Catchment Data Explorer (Environment Agency, 2020b)
- Environment Agency Consented Discharges and Abstraction data
- Highways Agency Drainage Data Management System (HA DDMS) (Highways England, 2020)
- Norfolk County Council Preliminary Flood Risk Assessment Report (PFRA) (Norfolk County Council, 2011)
- Breckland District Council Level 1 Strategic Flood Risk Assessment (SFRA) (AECOM, 2017)
- Greater Norwich Area Strategic Flood Risk Assessment (SFRA) (JBA, 2017)

- The preliminary findings of a 2020 ground investigation for the Proposed Scheme. Further details of this ground investigation are included in Appendix 13.4 (Groundwater Assessment) (**TR010038/APP/6.3**).

Site walkover

13.4.8. Site walkovers were carried out in March 2018, November 2019 and May 2020. The walkovers were undertaken to:

- ground truth surface water features identified within the study area from Ordnance Survey mapping which are to be included in the hydraulic model
- understand the hydrological connectivity across the Proposed Scheme
- understand the hydromorphology or fluvial geomorphology of the watercourses affected by the Proposed Scheme

Consultation

13.4.9. Statutory bodies, including the Environment Agency and Norfolk County Council, had the opportunity to respond to the EIA Scoping Report via the Planning Inspectorate in September 2019 (**TR010038/APP/6.5**).

13.4.10. For the purposes of this assessment, further consultation has been undertaken with the following organisations:

- The Environment Agency
- Anglian Water
- Norfolk County Council
- Norfolk Rivers District Internal Drainage Board
- Breckland Council
- Broadland District Council
- South Norfolk Council

13.4.11. The Environment Agency were consulted on the proposed methodology for flood modelling in March 2020 and their advice was incorporated into the subsequent assessments. The Environment Agency were consulted on the lifetime of the development (Proposed Scheme) and the River Tud Crossing in June 2020. They noted the following:

- that a narrow span bridge would not be appropriate and bridge abutments should preferably be out of the floodplain and flood compensation storage would be needed
- any construction and operational impacts should be avoided
- they would prefer to avoid flood attenuation culverts and any culverting as much as possible

13.4.12. The Environment Agency were further consulted on specific proposals for the River Tud Crossing at meetings in June, July, August, September and November 2020. Agreement in principle was reached regarding a proposed River Tud crossing with specific requirements relating to the offset of the river bank to the structure in order to allow for adequate width for a wildlife corridor and to allow for natural movement of the watercourse over the lifetime of the Proposed Scheme. The Environment Agency were consulted on the construction methodology of the River Tud Crossing in November 2020. Consultation on WFD assessment scope and proposed mitigation in July and November 2020.

13.4.13. The Environment Agency provided comments on a draft of the Drainage strategy report in December 2020. The Environment Agency confirmed in January 2021 that the proposed compensatory flood storage for the River Tud Crossing was agreed to be appropriately located to directly compensate on a volume-for-volume and level-for-level basis.

13.4.14. The Environment Agency have provided details in their Scoping Opinion (**TR010038/APP/6.6**) of a new public water supply abstraction (and its associated Source Protection Zone) located off Church Lane, to the north of East Tuddenham.

13.4.15. Consultation with Anglian Water commenced in January 2021 regarding the new public water supply abstraction at East Tuddenham. Discussions focused on the ground conditions determined from the 2020 ground investigation, potential impacts from intrusive structures and the essential and embedded mitigation measures incorporated to date. Anglian Water noted the following;

- The abstraction at East Tuddenham is the main public water supply abstraction of concern
- Turbidity generation from excavation works and future ground investigations are the impact of greatest potential concern
- Structures west of the abstraction pose the greatest risk to the East Tuddenham abstraction

13.4.16. Anglian Water have requested assurances that additional monitoring boreholes will not result in contamination risks, and that aquifer protection measures have been incorporated into the design, citing unexpected artesian conditions within the River Tud floodplain. Anglian Water have also requested that appropriate measures are taken to decommission the monitoring points at the end of the monitoring period.

13.4.17. Consultation with Anglian Water and the Environment Agency has also been undertaken regarding the drainage design of the Proposed Scheme with specific reference to infiltration to ground.

13.4.18. Norfolk County Council were consulted in August, September and November 2020 regarding the proposed structures crossing the ordinary watercourses at Hockering and Oak Farm. Discussions were focused on flood risk, capacity of the structures, requirements for freeboard and compensatory flood storage and opportunities for enhancements.

13.4.19. Norfolk County Council provided comments on a draft Drainage strategy report in January 2021 including detailed comments on aspects of the drainage design.

13.4.20. Feedback from Norfolk County Council on February 2021 requested further clarification regarding several aspects of the design related to Oak Farm and Hockering and the requirement for compensatory flood storage. In subsequent discussions, Norfolk County Council has accepted, in principle, that flood compensatory storage at Oak Farm and Hockering might not required. However, further information is required prior to determining this requirement regarding the off-site impacts and this is provided within the flood risk assessment and will be further detailed during detailed design.

13.4.21. The Flood risk assessment has been issued to Norfolk County Council and the Environment Agency in February 2021 for comment.

13.4.22. The Norfolk Rivers Internal Drainage Board were consulted on the Drainage Strategy in December 2020 and January 2021.

13.4.23. Breckland Council, Broadland District Council, South Norfolk Council were consulted regarding information on flooding history local to the Proposed Scheme.

Assessment criteria

13.4.24. The assessment identifies the water features within the study area (and any downstream water bodies) and determines the importance (value) of the features as set out in DMRB LA 113.

Value of receptor

13.4.25. The conservation value of water resources is in part defined by legislation which protects all controlled waters in England and Wales and, in effect, protects all water bodies (surface water or groundwater). Therefore, there cannot be any water feature which has negligible value. The value of controlled waters was defined by considering the use and conservation importance of the water body. The criteria used in this assessment to determine the value and importance of each water feature and its attributes are set out in Table 13-1, based on the definitions provided in Table 3.70 in DMRB LA 113.

13.4.26. The value and importance of water environment attributes within the study area are defined in Table 13-7 in section 13.4, based on definitions provided in Table 13-1.

Table 13-1 Criteria for Estimating the Importance of Water Environment Attributes

Value	Criteria	Examples
Very High	Nationally significant attribute of high importance	**Surface Water**: Watercourse having a WFD classification shown in a RBMP and Q95 ≥ 1.0m^3/s. Site protected / designated under EC or UK legislation (SAC, SPA, SSSI, Ramsar site, salmonid water) / Species protected by EC legislation Ecology and Nature Conservation. **Groundwater**: Principal aquifer providing a regionally important resource and / or supporting a site protected under EC and UK legislation Ecology and Nature Conservation. Groundwater locally supports GWDTE SPZ1. **Flood Risk**: Essential infrastructure or highly vulnerable development.
High	Locally significant attribute of high importance	**Surface Water**: Watercourse having a WFD classification shown in a RBMP and Q95 <1.0m^3/s. Species protected under EC or UK legislation Ecology and Nature Conservation. **Groundwater**: Principal aquifer providing locally important resource or supporting a river ecosystem. Groundwater supports a GWDTE SPZ2. **Flood Risk**: More vulnerable development.
Medium	Of moderate quality and rarity	**Surface Water**: Watercourses not having a WFD classification shown in a RBMP and Q95 >0.001m^3/s. **Groundwater**: Aquifer providing water for agricultural or industrial use with limited connection to surface water. SPZ3. **Flood Risk**: Less vulnerable development.
Low	Lower quality	**Surface Water**: Watercourses not having a WFD classification shown in a RBMP and Q95 ≤0.001m^3/s. **Groundwater**: Unproductive strata. **Flood Risk**: Water compatible development.

Magnitude of impact

13.4.27. Definitions for the magnitude of impact are given in Table 13-2 and are based on values set out in Table 3.71 of DMRB LA 113, and the typical examples should be used as a gauge.

Table 13-2 Estimating the Magnitude of an Impact on an Attribute

Magnitude	Criteria	Examples
Major adverse	Results in loss of attribute and / or quality and integrity of attribute	**Surface Water** Failure of both acute-soluble and chronic-sediment related pollutants in HEWRAT and compliance failure with EQS values. Calculated risk of pollution from a spillage ≥2% annually (spillage assessment). Loss or extensive change to a fishery. Loss of regionally important public

Magnitude	Criteria	Examples
		water supply. Loss or extensive change to a designated nature conservation site. Reduction in water body WFD classification. **Ground Water** Loss of, or extensive change to, an aquifer. Loss of regionally important water supply. Potential high risk of pollution to groundwater from routine runoff - risk score >250 (Groundwater quality and runoff assessment). Calculated risk of pollution from spillages ≥2% annually (Spillage assessment). Loss of, or extensive change to GWDTE or baseflow contribution to protected surface water bodies. Reduction in water body WFD classification. Loss or significant damage to major structures through subsidence or similar effects. **Flood Risk** Increase in peak flood level (> 100mm).
Moderate adverse	Results in effect on integrity of attribute, or loss of part of attribute	**Surface Water** Failure of both acute-soluble and chronic-sediment related pollutants in HEWRAT but compliance with EQS values. Calculated risk of pollution from spillages ≥1% annually and <2 % annually. Partial loss in productivity of a fishery. Degradation of regionally important public water supply or loss of major commercial / industrial / agricultural supplies. Contribution to reduction in water body WFD classification. **Ground Water** Partial loss or change to an aquifer. Degradation of regionally important public water supply or loss of significant commercial / industrial / agricultural supplies. Potential medium risk of pollution to groundwater from routine runoff - risk score 150-250. Calculated risk of pollution from spillages ≥1% annually and <2 % annually. Partial loss of the integrity of GWDTE. Contribution to reduction in water body WFD classification. Damage to major structures through subsidence or similar effects or loss of minor structures. **Flood Risk** Increase in peak flood level (> 50mm).
Minor adverse	Results in some measurable change in attribute's quality or vulnerability	**Surface Water** Failure of either acute soluble or chronic sediment related pollutants in HEWRAT. Calculated risk of pollution from spillages ≥0.5% annually and < 1% annually. Minor effects on water supplies. **Ground Water** Potential low risk of pollution to groundwater from routine runoff - risk score <150. Calculated risk of pollution from spillages ≥0.5% annually and <1%annually. Minor effects on an aquifer, GWDTEs, abstractions and structures. **Flood Risk** Increase in peak flood level (> 10mm).
Negligible	Results in effect on attribute, but of insufficient	The proposed project is unlikely to affect the integrity of the water environment.

Magnitude	Criteria	Examples
	magnitude to affect the use or integrity	**Surface Water** No risk identified by HEWRAT (pass both acute-soluble and chronic-sediment related pollutants). Risk of pollution from spillages <0.5%. **Ground Water** No measurable impact upon an aquifer and / or groundwater receptors and risk of pollution from spillages <0.5%. **Flood Risk** Negligible change to peak flood level (≤ + / - 10mm).
Minor beneficial	Results in some beneficial effect on attribute or a reduced risk of negative effect occurring	**Surface Water** HEWRAT assessment of either acute soluble or chronic-sediment related pollutants becomes pass from an existing site where the baseline was a fail condition. Calculated reduction in existing spillage risk by 50% or more (when existing spillage risk is <1% annually). **Ground Water** Calculated reduction in existing spillage risk by 50% or more to an aquifer (when existing spillage risk <1% annually). Reduction of groundwater hazards to existing structures. Reductions in waterlogging and groundwater flooding. **Flood Risk** Creation of flood storage and decrease in peak flood level (> 10mm).
Moderate beneficial	Results in moderate improvement of attribute quality	**Surface Water** HEWRAT assessment of both acute-soluble and chronic-sediment related pollutants becomes pass from an existing site where the baseline was a fail condition. Calculated reduction in existing spillage by 50% or more (when existing spillage risk >1% annually). Contribution to improvement in water body WFD classification. **Ground Water** Calculated reduction in existing spillage risk by 50% or more (when existing spillage risk is >1% annually). Contribution to improvement in water body WFD classification. Improvement in water body catchment abstraction management Strategy (CAMS) (or equivalent) classification. Support to significant improvements in damaged GWDTE. **Flood Risk** Creation of flood storage and decrease in peak flood level1 (> 50mm).
Major beneficial	Results in major improvement of attribute quality	**Surface Water** Removal of existing polluting discharge or removing the likelihood of polluting discharges occurring to a watercourse. Improvement in water body WFD classification. **Ground Water**

Magnitude	Criteria	Examples
		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. **Flood Risk** Creation of flood storage and decrease in peak flood level (> 100mm).
No Change		No loss or alteration of characteristics, features or elements; no observable impact in either direction.

Significance

13.4.28. The overall significance of effect was determined using the significance matrix provided in Table 3.8.1 in DMRB LA104 (provided in ES Chapter 4, Environmental Assessment Methodology, Table 4-2 (**TR010038/APP/6.1**)) using professional judgement to consider site specific factors that may be of relevance. Effects can be beneficial or adverse. Effects that are moderate, large, or very large, are considered significant effects. Effects that are slight or neutral are not significant. A description of the significance category is provided in Table 3.7 of DMRB LA104 and is set out in Chapter 4, Environmental Assessment Methodology, Table 4-1 (**TR010038/APP/6.1**).

13.5. Assessment assumptions and limitations

13.5.1. The current assessment is based on information contained within the Ground Investigation Factual Report. The 2020 ground investigation, and subsequent monitoring and sampling have provided comprehensive data relating to the geology and hydrogeology within the Proposed Scheme DCO boundary (the Site) for preliminary design. However, there may be data gaps for any subsequent design updates. A supplementary ground investigation is planned to determine the geotechnical and groundwater elements required for the latest design.

13.5.2. The recent groundwater level monitoring commenced in early summer 2020 and is unlikely to have captured peak seasonal groundwater levels. The assessments within this chapter use the maximum groundwater levels available as worst case values. The assessments will be revisited at the detailed design stage following receipt of the full baseline groundwater monitoring and supplementary ground investigation.

13.5.3. The Proposed Scheme is linear, and there is limited pertinent data outside of the DCO Boundary. This has implications with respect to the baseline conceptual hydrogeological model, particularly with respect to regional hydraulic gradients.

13.5.4. Temporary construction dewatering may be required for deep excavation works for the Proposed Scheme. Details regarding discharge or disposal of any dewatered volumes are unknown, so the worst-case scenario of discharging to a surface watercourse is assumed.

13.5.5. Whilst details of a new groundwater source for public water supply have been provided, the extents of its source protection zone have not, as yet, been confirmed by the Environment Agency. As suggested by the Environment Agency, a 1km stretch of the Proposed Scheme immediately to the north of the public water supply is assumed to represent the SPZ 1, although no details of the SPZ 2 or 3 are available at this stage.

13.5.6. Temporary drainage design during construction is to be confirmed. A reasonable assumption is that the surface water runoff from the main site, satellite and material storage compounds will be collected within a ditch surrounding the compound and be redirected to settlement ponds before being discharged to a surface watercourse or ground. It is assumed that foul waste from welfare areas would have their own waste storage that would be cleaned out, and removed from the compounds on a regular basis or would be discharged directly to sewer, subject to approval from Anglian Water.

13.5.7. The assessment of flood flows intercepted by the Proposed Scheme and the location and sizing of cross-drains and ‘dry culverts’ is based on available LiDAR data. A tailored topographic survey will be undertaken at detailed design to reassess and confirm the location and sizing of cross-drains. Otherwise, it is considered that the data limitations identified below do not introduce significant uncertainties with respect to surface water and flooding risks.

13.5.8. The drainage survey, to confirm the discharge locations from the existing A47 road drainage, is currently ongoing. For the purpose of this assessment it has been assumed it drains to both groundwater and surface water receptors as indicated by information available on HADDMS.

13.5.9. Excluding the impacts of spillages, which have been assessed, it is assumed that no significant adverse effects are predicted deriving from the vulnerability of the Proposed Scheme to risks of major accidents and / or disasters (e.g. major road traffic accident, structure collapse, ground instability, terrorist attack, fire, chemical spillage). This is due to the design, construction and operation of the Proposed Scheme which must comply with relevant health and safety legislation, current design standards and a response to any major incident would be in accordance with Highways England’s Traffic Incident Management and Contingency Planning framework.

13.5.10. Details of unlicensed abstractions have been requested from the three local district councils intersected by the Proposed Scheme. At the time of writing, details have only been received from Breckland Council.

13.6. Study area

13.6.1. The study area must encompass groundwater and surface water features that would potentially be affected by the Proposed Scheme. The study area is based on professional judgement to ensure that effects are sufficiently identified and comprises a 1km corridor surrounding the footprint of the Proposed Scheme DCO boundary. Where approporiate, the study area has been extended to include features further downstream (surface water features) or down-gradient (groundwater features) that may also be impacted, should a potential pathway or linkage be identified. This can be important for identifying groundwater dependent terrestrial ecosystems that rely on groundwater originating from within the DCO boundary, for example. The study area is shown in Figures 13.1 to 13.8 (**TR010038/APP/6.2**) along with the key surface water and groundwater features. The surface water and groundwater features included in the assessment are also described in section 13.7.

13.7. Baseline conditions

Surface water

Surface water features

13.7.1. The main surface water features within the study area that have the potential to be either directly or indirectly affected by the Proposed Scheme are shown in Figure 13.1 (Surface water features, abstractions and fluvial flood risk) (**TR010038/APP/6.2**). A summary of these features is provided below.

13.7.2. The River Tud, is the only main river located within the DCO boundary and flows for approximately 9.3km in an easterly direction south of the existing A47. It flows under the existing A47 carriageway at Honingham where it continues in an easterly direction to the north of the A47 before its confluence with the River Wensum (see Figure 13.1 (Surface water features, abstractions and fluvial flood risk) (**TR010038/APP/6.2**)). The study area has an elevation of between 32 to 52 metres above Ordnance Datum (mAOD). The majority of the catchment within the DCO boundary is rural with the villages of Easton, Honingham and Hockering located along the existing A47.

13.7.3. The Geomorphological assessment (Appendix 13.5 (**TR010038/APP/6.3**)) indicates the River Tud shows the typical features and dynamics of a chalk stream, which makes it particularly sensitive to siltation.

13.7.4. There are no gauging stations near to the Proposed Scheme. However, a gauging station at Costessey Park was identified approximately 4.5km downstream on the River Tud, where the annual Q_{95} flow (that is, the flow that is exceeded 95% of the time) is estimated to be 0.099m^3/s (Centre for Ecology and Hydrology, 2020a). The River Tud is assessed to have a baseflow index of 0.64 at Costessey Park suggesting a high degree of groundwater supply to river flows (Centre for Ecology and Hydrology, 2020a).

13.7.5. The River Tud is a tributary of the River Wensum with the confluence approximately 7.3km downstream of the study area. Approximately 5km upstream of the confluence with the River Tud, the annual Q_{95} flow for the River Wensum at Costessey Mill is estimated to be 1.36m^3/s (Centre for Ecology and Hydrology, 2020b). The River Wensum is considered an indirect receptor downstream of the River Tud confluence.

13.7.6. A section of the River Wensum catchment is located within the study area 2km to the north of Easton (Figure 13.1 (Surface water features, abstractions and fluvial flood risk) (**TR010038/APP/6.2**)). The DCO boundary within the Wensum catchment is related to road diversions (road signs changes and road blocks only) required on Honingham Lane. As these works will not impact on the water environment, the River Wensum is not considered a direct receptor.

13.7.7. The River Yare is located to the south of the Proposed Scheme, generally lying just within the study area (Figure 13.2 (WFD and IDB surface waterbodies) (**TR010038/APP/6.2**)). The Proposed Scheme is separated by the catchment divide (hydrologically disconnected) between the Tud and Yare for all but a small section of the DCO boundary (and study area), between 500 to 1000 metres west south-west of Easton which lies in the upper extents of the Yare catchment.

13.7.8. The Proposed Scheme lies within the hydraulic catchment and boundary of the Norfolk Rivers IDB and a small section of the River Tud between Church Lane and The Street at Honingham is identified to be an IDB river (Figure 13.2 (WFD and IDB surface waterbodies) (**TR010038/APP/6.2**)).

13.7.9. Numerous small ponds and ordinary watercourses are identified within the Proposed Scheme study area (see Figure 13.1 (Surface water features, abstractions and fluvial flood risk) (**TR010038/APP/6.2**)), with a large number of these being located around the existing A47. Within the DCO boundary the following small ponds and ordinary watercourses were identified:

- one watercourse, a tributary of the River Tud, is located to the east of the Proposed Scheme at Oak Farm
- four drains, which are tributaries of the River Tud, are located south of Hockering

- one watercourse, a tributary of the River Tud, is located east of Hockering
- one drain, a tributary of the River Tud, is located south-east of Hockering
- one drain, a tributary of the River Tud, is located north-east of Honingham where the Proposed Scheme crosses the River Tud
- one watercourse, a tributary of the River Tud, is located south-east of Honingham
- 16 small ponds across the Proposed Scheme

13.7.10. Outside of the DCO boundary, a cluster of four drainage ponds lie 0.5km to the north east of Hockering. All four ponds lie within arable farmland and drain into the River Tud approximately 700m to the south. The ponds make up part of Park Farm Lakes which is a local commercial fishery.

13.7.11. To the south-east of Hockering (approximately 1.1km) a large water body is identified, which is also used recreationally for fishing, this holds an abstraction licence for domestic and agriculture purposes.

13.7.12. A drainage pond and a cluster of drains are located to the north east of Honingham (approximately 0.8km and 0.5km respectively) near where the Proposed Scheme will cross the River Tud. These drain into the River Tud. Clusters of drains and small ponds are also identified 1.3km to the west of Honingham.

13.7.13. There is no water quality data available for any of the water bodies or watercourses within the study area which can inform the assessment. However, a six month water quality sampling regime was started in September 2020 for the River Tud and a tributary of the River Tud at Oak Farm to inform the HEWRAT and M-BAT assessment. The results show that the average bioavailable copper concentrations for the River Tud and the tributary at Oak Farm across the sampling period are 0.07ug/l and 0.16ug/l respectively. The EQS for dissolved copper in freshwaters is 1 µg/l (UKTAG, 2014b).

Water Framework Directive

13.7.14. The study area is split between the following WFD water body catchments:

- Tud WFD water body (WBID: GB105034051000) covers the entire Site. It is part of the Wensum Operational Catchment and the Broadlands Rivers Management Catchment. The River Tud is identified from OS mapping as being the main water body in this water body catchment.
- Wensum DS Norwich WFD water body (GB105034055882) is located to the east of the Proposed Scheme and is located outside of the study area. It is part of the Yare Operational Catchment and the Broadlands Rivers Management Catchment. The River Wensum is the main water body in this catchment. The waterbody catchment is located immediately downstream of

the confluence with the River Tud. Due to this, this water body has been identified as an indirect receptor.

- Yare (Tiffey to Wensum) WFD water body (GB105034051281) is located the south-east of the Proposed Scheme. It is part of the Yare Operational Catchment and the Broadlands Rivers Management Catchment. The River Yare is the main water body in this catchment. There are no water bodies or watercourses associated with this WFD catchment within the study area or DCO boundary. However, there is an abstraction point and surface water flood flow pathways (as discussed later) located within the waterbody catchment. Due to this, this water body has been identified as an indirect receptor.

13.7.15. A section of the Wensum US Norwich WFD water body (GB105034055881) catchment lies within the study area to the north of Easton. Works within the Wensum US Norwich WFD water body are isolated from the main construction area, are non-invasive and include replacement of signposts and temporary road blockages. There are no identified water bodies or watercourses hydrologically linking this WFD catchment to the main construction area of the Proposed Scheme. Therefore, it is assumed there would be no impact and it is scoped out of this assessment.

13.7.16. Small sections of the Yare (upstream (u/s) confluence with Tiffey – Lower) WFD water body (GB105034051270) catchment lies within the study area to the south of East Tuddenham and south of Honingham. The Proposed Scheme is separated by the catchment divide (hydrologically disconnected) between the Tud and Yare water bodies. Therefore, it is assumed there would be no impact to this small section of the River Yare (u/s confluence with Tiffey – Lower) and it is scoped out of the WFD assessment.

13.7.17. The WFD catchments are within the Anglian River Basin District and their locations are identified in Figure 13.2 (WFD and IDB surface waterbodies) (**TR010038/APP/6.2**).

13.7.18. Table 13-3 summarises the WFD surface water bodies within the study area and indicates their targets and objectives. Based on the 2019 status, the current Anglian River Basin Management Plan (RBMP), as shown by the Environment Agency's Catchment Data Explorer website (Environment Agency, 2020b) indicates that:

- Tud (WBID: GB105034051000) ecological potential is limited to moderate by the physico-chemical quality elements (moderate potential for phosphate). Reasons for not achieving good potential include sewage discharge (continuous), private sewage treatment, poor livestock and nutrient management, and transport drainage. The chemical status is classified as a fail due to the presence of priority hazardous substances (polybrominated diphenyl ethers). The source of this priority substance is not stated;

however, polybrominated diphenyl ethers are a class of organobromine compounds that are used as flame retardants. The overall status is expected to remain at moderate due to unfavourable balance of costs and benefits.

- The Wensum DS Norwich (WBID:GB105034055882) ecological potential is limited to moderate by the biological quality elements (moderate potential for macrophytes and phytobenthos combined) and supporting elements (moderate or less for mitigation measures assessment). Reasons for not achieving good potential include sewage discharge (intermittent and continuous), poor nutrient management, urbanisation – urban development, surface water abstraction and physical modification relating to local and central government, navigation and recreation. The chemical status is classified as a fail due to the presence of priority hazardous substances (polybrominated diphenyl ethers). The source of this priority substance is not stated; however, polybrominated diphenyl ethers are a class of organobromine compounds that are used as flame retardants. The overall status is expected to remain at moderate due to unfavourable balance of costs and benefits, and the cause of the adverse impacts being unknown.
- Yare (Tiffey to Wensum) WFD water body (GB105034051281) ecological potential is limited to moderate supporting elements (moderate or less potential for mitigation measures assessment), biological quality elements (moderate potential for macrophytes and phytobenthos combined) and physico-chemical quality elements (moderate potential for dissolved oxygen). Reasons for not achieving good potential include groundwater abstraction, surface water abstraction and flood protection – other operational management. The chemical status is classified as a fail due to the presence of priority hazardous substances (polybrominated diphenyl ethers). The source of this priority substance is not stated; however, polybrominated diphenyl ethers are a class of organobromine compounds that are used as flame retardants. The overall status is expected to remain at moderate due to unfavourable balance of costs and benefits, and disproportionate burdens.

Table 13-3 Summary of WFD surface water bodies within the study area

Water body Name	Tud	Wensum DS Norwich	Yare (Tiffey to Wensum)
Water body ID	GB105034051000	GB105034055882	GB105034051281
Operational Catchment	Wensum	Yare	Yare
Management Catchment	Broadland Rivers	Broadland Rivers	Broadland Rivers
River Basin District	Anglian	Anglian	Anglian
Type	River	River	River
Hydromorphological Status	Heavily modified	Heavily modified	Heavily modified

Water body Name	Tud	Wensum DS Norwich	Yare (Tiffey to Wensum)
Overall Classification (Cycle 2 – 2019)	Moderate	Moderate	Moderate
Current Ecological Quality (Cycle 2 – 2019)	Moderate	Moderate	Moderate
Current Chemical Quality (Cycle 2 – 2019)	Fail	Fail	Fail
Ecological Objective	Moderate by 2015 (maintain moderate status)	Good by 2027	Good by 2027
Chemical Objective	Good by 2015	Good by 2015	Good by 2015
Protected Area (within the study area)	Nitrates Directive	Nitrates Directive, Safeguard Zone and Drinking Water Protected Area	Nitrates Directive

13.7.19. The entire Proposed Scheme lies within the Tud (397) Nitrate Vulnerable Zone (NVZ) and a surface water Drinking Water Safeguard Zone (Surface Water) SWSGZ1016, which is designated at risk from pesticide (metaldehyde) (Environment Agency, 2020c).

Groundwater

Geology

13.7.20. The study area is predominantly underlain by glacial till of the Lowestoft Formation, with patches of glacial sands and gravels of the Sheringham Cliffs Formation that become more dominant towards the east of the study area around Easton. The Lowestoft Formation is absent in the incised valleys, with post glacial deposits of River Terrace Deposits and Alluvium present and directly overlying Chalk bedrock. Discrete patches of Alluvial Fan Deposits, peat and Happisburgh Glacigenic Formation are also found within the study area, as described below.

13.7.21. The geology underlying the study area is described in detail in Appendix 13.4 Groundwater assessment (**TR010038/APP/6.3**).

Aquifer designations

13.7.22. The spatial extents of the aquifers underlying the study area are provided in Figure 13.3 (Aquifer and environmental designations) (**TR010038/APP/6.2**).

13.7.23. The chalk bedrock is a Principal aquifer. Principal aquifers are strata that have high intergranular and/or fracture permeability, and as such usually provide a

high level of water storage. They may support water supply and/or river base flow on a strategic scale.

13.7.24. The superficial Sheringham Cliffs Formation, Lowestoft Formation – Sand, Happisburgh and Lowestoft (Undifferentiated), Alluvium, and River Terrace Deposits are classified as Secondary A aquifers. Secondary A aquifers are permeable layers capable of supporting water supplied at a local, rather than strategic scale, and in some cases, form an important source of baseflow to rivers.

13.7.25. The Lowestoft Formation - Diamicton is classified as a Secondary (undifferentiated) aquifer. Secondary (undifferentiated) aquifers are classified as such due to the formation previously having been designated as both a minor aquifer and non-aquifer (now defined as Secondary A and Secondary B respectively) in different locations, due to variable characteristics of the rock type. As such Secondary (undifferentiated) aquifers are likely to contain lower permeability layers and perched aquifers.

13.7.26. The Alluvial Fan Deposits are classed as unproductive and are impermeable.

Groundwater levels and flows

13.7.27. Groundwater strikes recorded during the 2020 ground investigation were encountered within the Alluvium, River Terrace Deposits, Sheringham Cliffs Formation, and the Chalk.

13.7.28. Groundwater levels across the site recorded over the summer of 2020 range between 48mAOD and 20mAOD.

13.7.29. Shallow and artesian groundwater levels were recorded in the Chalk aquifer during the 2020 ground investigation, notably where the Proposed Scheme crosses the River Tud at Honingham and a tributary of the River Tud south-east of Hockering.

13.7.30. Groundwater level monitoring across the Proposed Scheme indicates that:

- the groundwater within the study area is semi-confined by peat and low permeability layers within the River Tud floodplain and confined by low permeability layers of the Lowestoft Formation within the interfluves.
- artesian Chalk and Alluvium groundwater levels follow the same trend indicating that close to the River Tud there is a component of upward leakage into the superficial deposits, and which also likely provides baseflow to the River Tud.
- groundwater flow within the study area is shown to be driven by the Chalk and is predominantly towards the east, locally controlled by the River Tud.

13.7.31. Although not confirmed specifically by groundwater monitoring, it is also assumed that there may also be some local control on groundwater flows adjacent to groundwater abstractions.

13.7.32. Full details of the hydrogeological conditions determined by the 2020 ground investigation are included within Appendix 13.4 Groundwater assessment (**TR010038/APP/6.3**).

Aquifer properties

13.7.33. The properties of the aquifer define the capacity of the aquifer to release water and the ability of groundwater flow to be transmitted with ease.

13.7.34. The Lowestoft Formation largely confines the underlying Chalk aquifer within the study area. However, the formation includes permeable horizons which contain groundwater which may be perched or fed by upward leakage from the Chalk.

13.7.35. The Secondary A Alluvium aquifer was saturated where found within the River Tud floodplain and is likely hydraulically linked to the Chalk aquifer via upward leakage, and the River Tud. The Sheringham Cliffs Formation Secondary A aquifer was found to be dry where intersected.

13.7.36. The Chalk aquifer is fully saturated and under artesian pressure within the incised valley at the River Tud Crossing. The full thickness of the structureless upper chalk is unknown and was not proved to 50 metres below ground level (mbgl) during the 2020 ground investigation.

13.7.37. The permeable superficial deposits are interpreted to be in hydraulic continuity with the Chalk, and baseflow to surface watercourses from the Chalk likely flows primarily through permeable layers within the Alluvium and River Terrace Deposits.

13.7.38. Permeability test results range between $7.33x10^{-6}$ m/s and $1.21x10^{-4}$ m/s within the cohesive Lowestoft Formation and $2.61x10^{-5}$ m/s and $1.48x10^{-4}$ m/s within the granular Lowestoft Formation. The cohesive Lowestoft Formation has a large range, over two magnitudes. It is possible that the permeability test undertaken in DS231 (Cohesive Lowestoft Formation) is anomalous or may be due to a higher than anticipated gravel content within the monitored lithology. The Cohesive Lowestoft Formation is more likely have a lower permeability (10^{-6} m/s) due to the higher clay content.

13.7.39. Further details of aquifer properties are included in Appendix 13.4 Groundwater assessment (**TR010038/APP/6.3**).

Groundwater quality

13.7.40. Groundwater and soil quality sampling were carried out as part of the 2020 ground investigation.

13.7.41. Soil leachability results reported from laboratory analyses were compared against WFD and EQS screening values in terms of risk to groundwater. Exceedances of nitrogen as NH_4, metals, polycyclic aromatic hydrocarbons (PAHs) and total petroleum hydrocarbons (TPHs) were recorded. Of these exceedances, only PAH and TPH is considered as a potential risk to controlled waters.

13.7.42. Groundwater sampling results reported from laboratory analyses were compared against WFD and EQS screening values in terms of risk to surface water and groundwater. Exceedances of ammonium (NH_4), mercury, nickel and zinc were noted. However, the exceedances were negligible and therefore do not pose an unacceptable risk to controlled waters.

13.7.43. There are no known Environment Agency groundwater quality network monitoring points within the study area.

Groundwater vulnerability

13.7.44. Groundwater vulnerability classification for the study area is predominantly medium, where low permeability Diamicton is present. At the eastern extent of the Proposed Scheme, between Honingham and Easton, the vulnerability classification is medium-high where the Chalk is overlain by more permeable deposits outcropping at surface or is exposed. A patch of low vulnerability, to the west of Honingham, relates to low permeability alluvial fan deposits. A patch of low-medium vulnerability, to the east of Honingham, relates to an area where there is no superficial cover. It is unclear why this area has a low-medium vulnerability.

Surface water features supplied by groundwater

13.7.45. Designated sites which are potentially hydraulically connected to the Proposed Scheme within the 1km study area are included in this assessment. These are illustrated in Figure 13.3 Aquifer and environmental Designations (**TR010038/APP/6.2**).

13.7.46. Hockering Wood Site of Special Scientific Interest (SSSI) is an ancient woodland includes surface water features within its boundary, comprising ponds and streams, which may be fed by groundwater. The woodland is located up hydraulic gradient of the Proposed Scheme, however, and is therefore not at risk of impact and is not considered further in the assessment.

13.7.47. The River Tud, a main river, is supplied by the Chalk Principal Aquifer. The River Tud is considered to be of equal ecological value as the River Wensum by the Norfolk Wildlife Trust (Norfolk Wildlife Trust, 2020).

13.7.48. Water dependent priority habitats, including Floodplain Grazing Marsh, Lowland Meadow, and Lowland Fens, are located within the 1km study area predominantly along the course of the River Tud. There are also a number of designated County Wildlife Sites within the study area. The majority of these are designated Priority Habitats, with the exception of Gravel Pits, East Tuddenham (TG 075118), a fishing lake created following gravel extraction.

13.7.49. The River Wensum SSSI and Special Area of Conservation (SAC) is located within the study area, approximately 1.6km north of the Proposed Scheme at its closest point. The River Wensum is a chalk river and receives a significant portion of supply from baseflow from the underlying Chalk aquifer. It is not, however, directly down hydraulic gradient of the Proposed Scheme and is therefore not considered further in the assessment as an indirect groundwater receptor. Further details on the River Wensum SSSI and SAC are provided in the aquatic ecology section below.

Water Framework Directive

13.7.50. The study area is within the Broadland Rivers Chalk and Crag WFD groundwater body (GB40501G400300) and is part of the Broadland Rivers Chalk and Crag Operational Catchment and the Anglian Groundwater Management Catchment. The location of the groundwater body can be seen in Figure 13.4 WFD groundwater bodies (**TR010038/APP/6.2**). A summary of the groundwater body is given in Table 13.4.

Table 13.4 Summary of WFD groundwater bodies within the study area

Water body ID	GB40501G400300
Water body name	Broadland Rivers Chalk and Crag Groundwater Body
Operational catchment	Broadland Rivers Chalk and Crag Operational Catchment
Management catchment	Anglian Groundwater Management Catchment
River basin district	Anglian
Type	Groundwater Body
Hydromorphological status	N/A
Overall classification (cycle 2 – 2019)	Poor
Current chemical quality (cycle 2 – 2019)	Poor
Overall objective	Good (by 2027)
Protected area (within the study area)	Yes, Nitrates Directive

13.7.51. The Broadland Rivers Chalk and Crag groundwater body (GB40501G400300) has poor chemical and quantitative status (2019 cycle 2). The quantitative status is limited by the Groundwater Dependent Terrestrial Ecosystems test which scored poorly due to agricultural abstractions lowering the natural flow and levels of the groundwater. The objective is to achieve 'good' quantitative status by 2021. The site is located within the Norwich Crag and Gravels groundwater Nitrate Vulnerable Zone and is a Drinking Water Protected Area.

Licensed abstractions

13.7.52. The locations of surface water abstractions are shown in Figure 13.1 Surface water features, abstractions and fluvial flood risk (**TR010038/APP/6.2**). The locations of groundwater abstractions and source protection zones are shown in Figure 13.7 Groundwater abstractions, discharges and source protection zones (**TR010038/APP/6.2**).

13.7.53. The Proposed Scheme crosses a source protection zone (SPZ) 3 (Total Catchment) between Honingham and Easton. This is associated with major groundwater abstractions to the northeast, south and south-east of the Proposed Scheme.

13.7.54. The Proposed Scheme also crosses a SPZ 1 (Inner Zone) for a new public water supply east of Hockering, at the location of the Church Lane underpass. The extents of the SPZ for this source have not, as yet, been confirmed by the Environment Agency, although a 1km stretch of the Proposed Scheme immediately to the north of the public water supply is assumed to represent the SPZ 1.

13.7.55. A further SPZ 3 is present within the 1km study area, located approximately 250m to 1000m north of the Proposed Scheme. This SPZ is associated with public water supply abstractions 4km north of the study area at Lyng and includes a Drinking Water Safeguard Zone for groundwater.

13.7.56. According to data received from the Environment Agency in April 2020 there are six licensed surface water abstraction and two licensed groundwater abstractions located within the study area (see Table 13-5).

Table 13-5 Licensed abstractions within the study area.

License number	Use	Abstraction point name	Source of supply
7/34/12/*S/0066	Spray Irrigation - Direct	Reach B - River Tud at Honingham & Easton	Surface water
7/34/12/*S/0066	Spray Irrigation - Direct	Reach C - River Tud at Easton	Surface water

License number	Use	Abstraction point name	Source of supply
7/34/12/*S/0066	Spray Irrigation - Direct	Reach A - River Tud at Honingham	Surface water
AN/034/0012/002/R01	Spray Irrigation - Storage	River Tud at Hill Farm	Surface water
7/34/12/*S/0072	Spray Irrigation - Storage	Unnamed tributary and ditches of the River Tud -2	Surface water
7/34/12/*S/0072	Spray Irrigation - Storage	Unnamed tributary and ditches of the River Tud -2	Surface water
7/34/13/*G/0166	Make-Up Or Top Up Water	Borehole at Easton	Groundwater
7/34/13/*G/0166	Spray Irrigation - Direct	Borehole at Easton	Groundwater

13.7.57. The district councils have been contacted for details of unlicensed private water supplies. At the time of writing, only Breckland Council have provided details of private water supplies near to the Proposed Scheme. South Norfolk and Broadland district councils are yet to respond. A water features survey may be required to ground truth the unlicensed abstractions within the study area.

13.7.58. There are 26 unlicensed abstractions within the part of the 1km study area belonging to Breckland Council. Details of the abstraction uses, and aquifer units abstracted, have not been provided.

Consented discharges

13.7.59. According to data received from the Environment Agency in April 2020 there are 11 active consented discharges to surface water and groundwater within the study area (see Table 13-6). These can be seen in Figure 13.1 Surface water features, abstractions and fluvial flood risk (**TR010038/APP/6.2**) and Volume 2, Figure 13.7 Groundwater abstractions, discharges and source protection zones, respectively (**TR010038/APP/6.2**).

Table 13-6 Licensed consented discharges within the study area.

Consent number	Use	Receiving water body
PRENF08520	Treated effluent	Unnamed watercourse
PRENF11681	Biologically treated sewage effluent	A tributary of the River Tud
AEENF12408	Sewage in an emergency	Ditch leading to the River Tud
AW4NF290X	Sewage treatment works final effluent	River Tud

Consent number	Use	Receiving water body
EPR-DB3592NV	Secondary treated sewage effluent	Unnamed ditch leading to tributary of River Tud
EPR-KB3995WJ	Discharge into land of secondary treated sewage effluent	Groundwater via an infiltration system
PR4LF84215	Discharge of domestic sewage from a septic tank and soakaway system	Groundwater via an infiltration system
EPR-AB3099AM	Discharge into land of secondary treated sewage effluent	Groundwater
EPR-MP3724GQ	Discharge into land of secondary treated sewage effluent	Groundwater
NPSWQD009058	Trade effluent derived from heat exchange use of abstracted groundwater	Groundwater
PR4LF69	Discharge of sewage effluent from a septic tank soakaway system	Groundwater via an infiltration system

Existing drainage

13.7.60. HA DDMS (Highways England, 2020) identified nine priority outfalls located within the Proposed Scheme DCO boundary (Figure 13.5 Surface water flood risk (**TR010038/APP/6.2**)). The pollution risk is defined by HEWRAT according to the priority outfall risk assessment process defined on HA DDMS. Outfalls categorised as medium risk or above require remediation. The assessment is based on current A47 traffic forecasts. Of the nine priority outfalls:

- Seven were identified as low pollution risk (Priority D) which are located to the east of Hockering; and,
- Two draining to the Oak Farm tributary were identified as medium pollution risk (Priority C), which are located in and to the west of Hockering.

13.7.61. To the west, outside the Proposed Scheme DCO boundary, but within the study area, three additional priority outfalls were identified on HA DDMS (Highways England, 2020):

- Two of these were identified as medium pollution risk (Priority C); and,
- One was identified as high pollution risk (Priority B).

13.7.62. All of the outfalls identified either discharge into the tributaries or drains which supply the River Tud.

13.7.63. Ten soakaways are identified by HA DDMS (Highways England, 2020) on the hard shoulder of the existing A47 route between North Tuddenham and Easton. All of the soakaways were identified as low pollution risk (Priority D) to groundwater. The locations of the soakaways are shown in Figure 13.7 Groundwater abstractions, discharges and source protection zones (**TR010038/APP/6.2**).

13.7.64. HA DDMS (Highways England, 2020) and other available information on the existing highway drainage outfalls and soakaways is relatively limited. Existing drainage arrangements indicate the sections east of Hockering and near Honingham discharge to the River Tud It is assumed almost all of the existing drainage will not be used as part of the Proposed Scheme. This is excluding the furthest western section and at Honingham Roundabout where the Proposed Scheme joins the existing A47, and where a new access road will be connected at Dereham Road. A survey of the existing drainage will be undertaken. Further details of the existing drainage are provided in Appendix 13.2 Drainage strategy (**TR010038/APP/6.3**).

Flood risk

13.7.65. According to the Environment Agency Flood Map for Planning (Environment Agency, 2020d), the majority of the study area, and Proposed Scheme DCO boundary, is located within Flood Zone 1 (see Figure 13.1 (Surface water features, abstractions and fluvial flood risk) (**TR010038/APP/6.2**)). Flood Zone 1 is associated with a low risk of flooding from fluvial and coastal sources (an annual probability of less than 1 in 1,000 (0.1%) of river and sea flooding).

13.7.66. The land immediately surrounding the River Tud is primarily designated as Flood Zone 2 and 3 (Environment Agency, 2020d). The Proposed Scheme crosses two sections of Flood Zone 2 and 3 east of Honingham where it crosses the River Tud and south-east of Hockering where it crosses an ordinary watercourse / drain which is tributary of the River Tud. The Proposed Scheme runs adjacent to Flood Zones 2 and 3 south-east of Hockering and at Taverham Road, within the DCO boundary. Areas of Flood Zone 3 are within the Proposed Scheme DCO boundary but outside of the permanent construction area of the Proposed Scheme at Berrys Lane, west of Honingham, and east of Taverham Road. The Flood Zones are defined as:

- Flood Zone 2 is associated with a medium risk of flooding (land assessed as having between a 1 in 100 and 1 in 1,000 annual probability of flooding (1%-0.1%) or between 1 in 200 and 1 in 1,000 annual probability flooding from the sea (0.5%-0.1%) in anyone year).
- Flood Zone 3 is associated with high risk of flooding (land assessed as having a 1 in 100 year or greater annual probability of river flooding (>1%) or

a 1 in 200 or greater annual probability of flooding from the sea (>0.5%) in any year).

13.7.67. Flood Zone 3 is split into two separate zones; 3a and 3b:

- Flood Zone 3a comprises of land assessed as having a 1 in 100 or greater annual probability of river flooding; or land having a 1 in 200 or greater annual probability of sea flooding.
- Flood Zone 3b comprises as land where water has to flow or be stored in times of flood.

13.7.68. According to the Breckland Council's SFRA and the Greater Norwich SFRA, where the Proposed Scheme crosses the River Tud east of Honingham and an ordinary watercourse / drain at Berrys Lane, Flood Zone 3 is comprised of Flood Zone 3a and Flood Zone 3b (functional floodplain) (AECOM, 2017 and JBA, 2017). Where the Proposed Scheme crosses an ordinary watercourse / drain south east of Hockering, Flood Zone 3 is identified as 3a (AECOM, 2017).

13.7.69. The construction compounds and material stores are not located within areas identified as Flood Zones 2 or 3.

13.7.70. Hydraulic modelling has been undertaken to characterise the baseline conditions of The River Tud, its two tributaries at Oak Farm and Hockering and the respective floodplain (Appendix 13.1 Flood risk assessment (**TR010038/APP/6.3**)). Predictions from the flood risk model confirm that under baseline conditions:

- For the River Tud:
  - There are areas of notable flooding around Hockering and to the east of Honingham associated with the River Tud, where the River Tud Crossing is proposed. The predicted peak water levels at the cross-section close to the upstream face of the proposed bridge is 22.412m AOD for the 100-year event and 22.563m AOD with a 65% climate change allowance.
  - Most of the Proposed Scheme footprint is outside of the existing 100-year floodplain, both with and without a 65% climate change allowance. A small section of embankment close to Hockering overlaps the 1 in 100-year with 65% climate change floodplain. The only element of the design within the floodplain are the abutments of the River Tud Crossing downstream of the existing A47.
- For Oak Farm watercourse:
  - The culvert downstream of the A47 (close to Oak Farm) was found to provide a significant constraint on flows which results in backing up upstream where the West Culvert Extension is proposed. An increase in water depth of 0.232m and 0.327m for the 1 in 100-year without and with 65% climate change, respectively, was predicted at this location. The

flood extent upstream of the existing A47 overlaps both the location of the new link road and the extension to the existing A47.

- Flooding, caused by an undersized footpath culvert, was predicted from the northern bank downstream of the A47 for all modelled events. Similarly, flooding is predicted for all events over Low Road to the south due to an undersized culvert outfall.

- For Hockering watercourse:
  - Flooding was predicted to remain in or close to the channel within the vicinity of the bridge crossing for all modelled events
  - The existing A47 culvert, south-east of Hockering, provides a significant constraint to flows with backing up upstream during the 1 in 100-year event with 65% climate change and the 1000-year flood. However, the deck level of the road was not predicted to be overtopped or flooded with water remaining within the upstream channel for all events.

13.7.71. The Environment Agency's indicative long-term flood risk map (Environment Agency, 2020e) shows that the majority of the Proposed Scheme is at very low risk of surface water flooding (see Figure 13.5 Surface water flood risk (**TR010038/APP/6.2**)). However, there are isolated areas of low to high surface water flood risk. These are classified by the Environment Agency as:

- Low - each year, the area has between 1 in 1000 (0.1%) and 1 in 100 (1%) chance of pluvial flooding in any given year
- Medium - each year, the area between 1 in 100 (1%) and 1 in 30 (3.3%) chance of pluvial flooding in any given year
- High - each year, the area has greater than 1 in 30 (3.3%) chance of pluvial flooding in any given year

13.7.72. The Proposed Scheme crosses isolated areas of low and medium flood risk associated with flood flow pathways which run in a southerly direction. There are ten instances where the Proposed Scheme would cross these pathways:

- east of Hockering
- east of, and at, Church Lane (east Tuddenham)
- at the proposed junction at Wood Lane, high surface water flood risk ponding is also observed here
- east of the proposed junction at Wood Lane, high surface water flood risk ponding is also observed here
- west of the River Tud Crossing
- west of, and at, Blind Lane
- east of Blind Lane
- west of Easton

13.7.73. The Proposed Scheme crosses the following areas of high surface water flood risk;

- at the existing A47 West Culvert near Oak Farm, where flow appears to back up at the culvert, low to medium surface water flooding is associated in the upstream area due to this
- south-east of Hockering originating from a drain running adjacent to the River Tud
- east of Hockering (near the Sandy Lane Junction) due to a depression in the land which would collect overland flow upstream of the existing A47
- north and east of Honingham originating from the cluster of drains and the River Tud

13.7.74. Outside of the DCO boundary, areas of low and medium flood risk associated with flood flow pathways are identified:

- to the north-east of North Tuddenham flowing in a northerly direction
- to the south of Honingham flowing in a west and northerly direction
- to the north of Easton flowing in an east and southerly direction
- to the south of Easton flowing in an easterly direction

13.7.75. The Environment Agency's indicative flood risk map (Environment Agency, 2020e) also shows that there is risk of flooding from reservoirs where the Proposed Scheme crosses the River Tud. From the flood depth maps it is assumed the risk originates from the reservoir at Colton, which is used for fishing.

13.7.76. The Environment Agency's Historic Flood Map (Environment Agency, 2020f) does not indicate any areas of previous flooding within the study area.

13.7.77. There are no flood defences, areas benefitting from defences or flood storage areas within the study area (Environment Agency, 2020d). However, the Proposed Scheme is within an area that benefits from both flood alerts (The Rivers Tud and Wensum from Fakenham to Costessey, including Wendling Beck) and flood warnings (The River Tud from East Dereham to New Costessey) (Environment Agency, 2020g).

13.7.78. The Highways Agency Drainage Data Management System (HADDMS) (Highways England, 2020) identified 15 instances of historic flooding within the Proposed Scheme area. HADDMS identified 11 of these flooding instances to be between Hockering and Honingham, mainly around the Wood Lane junction and Sandy Lane junction. The majority of these events were due to blocked gully pot covers, and once the gullies were cleared the water drained away. Four instances of historical flooding were identified between Easton and Honingham,

however, there was no further information provided on HADDMS. Further details can be found in the FRA (**TR010038/APP/6.3**).

13.7.79. Anglian Water confirm that there was no record of flooding in the vicinity of the Proposed Scheme that can be attributed to capacity limitations in the public sewerage system.

13.7.80. The majority of the Site lies within areas that has limited potential for groundwater flooding to occur. However, there is potential for groundwater flooding to above ground structures within the Proposed Scheme DCO boundary to the south and east of Hockering and north-east of Honingham. This occurs along the route of the River Tud at a ground level of approximately 25-35mAOD.

13.7.81. Within the same area, there is also potential for groundwater flooding to subsurface structures. This corresponds to a ground level of approximately 35-40mAOD along the route of the River Tud (see Figure 13.6 Susceptibility to groundwater flooding (**TR010038/APP/6.2**)).

Aquatic ecology

13.7.82. The study area is ecologically diverse and contains a range of wildlife species which are likely to be dependent on the water environment. The River Tud is classified as having moderate ecological potential. However, it is hydraulically connected to the River Wensum which, is designated as a SAC and SSSI due to the observed presence of species such as White-clawed crayfish *Austropotamobius pallipes*, Desmoulin's whorl snail *Vertigo moulinsiana* and the potential presence of Brook lamprey *Lamptera planeri*, and Bullhead *Cottus gobio*.

13.7.83. The River Wensum SSSI and SAC (UK0012647) Defra, 2020) is located within the study area north of Easton and is approximately 7.3km downstream of the study area. Although this lies away from the main works of the Proposed Scheme, the downstream reach has been considered as a potentially sensitive receptor due to the contribution of flow or changes in water quality from the River Tud to the River Wensum, and it receives baseflow from the underlying Principal Chalk and Secondary Superficial aquifers.

13.7.84. Hockering Wood SSSI is located within the 1km study area. Ponds within the area of the SSSI may support breeding great crested newts.

13.7.85. Twelve areas of Priority Habitat Lowland Fens are present within the study area. The Lowland Fens receive water and nutrients from the soil, rock and groundwater. Seven areas of Priority Habitat Coastal and Floodplain Grazing Marshes are present within the study area, one area is located where the River Tud Crossing is planned. The locations of these priority habitats are shown in

Figure 13.3 Aquifer and environmental designations (**TR010038/APP/6.2**). Further details of the National Vegetation Classifications of these Priority Habitats are included within the Groundwater Dependent Terrestrial Ecosystems assessment within Appendix 13.4 Groundwater assessment (**TR010038/APP/6.3**).

13.7.86. A County Wildlife Site (Gravel Pits, East Tuddenham) is located within the study area that supports trout populations.

13.7.87. Further information on sensitive species and aquatic ecology is available in ES Chapter 8, Biodiversity (**TR010038/APP/6.1**).

Recreation and human health

13.7.88. The site falls within a SPZ 1 for a public water supply at Church Lane and SPZ 3 for further public water supplies to the east of Berrys Lane. A number of unlicensed abstractions have been identified, although the use of abstracted water is not known.

13.7.89. It is understood that the River Tud and Wensum are used recreationally, for example, for angling. Angling is mostly private on the River Tud but Dereham and District Angling Club and Norwich Union Angling Club has waters on the River Wensum.

13.7.90. The Gravel Pits, East Tuddenham County Wildlife Site is used for recreational fishing.

Events

13.7.91. Norfolk County Council Local Flood Risk Management Strategy (Norfolk County Council, 2015) identified historic flooding events in Norwich with the largest in 1912 with an estimated return period of 800 years. Fifteen flooding events were reported between 2001 and 2009 with the most significant in 2008.

13.7.92. No further information was available on major accidents, disasters or pollution events and spills within the study area.

13.7.93. South Norfolk Council, Broadland District Council and Breckland Council did not have any information regarding historic flooding. Anglian Water confirm that there were no records of flooding in the vicinity of the Proposed Scheme that can be attributed to capacity limitations in the public sewerage system.

Climate change

13.7.94. The Meteorological Office regional climate summary for Eastern England (Met Office, 2016) indicates the current climate baseline within the study area to be:

- Mean annual temperatures ranging from 9.5°C to around 10.5°C in the low-lying areas with mean daily minimum temperatures of 1°C in winter and mean daily temperatures of 20 to 23°C in summer
- Average annual sunshine durations over Eastern England range from over 1,600 hours in Norfolk, Suffolk and Essex to less than 1,450 hours in East Yorkshire and Lincolnshire
- Eastern England has a more even annual distribution of rainfall when compared with the rest of the UK with an average of 30 rain days in winter and less than 25 days in summer
- The average number of days with snow falling is about 20 per year in low lying areas
- Eastern England is one of the more sheltered parts of the UK in terms of wind

13.7.95. Climate change predictions suggest that the future annual recharge volumes for groundwater are broadly stable although the groundwater recharge season is likely to condense into a shortened period, leading to more variable groundwater levels and a greater drought vulnerability (Environment Agency, 2019).

Sensitivity of receptors

13.7.96. The following receptors / features have been identified that could potentially be affected by the construction and / or operation of the Proposed Scheme. In accordance with DMRB LA 113, the importance of these features in terms of their attributes are summarised in Table 13-7 below.

13.7.97. Watercourses and water features that are assumed to be hydrologically isolated from the Proposed Scheme have not been included in this assessment. As there are no watercourses of waterbodies, consented discharges, or designated sites within the River Yare waterbody catchment, within the study area, the following attributes have not been included:

- dilution and removal of waste products
- recreation
- biodiversity

13.7.98. The licensed and unlicensed abstractions and groundwater dependent terrestrial ecosystems, as identified in both this chapter and also in Appendix 13.4 Groundwater assessment (**TR010038/APP/6.3**), have been assessed as indirect receptors of the aquifers (direct receptors). These are considered attributes of the Principal and Secondary aquifers listed in the table below.

Table 13-7 Importance of water environment attributes in study area

Feature	Attribute	Importance	Reason for assigned value
The River Tud (including Norfolk Rivers IDB section)	Water supply/quality	High	Four licensed abstractions from the River Tud for agricultural purposes, WFD fail chemical status.
	Dilution and removal of waste products	High	Consented discharges to the River Tud. Q_{95} flow = 0.099m^3/s
	Recreation	Medium	Private angling
	Value to economy	Medium	Four licensed abstractions from the River Tud for agricultural purposes
	Conveyance of flow	High	Majority of Proposed Scheme is in Flood Zone 1, however, there are areas of Flood Zones 2 to 3b within the Site. Q_{95} flow = 0.099^3/s. Floodplain includes areas of 'More Vulnerable' receptors (for example, residential properties).
	Biodiversity	High	Priority habitats adjacent to the River Tud. WFD moderate ecological potential.
Unnamed ordinary watercourses (within the Tud WFD water body catchment)	Water supply/quality	Medium	Two licensed abstractions from tributaries of the River Tud for agricultural purposes
	Dilution and removal of waste products	Medium	Consented discharges to ordinary watercourses, ditches and tributaries of the River Tud.
	Recreation	Low	No known recreational use
	Value to economy	Medium	Two licensed abstractions from tributaries of the River Tud for agricultural purposes
	Conveyance of flow	High	Flood Zone 1 to 3a, some areas local to this consists of 'more vulnerable' development. Q95 unknown but assumed to be ≤0.001m3/s.
	Biodiversity	High	Priority habitats
The River Wensum (as indirect downstream receptor)	Water supply/quality	Medium	Unknown abstraction, WFD fail chemical status
	Dilution and removal of waste products	Very High	Unknown consented discharges, Q95 = 1.36 m^3/s
	Recreation	High	District angling clubs
	Value to economy	Medium	Unknown abstractions. Limited known usage of watercourses.
	Conveyance of flow	High	Q_{95} flow = 1.36^3/s. Floodplain includes areas of 'More Vulnerable' receptors (for example, residential properties).
	Biodiversity	Very High	SSSI and SAC. WFD Moderate ecological potential.

Feature	Attribute	Importance	Reason for assigned value
The River Yare	Water supply/quality	Medium	One licensed abstraction within the Yare (Tiffey to Wensum) WFD waterbody catchment for agricultural purposes, WFD fail chemical status
	Value to economy	Medium	One licensed abstraction within the Yare (Tiffey to Wensum) WFD waterbody catchment for agricultural purposes
	Conveyance of flow	Medium	Flood Zone 1 and no watercourses or waterbodies within the study area. Low to medium surface water flood risk pathways and some areas local to this consists of 'more vulnerable' development.
Ponds	Water supply/quality	Medium	No known abstractions. Not a WFD water body but lies within a WFD water body catchment that has a fail chemical status
	Dilution and removal of waste products	Low	No known consented discharges
	Recreation	Medium	Five ponds are used for commercial fisheries
	Value to economy	Medium	Five of ponds are used for commercial fisheries
	Biodiversity	High	Five ponds are used for commercial fisheries. Not a WFD water body but lies within a WFD water body catchment that has moderate ecological potential. Priority habitats.
River Tud floodplain	Conveyance of flow	High	Floodplain includes areas of 'More Vulnerable' receptors (for example, residential properties).
Chalk Principal Aquifer (Broadland Rivers Chalk and Crag groundwater body)	Water supply/quality	Very High	Principal aquifer providing strategic public water supply, local private water supplies (agricultural purposes) and significant baseflow to rivers. These are considered indirect receptors.
	Soakaway	Low	High sensitivity of Chalk aquifer to pollution, therefore discharges are made to overlying superficial deposits.
	Vulnerability	Very High	Study area has designated medium overall sensitivity by the Environment Agency and has soluble rock risk.
	Economic Value	Very High	Principal aquifer providing strategic public water supply, local private water supplies (from both groundwater and surface water – agricultural uses). These are considered indirect receptors.
	Conveyance of flow	Very High	Principal aquifer providing significant baseflow to the River Tud and adjacent priority habitat lowland fens, as well as the River Wensum. These are considered indirect receptors.
	Biodiversity	Very High	River Wensum SSSI/SAC.
	Water supply/quality	High	Secondary aquifer providing local baseflow to rivers and private water supplies. These are considered as indirect receptors.

Feature	Attribute	Importance	Reason for assigned value
Secondary superficial aquifers	Soakaway	High	A number of road drainage and consented discharges to ground
	Vulnerability	Medium	Study area has designated medium overall sensitivity by the Environment Agency.
	Economic Value	High	Secondary aquifer providing private water supply and local baseflow to rivers. These are considered as indirect receptors.
	Conveyance of flow	High	Secondary aquifer providing local water supply, local private water supplies (both groundwater and surface water – mainly agricultural uses) and local baseflow to rivers and adjacent priority habitats. These are considered indirect receptors.
	Biodiversity	High	River Tud and priority habitats are nationally important and included in Biodiversity Action Plans

13.8. Potential impacts

13.8.1. This section considers the potential impacts on surface water, groundwater and flood risk receptors, prior to the implementation of mitigation measures.

13.8.2. Where the effect of the Proposed Scheme on a receptor will result in significant impact, this has been assessed below. This assessment is based on the design elements provided in Chapter 2 (The Proposed Scheme) (**TR010038/APP/6.1**).

Construction

Surface water

13.8.3. There is the potential for mobilisation of sediment and contaminants from surface water runoff to watercourses and ponds from road construction activities such as earthworks, ground improvements, plant and vehicle washing.

13.8.4. Construction activities, including the demobilisation of site compounds, increase the risk of a pollution incident from accidental spillages or leakage of fuels, oils, chemicals, wastewater, concrete or cement admixtures used. Such accidental spillages are likely to impact directly on surface water features including the River Tud, unnamed ordinary watercourses and ponds where works are in close proximity. There may be an indirect impact on the River Wensum as a downstream receptor. This, in turn, may have a negative impact on downstream aquatic environments, recreation, water supply and quality and recreation.

13.8.5. Construction works will have the greatest potential to impact on the surface water environment when they take place within, adjacent, over or close to surface water features, including the fluvial floodplain. The placement of construction materials, washing of plant, cleaning areas of hardstanding, for example increases the potential for mobilisation of sediment and contaminants

from surface water runoff to drainage ditches and ponds. These activities could adversely impact on water quality, recreational users, value to the economy and the aquatic ecology aspects of surface water features including the River Tud, unnamed ordinary watercourses and ponds, where works are in close proximity. There may be an indirect impact on the River Wensum as a downstream receptor. Due to the Proposed Scheme being hydraulically disconnected from the River Yare, it is considered there will be no impact caused by this activity.

13.8.6. Water quality impacts are likely to be short term during the construction period. However, some potential construction impacts, such as the deposition of sediments in watercourses, can have longer term consequences. Especially with respect to aquatic ecology, where increased sediment loading of streams and changes to turbidity can have a negative impact. The Geomorphological assessment (Appendix 13.5 (**TR010038/APP/6.3**)) notes the River Tud appears to have limited capacity for sediment conveyance which is likely due to having relatively low stream power. Therefore, any increase in sedimentation caused by construction would have a disproportionate impact on the channel due to the residence time in a particular channel reach. The WFD ecological quality elements that could be impacted include:

- physicochemical quality elements (ammonia, dissolved oxygen, pH, phosphate and temperature, and biochemical oxygen demand for the Wensum DS Norwich only)
- biological quality elements (fish and invertebrates, and macrophytes and phytobenthos for the Wensum DS Norwich only)

13.8.7. During construction there will be a requirement to work within, adjacent, over or close to water bodies, watercourses, or the fluvial floodplain in order to complete the construction of new outfalls, the River Tud Crossing, Newgate House Culvert, West Culvert Extension and New West Culvert, the minor watercourse diversions associated with the culverts, and the compensatory flood storage area. This may cause an increase in risk of fluvial flooding to the Proposed Scheme or others due to obstruction or changes in the flows within the channels and on the floodplain. Additionally, this could adversely impact upon downstream flood-sensitive receptors, aquatic environments, value to economy, water quality and recreational users of surface water features including the ponds, River Tud and its unnamed ordinary watercourses. Due to distance of the River Wensum from the Proposed Scheme and the Proposed Scheme being hydraulically disconnected from the River Yare, it is considered there will be no impact caused by this activity.

13.8.8. There is potential to impact on habitat and ecology of the local environment during construction of:

- the River Tud Crossing

- the culverts on tributaries of the River Tud (Newgate House Culvert located on a tributary of the River Tud south of Hockering and the West Culvert Extension and New West Culvert both located at Oak Farm on a tributary of the River Tud)
- minor watercourse diversion in associated with the culverts
- the flood compensatory storage area upstream of the River Tud Crossing
- proposed highway drainage and outfalls

13.8.9. Disturbance or removal of this habitat could negatively impact upon the water quality and biodiversity of the River Tud, its tributaries and its downstream receptor, the River Wensum. The WFD ecological quality elements that could be impacted include:

- physicochemical quality elements (ammonia, dissolved oxygen, pH, phosphate and temperature, and biochemical oxygen demand for the Wensum DS Norwich only)
- biological quality elements (fish and invertebrates, and macrophytes and phytobenthos for the Wensum DS Norwich only)
- hydromorphological quality elements (hydrological regime and morphological conditions)

13.8.10. During construction, there is an increased risk of flooding during and following extreme rainfall events, including those areas identified as at risk of surface water flooding. Works may lead to temporary changes in the surface water runoff regime by the alteration of ground elevations and overland flow pathways, pond infilling (six for the construction of the Proposed Scheme and two for soil storage compounds) or the construction of above ground structures acting as a barrier to flow. This could cause localised flooding to the Proposed Scheme and nearby receptors due to changes in surface water flood flow pathways. Indirectly, overloading of the temporary drainage system could adversely impact on surface water features including the River Tud, River Yare, unnamed ordinary watercourses and ponds where works are in close proximity. This, in turn, may have a negative impact on down gradient flood-sensitive receptors, aquatic environments, value to economy, water quality (mobilisation of sediment and pollutants) and recreational users. Due to distance of the River Wensum from the Proposed Scheme, it is considered there will be no impact caused by this activity.

13.8.11. During construction there will be an increase in new hardstanding areas, including the compounds and infilling of ponds, which, if not mitigated, would increase the volume and flow rate of runoff from the construction areas. This could result in the increased localised flooding to the Proposed Scheme and other flood-sensitive downstream receptors. Additionally, this could adversely impact upon downstream flood-sensitive receptors, aquatic environments, value

to economy, water quality and recreational users of surface water features including the River Tud, River Wensum, unnamed ordinary watercourses and ponds. Due to the Proposed Scheme being hydraulically disconnected from the River Yare, it is considered there will be no impact caused by this activity.

13.8.12. The construction of the Proposed Scheme would also result in the loss of eight ponds and any aquatic biodiversity associated with them:

- one pond north of Oak Farm adjacent to the existing A47 where the Proposed Scheme would be constructed
- a cluster of three ponds located east of Oak Farm adjacent to the existing A47 where the Proposed Scheme would be constructed
- one pond located south-east of the proposed River Tud crossing where the Proposed Scheme would be constructed
- one pond located south-east of St Andrew's Church where the Proposed Scheme would be constructed
- one pond located east of Blind Lane where a new road is required to connect Easton with Norfolk Road junction

Groundwater

13.8.13. The key construction activities that are likely to impact on groundwater relate to excavations for ground improvement works, utilities and cuttings or installation of below-ground structures such as piles or foundations, in particular in areas where shallow or artesian groundwater is expected. Such conditions have been identified at the mainline cutting west of the River Tud Crossing, and at the Honingham church underpass to St Andrew's Church. Other structures (the side road cuttings for underbridges at Mattishall Lane Link Road, Wood Lane junction and Norwich Road junction, and where ground improvement works are required for an embankment southeast of Hockering) were assessed assuming a seasonal maximum groundwater level and found unlikely to intercept groundwater (see Appendix 13.4 Groundwater assessment (**TR010038/APP/6.3**)). These areas are to be further investigated during the proposed supplementary ground investigation, and this assessment is based on information currently available.

13.8.14. Below ground construction for deep cuttings and ground improvements may necessitate dewatering. Where required, this has the potential to adversely impact direct groundwater receptors (the aquifers) and indirect groundwater receptors dependent on groundwater supply (including abstractions and groundwater dependent terrestrial ecosystems) in terms of groundwater levels and flow. Construction dewatering discharges may contain suspended solids that have the potential to contaminate the receiving water body. Details of the

risk to GWDTEs from dewatering at the mainline cutting west of the River Tud Crossing and at the Honingham church underpass to St Andrew's Church are provided within Appendix 13.4 Groundwater assessment (**TR010038/APP/6.3**). The radius of influence was calculated using worst case values to be 76.68m at the mainline cutting west of the River Tud, and 26.29m at the Honingham church underpass. This risk is therefore assessed to be negligible, as the nearest known receptors (the River Tud and associated Priority Habitats) are approximately 250m or greater. The risk is also negligible for licensed abstractions, which are located outside of the predicted radius of influence (see Appendix 13.4 Groundwater Assessment (**TR010038/APP/6.3**), Annex A Location Plan). However, details of private water supplies within the Broadland and South Norfolk district council areas are outstanding.

13.8.15. There are a number of utilities diversions required, which mainly occur around road junctions. The depth of utilities diversion excavations is likely to be less than 2m where open cut methods are to be used but may be more than 10m where directional drilling is used, such as for the gas main works adjacent to the Wood Lane junction.

13.8.16. Excavation works or foundation installation in areas of shallow groundwater have the potential to create pathways between aquifer units, resulting in a disruption of the vertical hydraulic gradients, or even groundwater flooding in areas of artesian groundwater.

13.8.17. The placement of below ground structures may affect groundwater quality. This is via direct contact with construction materials, down-drag of contaminants, or generation of suspended solids. It is anticipated that the directional drilling for the gas mains diversion at Wood Lane junction will use a bentonite slurry in the process, which may enter the groundwater. These construction activities may subsequently impact the water quality provided to groundwater dependent features, and abstractions.

13.8.18. Excavation works for cutting sections or groundworks also have the potential to create a contamination pathway from the open excavation to underlying aquifers. This increases the aquifer vulnerability and may potentially result in groundwater contamination due to accidental spillages or leakages. This is of particular concern where the Chalk may be exposed at the excavation for ground improvement works south-east of Hockering. Supplementary ground investigation exploratory boreholes and existing road drainage soakaways may also act as a pathway for accidental spillages or leakages, especially where these are within the construction footprint but are no longer required.

13.8.19. Further details of these impacts prior to mitigation are included within Appendix 13.4 Groundwater assessment (**TR010038/APP/6.3**). An assessment of the significance of construction impacts post-mitigation are presented in Table 13.8.

Operational

Surface water

13.8.20. There is a risk of pollution to surface water features resulting from accidental spillage or pollution incidents. This risk would increase with the increase in the volume of traffic as a result of the Proposed Scheme. Such accidental spillages could result in short term adverse impacts on water quality, recreational users, value to the economy and aquatic ecology of surface water features, including the River Tud, ordinary watercourses and ponds. The River Wensum may also be adversely affected, as an indirect receptor. Due to the Proposed Scheme being hydraulically disconnected from the River Yare, it is considered there will be no impact caused by this aspect.

13.8.21. The Proposed Scheme would result in an increase in highway drainage area discharging to the River Tud and Oak Farm tributary. The location of these can be found in Appendix 13.3 Water quality assessment (**TR010038/APP/6.3**). This coupled with the associated increase in traffic volumes will result in an increase in pollutant loads in highway runoff. This could result in a long-term increase in diffuse pollution, adversely impacting on water quality, recreational users, value to the economy and aquatic ecology of surface water features, including the River Tud, ordinary watercourses and ponds. The River Wensum may also be adversely affected, as an indirect receptor. As the Proposed Scheme is hydraulically disconnected from the River Yare, it is considered there will be no impact caused by this aspect.

13.8.22. There are a number of known existing outfalls draining the existing A47 where it is to be retained (de-trunked) as a local access road. These outfalls are currently classed as low pollution risk (see paragraph 13.7.60) and given the significantly reduced traffic forecast for the proposed local access road then no water quality treatment is required (subject to drainage survey).

13.8.23. The WFD ecological quality elements that could be impacted from accidental spillage or increases in highway drainage area include:

- physicochemical quality elements (ammonia, dissolved oxygen, pH, phosphate and temperature, and biochemical oxygen demand for the Wensum DS Norwich only)
- biological quality elements (fish and invertebrates, and macrophytes and phytobenthos for the Wensum DS Norwich only)
- specific pollutants (copper and zinc)

13.8.24. The Proposed Scheme could lead to a change in the surface water runoff regime by the alteration of ground elevations, overland flow pathways or pond infilling. This could result in the diversion of flood flow pathways, increased localised flooding next to the Proposed Scheme with potential increased flood risk to the Proposed Scheme and to others. Indirectly, this would potentially affect downstream aquatic environments, recreational users and value to economy associated with surface water features including the River Tud, ordinary watercourses and ponds. Due to distance of the River Wensum from the Proposed Scheme, it is considered there will be no impact caused by this aspect. As the Proposed Scheme is hydraulically disconnected from the River Yare, it is considered there will be no impact caused by this aspect.

13.8.25. The Proposed Scheme would also result in the loss of seven ponds due to the location of the Proposed Scheme (as identified in the construction section above). The loss of these surface water features would result in the loss of any aquatic biodiversity associated with them.

13.8.26. The Proposed Scheme, through creation of the new carriageway hardstanding areas, will result in an increase in impermeable area which, if not mitigated, would increase the peak flow rate of runoff as well as the volume from the carriageway. This could result in increased localised flooding to the Proposed Scheme and to others downstream. Additionally, this would potentially adversely impact upon downstream aquatic environments, recreational users and value to economy associated with surface water features including the River Tud and ordinary watercourses. Due to distance of the River Wensum from the Proposed Scheme and the Proposed Scheme being hydraulically disconnected from the River Yare, it is considered there will be no impact caused by this activity. As there are no direct discharges to the ponds, and they are hydraulically disconnected from the Proposed Scheme, it is considered there will be no adverse impacts to this receptor

13.8.27. The Proposed Scheme would lead to a change of flow within the floodplain due to the presence of embankments associated with the River Tud Crossing, the culverts (Newgate House Culvert, West Culvert Extension and New West Culvert) and outfalls acting as a barrier to flow. The design of the Proposed Scheme would result in a loss of floodplain storage with a potential increase in flood risk to the Proposed Scheme and to others. In addition, this could adversely affect downstream aquatic environments, recreational users and value to economy for surface water features including the River Tud and ordinary watercourses. The River Wensum may also be adversely affected, as an indirect receptor. As there are no direct discharges to the ponds, and they are hydraulically disconnected from the Proposed Scheme, it is considered there will be no adverse impacts to this receptor. Due to the Proposed Scheme being

hydraulically disconnected from the River Yare, it is considered there will be no impact caused by this aspect.

13.8.28. The Geomorphological assessment (Appendix 13.5 (**TR010038/APP/6.3**)) indicates that some lateral movement of the channel has occurred over the past 100 years on reaches of the River Tud south of Hockering and east of the proposed River Tud Crossing. The River Tud Crossing could restrict natural lateral movement which in turn which could lead to erosion of the bed and bank. The River Tud Crossing would also cause some localised shading of the river bank and bed potentially impacting on channel stability, structural damage and an increase in sediment in downstream reaches leading to degradation of the watercourse habitat. The WFD ecological quality elements that could be impacted include:

- physicochemical quality elements (ammonia, dissolved oxygen, pH, phosphate and temperature, and biochemical oxygen demand for the Wensum DS only)
- biological quality elements (fish and invertebrates, and macrophytes and phytobenthos for the Wensum DS Norwich only)
- hydromorphological quality elements (hydrological regime and morphological conditions)

13.8.29. The proposed outfalls (locations to be confirmed) would discharge highway drainage and natural catchment runoff from the Proposed Scheme with the potential to cause river erosion. The outfall structure itself, if not set back into the river bank, can create localised turbulent flows which could lead to erosion of the bed and bank. In turn this can impact on channel stability, structural damage and an increase sediment in downstream reaches leading to degradation of the watercourse habitat. This could adversely affect the River Tud and its tributaries, which has been identified as being sediment sensitive. The River Wensum may also be adversely affected, as an indirect downstream receptor. Due to the Proposed Scheme being hydraulically disconnected from the River Yare, it is considered there will be no impact caused by this aspect.

13.8.30. The West Culvert Extension and New West Culvert at Oak Farm causes a total loss of approximately 58m of channel and riparian vegetation (17m for the existing culvert extension and 43m for the new culvert). The Newgate House Culvert south of Hockering causes a loss of approximately 44m of channel and riparian vegetation. In turn these three culverts and the associated minor watercourse diversions associated with the culverts have the potential to impact on channel morphology and reduce hydromorphological complexity. This can lead to degradation of the River Tud tributaries' habitat and supporting ecological features including impeding aquatic species movement. In turn this could adversely impact on WFD ecological and hydromorphological quality

elements of the River Tud. The River Wensum is unlikely to be adversely affected, as an indirect receptor as a result of this aspect. Due to the Proposed Scheme being hydraulically disconnected from the River Yare, it is considered there will be no impact caused by this activity. The WFD ecological quality elements that could be impacted include:

- physicochemical quality elements (ammonia, dissolved oxygen, pH, phosphate and temperature, and biochemical oxygen demand for the Wensum DS only)
- biological quality elements (fish and invertebrates, and macrophytes and phytobenthos for the Wensum DS Norwich only)
- hydromorphological quality elements (hydrological regime and morphological conditions)

Groundwater

13.8.31. Structures extending below the water table, comprising overbridge foundations and cuttings, have the potential to impede flow to groundwater dependent features, and possibly locally raise groundwater levels up-gradient and lower groundwater levels down-gradient of the structure. Subsurface structures may also create cross-contamination pathways from surface to groundwater, and between aquifer units.

13.8.32. There is likely to be a disruption of groundwater flows within the superficial deposits as a result of the River Tud Crossing, resulting in localised impacts to the baseflow to the river in the immediate vicinity. As no groundwater is being removed from the catchment at this location, however, this will not result in an overall reduction in baseflow.

13.8.33. Cuttings intersecting the water table, or perched groundwater, may require permanent drainage systems to be installed to divert groundwater flows away from the Proposed Scheme. There are no GWDTEs present within the calculated radius of influence for permanent slope drainage at the mainline cutting west of the River Tud Crossing and at the Honingham Church underpass (see Appendix 13.4 Groundwater assessment (**TR010038/APP/6.3**). This risk is therefore assessed to be negligible. The risk is also negligible for licensed abstractions, which are located outside of the predicted radius of influence. However, details of private water supplies within the Broadland and South Norfolk district council areas are outstanding.

13.8.34. The proposed drainage design includes the use of filter drains throughout the Proposed Scheme. Filter drains contain a permeable liner and therefore may result in contaminated road drainage discharging to ground, and ultimately impacting on the water quality of the received aquifer and its indirect receptors. In addition, one of the proposed road drainage outfalls discharges to a stream

with seasonally observed low flows (Oak Farm tributary), which as a result may infiltrate to ground and pose a risk to groundwater quality within both the superficial deposits and the underlying Chalk aquifer, if not mitigated. Further details of the hydrogeological assessment for this outfall are provided in Appendix 13.4 (Groundwater assessment) (**TR010038/APP/6.3**).

13.9. Design, mitigation and enhancement measures

13.9.1. This section provides details of the following measures:

- 'Essential mitigation' measures – these are critical for the delivery of the Proposed Scheme and can be acquired through statutory powers. They are generally incorporated into construction activities, through the appropriate selection of construction methods and materials, adoption of best practice measures and monitoring, and also long-term maintenance.
- 'Embedded mitigation' measures – these are incorporated into the project design in order to avoid or prevent adverse environmental effects. They are generally incorporated into operation of the Proposed Scheme, as part of the design.

13.9.2. An overview of embedded mitigation is also reported in ES Chapter 2 (The Proposed Scheme) (**TR010038/APP/6.1**).

Construction

13.9.3. During construction, best practice methods for pollution prevention and water management would be implemented as part of the overall Environment Management Plan (EMP) (**TR010038/APP/7.4**). Guidance on best practice in relation to pollution prevention and water management is set out in CIRIA guidelines (C741 Charles and Edward, 2015; C648 Murnane *et al*., 2006) and the Environment Agency's approach to groundwater protection (Environment Agency, 2017a) and groundwater protection guides (Environment Agency, 2006, 2017b). Best practice methods specific to the identified potential impacts are discussed further below.

Surface Water

13.9.4. The design and construction of all above ground structures shall aim to minimise the potential to impact on surface water features and flood risk. Specific mitigation measures to achieve this include both embedded and essential mitigation and are described below.

13.9.5. The potential for impacts to occur as a result of contamination from accidental spillages shall be minimised by the following measures:

- Appropriate storage of construction materials, including bunding of storage tanks, use of silt fencing and covering stockpiles.
- Spill kits should be located on sites near to ordinary watercourses or drainage ditches and within the works compounds and staff should be trained in their use.
- Emergency response procedures included in the EMP to handle any leakages or spillages of potentially contaminating substances

13.9.6. No pollution pathways shall be created between the construction sites, including compounds and material storage areas, and surface water features. Measures shall be implemented to prevent surface water runoff containing suspended sediment reaching main rivers or ordinary watercourses through overland flow during rainfall events. This shall include an appropriate treatment train to prevent accidental spillages reaching groundwater, remove sediment and other contaminants as well as attenuating runoff. This must be specified as part of a temporary drainage strategy within the EMP (**TR010038/APP/7.4**).

13.9.7. The River Tud is designated as a NVZ for surface water and for groundwater. The Tud WFD water body is prevented from achieving good ecological potential due to the phosphate concentrations found in the catchment. Where construction activities have the potential to mobilise nitrate and phosphate during, for example, earthworks in areas of agriculture, there is a potential to increase nitrate and phosphate concentrations within the Tud or to groundwater. The risk of nitrate and phosphate mobilisation will be managed by the implementation of best practice construction measures and the temporary drainage strategy through the EMP (**TR010038/APP/7.4**).

13.9.8. Temporary drainage from the main construction compound would typically be collected within a ditch surrounding the compound and redirected to settlement ponds before being discharged to either a surface watercourse or ground. Discharges to groundwater, surface water and / or sewer must only be made with the appropriate consents or permits in place. Any non-compliant discharges must be collected and disposed of off-site at a licensed facility.

13.9.9. The above-mentioned measures will mitigate impacts to the WFD physicochemical and biological quality elements of the Tud and Wensum (DS Norwich) water bodies caused by construction activities and spillages.

13.9.10. There are construction activities planned over and within 8m of a main river (the River Tud) and its floodplain. As such, in accordance with the Environmental Permitting Regulations consent (in the form of a Flood Risk Activity Permit) must be obtained from the Environment Agency prior to the start of construction activities. In addition to this there are works within and adjacent to ordinary watercourses and adjacent to a watercourse managed by the Norfolk Rivers

District IDB. As such, consent from Norfolk County Council and the IDB must be obtained prior to the start of construction activities. The potential increase in flood risk and negative impacts on surface water receptors must be managed by the implementation of a construction-phase drainage system as specified by a temporary drainage strategy in the EMP (**TR010038/APP/7.4**).

13.9.11. The potential impacts from the construction of the Proposed Scheme including drainage, crossings and associated features shall be managed through the phased construction plan. The River Tud Crossing, Newgate House Culvert, West Culvert Extension and New West Culvert, the minor watercourse diversions associated with the culverts, and the compensatory flood storage area must be designed to minimise impacts on water quality and ensure there is no loss of habitat or biodiversity. Best practice construction measures, including in-river sediment controls (for example, straw matting) shall be used and it shall be undertaken during low flows to minimise sediment transport. Due to the installation of two new culverts and the extension of one culvert it is deemed there would be a minor adverse impact on the biodiversity of the River Tud and its tributaries as a result. However, the Proposed Scheme has been designed to minimise impacts on the water environment by:

- Providing a clear span structure that will retain the natural river bed and watercourse alignments at the River Tud Crossing
- Setting the abutments for the River Tud Crossing at least 5m from the channel top-of-bank and avoiding undertaking any construction activities within 5m from the channel top-of-bank
- The Newgate House Culvert south of Hockering must accommodate natural river bed material in the base of the culvert, together with a mammal ledge above the design flood level to maintain habitat connectivity.
- The West Culvert Extension and New West Culvert at Oak Farm must throttle flood flows in order to minimise flood risk to the sensitive receptors downstream, therefore habitat restoration measures including the planting of riparian buffer strips and re-meandering of the watercourse upstream will be provided to offset any negative impacts of the additional culverting.

13.9.12. These measures will also mitigate impacts to WFD physicochemical and biological quality elements of the Tud and Wensum (DS Norwich) water bodies. The minor impacts noted above are not considered to have an impact on the overall WFD status of the waterbodies.

13.9.13. Works would lead to temporary changes in overland flow and volume by the alterations of ground elevations due to re-profiling, pond infilling, alterations of overland flow pathways and construction of above ground structures acting as a barrier to flow. This increased flood risk and negative impacts on surface water receptors must be managed by the implementation of a construction-phase

drainage system. This must also include the construction of 'dry culverts' or cross drains to maintain natural flood flow pathways (up to a 1 in 100-year event including a 65% allowance for climate change) where they are intercepted by the Proposed Scheme. A temporary surface water drainage strategy must be developed and be incorporated into the EMP (**TR010038/APP/7.4**) to prevent increased flood risk to people and property elsewhere, and to manage pollution risks particularly associated with increased sediment mobilisation. Where practicable, drainage shall be constructed in the early stages of the Proposed Scheme.

13.9.14. Increased flood risk and negative impacts on surface water receptors caused by an increase in impermeable area, leading to an increase in the peak flow rate, volume or change in the direction of surface water runoff, must be managed by the implementation of a temporary surface water drainage strategy. The strategy shall adopt SuDS principles to attenuate runoff to existing rates as well as provide water treatment; this must be incorporated into the EMP (**TR010038/APP/7.4**). This would prevent increased flood risk to people and property elsewhere and manage any impacts on aquatic environment, recreation and value to economy.

13.9.15. The provision of one replacement pond is required for each pond lost in the location of the Proposed Scheme (seven ponds lost). The replacement ponds shall be constructed prior to the existing ponds being lost. This shall mitigate the potential negative impact on biodiversity and aquatic ecology caused by the loss of these water features. The location of the replacement ponds within the DCO boundary is shown on the Environmental Masterplan (**TR010038/APP/6.8**). This has been discussed, along with detailed mitigation requirements of the replacement ponds in Chapter 8 (Biodiversity) (**TR010038/APP/6.1**).

Groundwater

13.9.16. The design and construction of all below ground structures should aim to minimise the potential to impact on either groundwater supply or groundwater quality. Specific mitigation measures to achieve this include both embedded and essential mitigation:

- Piling, including foundation piles, ground improvements works such as Controlled Modulus Columns (CMCs) and box sheet piles, shall be appropriately designed to minimise the disruption of groundwater flows, and thus supply to indirect receptors. This includes careful consideration of any ground improvement works for CMC platforms, which must have appropriately selected fill material for working in saturated ground, thus allowing groundwater to dissipate in a controlled manner. The proposed bridge structure for the River Tud Crossing shall also be designed to minimise disruption to groundwater flows to the river.

- Piling design shall also ensure appropriate methods are selected to prevent creation of preferential pathways between aquifer units and for artesian groundwater to rise to surface.
- The piling method shall minimise the generation of suspended solids that may impact nearby indirect receptors.
- Construction materials shall be chosen appropriately to minimise groundwater contamination via direct contact.
- A piling risk assessment shall be undertaken prior to commencement of the works. Environment Agency guidance on minimising pollution risk due to piling shall be adhered to (Environment Agency, no date; 2001; and Westcott *et al.,* 2001).
- Where below ground structures are to be situated in areas where there are nearby indirect receptors, such as licensed or unlicensed abstractions or sensitive groundwater dependent terrestrial ecosystems, monitoring plans should incorporate water level and water quality threshold criteria agreed with the Environment Agency and Anglian Water Services.

13.9.17. Works within the saturated aquifer may require dewatering. Dewatering volumes above 100m^3/day require a transfer or abstraction licence to be approved by the Environment Agency. This licensing exemption limit may be reduced to 50m^3/day, depending on whether there are conservation sites within 500m or springs, wells or boreholes used to supply water for any lawful use within 250m of the proposed abstraction. Licensing will be subject to water features surveys, further impact assessments on any identified receptors and monitoring during works.

13.9.18. Discharging of dewatered volumes may also require a bespoke discharge consent. Treatment measures may be required depending on the quality of water abstracted, and the receiving waterbody.

13.9.19. To mitigate against the potential impact of accidental spillages and leakages on groundwater quality in areas of high or increased aquifer vulnerability, the EMP (**TR010038/APP/7.4**) must include essential mitigation such as the appropriate storage of construction materials (bunding, silt fencing and covering of stockpiles), provision of spill kits adjacent to excavation areas, and inclusion of emergency response procedures for spillages of potentially contaminating substances. Such mitigation measures must also be adopted for any emergency or unanticipated artesian groundwater discharges during construction. Existing road drainage soakaways no longer required as part of the Proposed drainage design must also be backfilled.

13.9.20. To mitigate against potential impacts from further ground investigation works, aquifer protection measures in line with best practice, including above ground standpipes and grouted annulus, must be incorporated into the design and

construction of groundwater monitoring boreholes. The groundwater monitoring boreholes must be backfilled after the monitoring period is complete. This is of particular importance within the SPZ1 for the new public water supply abstraction at East Tuddenham.

Operational

13.9.21. The potential effects of the operation of the Proposed Scheme on the water environment are generally addressed through embedded mitigation.

Surface water

13.9.22. The Drainage strategy (Appendix 13.2 (**TR010038/APP/6.3**)) proposes all road drainage will drain by surface water outfalls discharging to the River Tud and its tributaries. The proposed highway drainage will discharge to 12 locations, utilising nine new outfalls, subject to drainage survey. The location of the outfalls can be found in Appendix 13.3 (Water quality assessment) (**TR010038/APP/6.3**). Prior to discharging to the River Tud and its tributaries, the runoff from the new outfalls will discharge to surface water via filter drains and vegetated detention basins or wetlands. A drainage basin must be provided prior to the Oak Farm tributary outfalls to mitigate copper pollution impacts. Filter drains must be provided on catchment M1 prior to where it ties into the existing drainage and subsequent outfall which is outside of the DCO boundary.

13.9.23. The potential water quality impacts of routine runoff on surface water receptors has also been assessed using DMRB LA 113 HEWRAT assessment (assessment of pollution impacts from routine runoff to surface waters), as described in Appendix 13.3 (Water quality assessment) (**TR010038/APP/6.3**). The assessment shows that there is a negligible impact following dilution in the channel for both soluble and sediment-bound pollutants when the required measures from the drainage design have been included.

13.9.24. The potential water quality impacts of accidental spillages on surface water bodies were assessed using HEWRAT spillage assessment, as described in Appendix D of DMRB LA 113. All outfalls passed this assessment with the results indicating all drainage areas would have <0.5% annual risk of pollution. The output from these assessments can be found in Appendix 13.3 (Water quality assessment) (**TR010038/APP/6.3**). Pollution control devices such as penstocks shall be provided to the inlets and outlets to the detention basins and wetlands, in order to reduce any pollution that may occur in the event of a spillage as described in Appendix 13.2 (Drainage strategy) (**TR010038/APP/6.3**).

13.9.25. Water quality enhancements shall be implemented as part of the Proposed Scheme (Appendix 13.3 Water quality assessment (**TR010038/APP/6.3**)). Two

of the detention basins shall be developed as a wetland feature at Gypsy Lane, south-east of Hockering, and south of the River Tud Crossing to provide additional pollution treatment and biodiversity enhancement. The remaining detention basins shall be vegetated with suitable local species to provide biodiversity and further water quality enhancements.

13.9.26. The above mentioned embedded mitigation measures will mitigate against impacts to WFD physicochemical (dissolved oxygen), biological and specific pollutant (copper, zinc) quality elements of the Tud and Wensum (DS Norwich). The enhancement measures would reduce phosphate and nitrate input into the watercourses. Phosphate and nitrogen are not typically associated with road runoff but are may enter the watercourse directly as the result of agricultural runoff local to the Proposed Scheme.

13.9.27. As the Proposed Scheme option has a footprint greater than 1ha and crosses Flood Zone 3, a Flood risk assessment (Appendix 13.1 (**TR010038/APP/6.3**)) has been prepared. The pattern of flood risk impacts and the required mitigation depends on the location and the proposed works, as discussed below.

13.9.28. Existing surface water pathways for overland flows must be maintained or facilitated through interception using appropriately designed collection drains and cross-drains, also known as ‘dry culverts’. Cross-drains must be designed to convey a 1 in 100-year flow including an additional 65% climate change allowance in order to maintain connectivity of surface water flooding pathways and to mitigate against any increase in flood risk. Further details can be found in the Flood risk assessment (Appendix 13.1 (**TR010038/APP/6.3**)) and the Drainage strategy (Appendix 13.2 (**TR010038/APP/6.3**)).

13.9.29. The proposed increase in areas of hard standing and alteration of ground elevations due to re-profiling would result in an increase in peak flow rates and volumes discharging to the River Tud and its tributaries, particularly within areas of Flood Zones 2 and 3. Any increase in surface water runoff must be attenuated using wetlands, vegetated detention basins or oversized pipes. The drainage is designed to attenuate new drainage systems to the greenfield runoff rate up to a 1 in 100-year rainfall event including a 40% climate change allowance. For existing drainage systems that are modified as part of the Proposed Scheme and will continue to tie into the existing drainage, there must be no increase in existing runoff rate. This shall include a 40% climate change allowance for contributing new hardstanding areas; these standards are in accordance with DMRB CG501. Attenuation will be in the form of flow controls and oversized pipes. This shall ensure there is no increase in surface water runoff peak flow rate resulting from the Proposed Scheme. Further details can be found in the Drainage strategy (Appendix 13.2 (**TR010038/APP/6.3**)).

13.9.30. The River Tud Crossing, Newgate House Culvert, West Culvert Extension and New West Culvert have the potential to alter the conveyance of flow in the floodplain. The flood risk impact of the Proposed Scheme has been fully assessed using hydraulic modelling where three hydraulic models were developed that cover the River Tud and two of its tributaries at Oak Farm and Hockering. The details of the assessment and impacts are presented in the Appendix 13.1 (Flood risk assessment) (**TR010038/APP/6.3**) and summarised below.

13.9.31. The River Tud Crossing has been designed to the peak flood level for the 1 in 100 year event plus 65% climate change including freeboard allowance, however, the bridge soffit will have an elevation of approximately 2.7m above to river bank to maintain access. When compared to the baseline scenario, the Proposed Scheme model indicated that the River Tud Crossing will increase water levels upstream and downstream of the new crossing. A maximum increase of 17mm is predicted immediately upstream of the bridge for the 1 in 100-year event and 72mm with a 65% climate change allowance respectively. This increase is due to the abutments intercepting and funnelling floodwater back into the channel. The impact extends approximately 400m downstream and 700m upstream of the crossing, beyond the existing A47. The increase in peak levels upstream of the existing A47 is below 10mm. The hydraulic model demonstrates that no new receptors will be affected by the Proposed Scheme. Compensatory flood storage must be provided immediately upstream of the proposed River Tud Crossing to mitigate against any loss of floodplain storage and predicted flood levels. As such the impact of the River Tud Crossing is considered to be of negligible significance.

13.9.32. Flooding is predicted to occur upstream of the existing A47 at Oak Farm. The Proposed Scheme extends the existing A47 culvert (West Culvert Extension) upstream. The watercourse reach between the two culverts will be realigned. The culvert is to be extended using similar dimensions to retain the throttling of flood flows. The New West Culvert under the new local access road near Oak Farm must be constructed to similar dimensions. To prevent water backing up, as identified in the baseline model, and to ensure that there is no detrimental impact on flood risk downstream, a 350mm circular orifice will be placed at the inlet to the New West Culvert to throttle flood flows. An embankment will be constructed upstream to contain floodwater and ensure that there is no flood risk to the new local access. This has the impact of displacing flood waters further upstream but no flood-sensitive receptors are impacted during the 1 in 100-year with 65% climate change allowance. The model also demonstrated that the proposed embankment crest level of 46.5m AOD provides greater than 600mm freeboard for the 100-year event (with 65% climate change).

13.9.33. Immediately upstream of the New West Culvert water levels are predicted to increase by a maximum of 1011mm for the 100-year event without climate change (44.078 to 45.089m AOD) and by 825mm with a 65% allowance (44.688 to 45.513m AOD). A maximum decrease in water levels of 678mm and 1047mm is predicted immediately downstream of the existing A47 culvert. Further downstream there is a reduction in flood depth of between 5mm and 167mm for the 100 year event without climate change and between 1mm and 78mm with a 65% allowance for climate change. Upstream of the Proposed Scheme an impact of major adverse to major beneficial magnitude results where flood water is displaced upstream as a result of the embankment and orifice needed to hold back flood water to protect the new local access road. However, further downstream an impact of negligible beneficial to moderate beneficial magnitude (climate change scenario) is predicted as a result of the embankment. Given that no sensitive flood receptors are affected by the displaced flood water upstream of the Proposed Scheme; the overall effect is classed as negligible to moderate beneficial significance.

13.9.34. The placement of the Proposed Scheme within the Oak Farm tributary floodplain (1 in 100 year plus 35% climate change allowance) would normally require the provision of compensatory flood storage and an area has been allowed within the Environmental Masterplan (**TR010038/APP/6.8**) to mitigate against the loss of floodplain. However, given that there are no sensitive receptors impacted by the Proposed Scheme, as well as the essential need to maintain the existing throttle downstream and protect the new local access road, and given that flood compensatory storage area would require extensive landscaping of the arable land upstream, it is in the process of being agreed, with Norfolk County Council and the Environment Agency that flood compensatory storage may not be required. As this is still to be confirmed, the flood compensatory storage is still considered as a worst case approach.

13.9.35. As part of the Proposed Scheme a section of the Hockering watercourse would be culverted (Newgate House Culvert) with a minor watercourse realignment. The new box culvert is approximately 44m in length, box shaped with a width of 2.05m and height of 1.75m and is designed to convey a 1 in 100-year peak flow (including a 65% climate change allowance) with a freeboard exceeding 600mm. A natural bed (300mm) would be installed in the base of the culvert and a mammal ledge provided to maintain connectivity of habitat.

13.9.36. A maximum reduction in water levels of approximately 145mm was predicted upstream of the proposed culvert for the 100-year event without climate change and 68mm for the 100-year event with a 65% climate change allowance. The effects are, however, very localised and do not extend beyond the footpath culvert upstream. No change in water level was predicted immediately downstream of the Newgate House Culvert. The Proposed Scheme results in an

impact of negligible to moderate beneficial magnitude identified on the floodplain and conveyance of flow depending on the location; this, in turn, results in an effect of negligible to moderate beneficial significance. It has been agreed, in principle, with Norfolk County Council and the Environment Agency that no flood compensatory storage is required for the Hockering tributary as the estimated loss in floodplain storage is 27m^3 and there are no flood risk impacts.

13.9.37. Due to the installation of the new culverts and the extension of an existing culvert, it is deemed there will be minor adverse impacts on the biodiversity of both watercourses as a result.

13.9.38. As agreed with the Environment Agency, the abutments and embankments of the River Tud Crossing must be placed at least 5 metres away from the top of the river bank. The natural river bed and watercourse alignment of the River Tud would be retained. This would minimise impacts on the sensitive chalk river and provide habitat connectivity. This would also avoid degradation or destabilisation of the riparian channel and banks and allow for lateral migration of the channel. The bridge deck is designed to be 30m in width, therefore it is unlikely that riparian vegetation would be impacted by shading to the degree that this may impact morphological stability in this reach. This has been discussed in the Geomorphological assessment (Appendix 13.5) (**TR010038/APP/6.3**). These measures would also mitigate impacts to WFD physicochemical, biological and hydromorphological quality elements of the Tud and Wensum (DS Norwich) water bodies.

13.9.39. To minimise the risk of erosion of the watercourse banks and bed due to the discharge from the proposed outfalls, flow rates and velocities must be kept to existing runoff rates. All surface water runoff from road runoff must be attenuated to greenfield runoff rates at source using SuDS systems such as vegetated detention basins. Scour protection downstream of the outfall must be provided to ensure the risk of erosion is minimised. The proposed outfalls must be set back into the bank to minimise the impact on flow conveyance and minimise the impact of erosion and scouring of river banks.

13.9.40. Newgate House Culvert, West Culvert Extension and New West Culvert will result in the loss of riparian banks and bed including associated habitat. To mitigate against the impacts, Newgate House Culvert must be constructed to maintain a natural sediment bed at the base of the culvert and a mammal ledge shall be provided above the design flood level. This will maintain connectivity of the habitat and allow mammal passage. At Oak Farm, the requirement to throttle flood flows prevents the inclusion of larger culverts to enable mammal passage and construction of a natural bed.

13.9.41. Habitat restoration measures on both the Oak Farm and Hockering tributaries, upstream of the existing A47, including riparian buffer strips / planting, re-meandering of the watercourse and leaky dams must be included to mitigate against the additional culverting. Riparian buffer planting will increase habitat for fauna, reduce surface water runoff and improve water quality (sediment, nitrate and phosphate) entering into the watercourse (particularly where arable or pasture borders the watercourse). Additional riparian (buffer) planting will also be included along the watercourse at the locations of the proposed outfalls. This will mitigate the impacts of the outfalls, new culverts, culvert extension and associated minor watercourse diversion on the channel morphology including aquatic habitat and to ensure no reduction in WFD status.

13.9.42. The locations of the habitat restoration measures associated with Oak Farm and Hockering can be seen in the Environmental Masterplan (**TR010038/APP/6.8**). The design of the measures shall be undertaken at detailed design stage in discussion with the Environment Agency, Norfolk County Council, landowners and other stakeholders.

13.9.43. The provision of one replacement pond is required for each pond lost in the location of the Proposed Scheme (a total of seven ponds lost). The replacement ponds shall be constructed prior to the existing pond being lost. This will mitigate the potential negative impact on biodiversity and aquatic ecology caused by the loss of these water features. The location of the replacement ponds within the DCO boundary is shown on the Environmental Masterplan (**TR010038/APP/6.8**). This has been discussed, along with detailed mitigation requirements of the replacement pond in Chapter 8 (Biodiversity) (**TR010038/APP/6.1**).

13.9.44. These measures noted above will also mitigate impacts to WFD physicochemical, biological and hydromorphological quality elements of the Tud and Wensum (DS Norwich). Although an impact of minor adverse significance has been identified on Oak Farm and Hockering tributaries, it is considered not to have an impact on the WFD status of either water bodies.

Groundwater

13.9.45. As with the embedded mitigation requirements to address potential construction impacts, the piling design shall aim to minimise the disruption of groundwater flows, and thus supply to indirect receptors. This includes careful consideration of any ground improvement works such as CMC platforms, which must have appropriately selected fill material for working in saturated ground, thus allowing groundwater to dissipate in a controlled manner. The proposed bridge structure for the River Tud Crossing shall also be designed to minimise disruption to groundwater flows to the river.

13.9.46. As well as the piling design measures detailed above, operational design features that may be required for groundwater aspects of the Proposed Scheme include permanent drainage from cutting slopes, where required, to divert groundwater away from the Proposed Scheme and into the road drainage system. As information on unlicensed abstractions is limited, a water features survey must be undertaken to identify any additional groundwater receptors.

13.9.47. Embedded mitigation measures shall be incorporated into the road drainage design, including ensuring discharges to groundwater do not occur in areas of shallow groundwater (less than one metre unsaturated zone) and SPZ1. Further water quality monitoring shall be undertaken to further confirm baseline groundwater quality.

13.10. Assessment of likely significant effects

13.10.1. Potential effects on surface water and groundwater receptors during construction are summarised in Table 13.8, together with residual impacts after mitigation. The mitigation measures described in Table 13.8 are discussed in detail in Section 13.9. The impact on surface water receptors is based on the outcome of the Flood risk assessment (Appendix 13.1) (**TR010038/APP/6.3**), Water quality assessment (Appendix 13.3) (**TR010038/APP/6.3**) and Geomorphological assessment (Appendix 13.5) (**TR010038/APP/6.3**). These impact assessments include potential receptors identified in the assessments for groundwater levels and flow and groundwater dependent terrestrial ecosystems detailed in Appendix 13.4 Groundwater assessment (**TR010038/APP/6.3**).

13.10.2. Potential effects on surface water and groundwater receptors during operation are summarised in Table 13.9, together with residual impacts after mitigation. The mitigation measures described in Table 13.9 are discussed in detail in Section 13.9. The impact on surface water receptors is based on the outcome of the Flood risk assessment (Appendix 13.1) (**TR010038/APP/6.3**), Water quality assessment (Appendix 13.3) (**TR010038/APP/6.3**) and Geomorphological assessment (Appendix 13.5) (**TR010038/APP/6.3**). These impact assessments include potential receptors identified in the assessments for groundwater levels and flow and groundwater dependent terrestrial ecosystems detailed in Appendix 13.4 Groundwater assessment (**TR010038/APP/6.3**).

13.10.3. Where potential impacts have multiple receptors (direct and indirect) the highest importance value has been listed in the table and used for the assessment.

13.10.4. The impact of the Proposed Scheme on the Water Framework Directive status of the affected water bodies is also considered in this section.

Table 13.8 Potential effects on groundwater and surface water receptors during construction of the Proposed Scheme

Construction Activity	Potential effects on direct and indirect receptors	Feature	Relevant attributes	Importance (value)	Mitigation	Magnitude of impact after mitigation	Significance of effect after mitigation
Accidental leakage or spillages	Pollution of surface water features due to accidental spillage or leakage of fuel and oils, or due to placement of construction materials, washing of plant, cleaning areas of hardstanding etc. (suspended solids and dissolved contaminants) Deterioration of downstream aquatic environments and abstraction water quality.	The River Tud (including Norfolk Rivers IDB section)	Water supply and quality	High	EMP (pollution prevention measures in the construction drainage design, emergency response procedures and provision of spill kits). Adhere to CIRIA guidelines on control of water pollution on linear construction sites (C648) and environmental best practice on site (C741) Monitoring plan must include water quality monitoring prior to, during and after construction (to be agreed with the Environment Agency).	Negligible	Slight adverse
			Recreation	Medium		Negligible	Neutral
			Value to economy	Medium		Negligible	Neutral
			Biodiversity	High		Negligible	Slight adverse
		Unnamed ordinary watercourses (within the Tud WFD water body catchment)	Water supply and quality	Medium		Negligible	Neutral
			Value to economy	Medium		Negligible	Neutral
			Biodiversity	High		Negligible	Slight adverse
		The River Wensum	Water supply and quality	High		Negligible	Slight adverse
			Recreation	High		Negligible	Slight adverse
			Value to economy	Medium		Negligible	Neutral
			Biodiversity	Very High		Negligible	Slight adverse
		Ponds	Water supply and quality	Medium		Negligible	Neutral
			Recreation	Medium		Negligible	Neutral

Construction Activity	Potential effects on direct and indirect receptors	Feature	Relevant attributes	Importance (value)	Mitigation	Magnitude of impact after mitigation	Significance of effect after mitigation
			Value to economy	Medium		Negligible	Neutral
			Biodiversity	Very high		Negligible	Slight adverse
Works within, adjacent, over or close to water bodies, watercourses, ponds or the fluvial floodplain	Pollution of surface water bodies due to placement of construction materials, washing of plant, cleaning areas of hardstanding etc. (suspended solids and dissolved contaminants) Deterioration of downstream aquatic environments.	The River Tud (including Norfolk Rivers IDB section)	Water supply and quality	High	Construction design and EMP (REAC). Monitoring plan must include water quality monitoring prior to, during and after construction (to be agreed with the Environment Agency). Environment Agency Flood Risk Activity Permit, Norfolk County Council Ordinary Watercourse Consent and Norfolk Rivers District IDB Consent required prior to commencement of construction activities.	Negligible	Slight adverse
			Recreation	Medium		Negligible	Neutral
			Value to economy	Medium		Negligible	Neutral
			Biodiversity	High		Negligible	Slight adverse
		Unnamed ordinary watercourses (within the Tud WFD water body catchment)	Water supply and quality	Medium		Negligible	Neutral
			Value to economy	Medium		Negligible	Neutral
			Biodiversity	High		Negligible	Slight adverse
		The River Wensum	Water supply and quality	High		Negligible	Slight adverse
			Recreation	High		Negligible	Slight adverse
			Value to economy	Medium		Negligible	Neutral
			Biodiversity	Very High		Negligible	Slight adverse

Construction Activity	Potential effects on direct and indirect receptors	Feature	Relevant attributes	Importance (value)	Mitigation	Magnitude of impact after mitigation	Significance of effect after mitigation
		Ponds	Water supply and quality	Medium		Negligible	Neutral
			Recreation	Medium		Negligible	Neutral
			Value to economy	Medium		Negligible	Neutral
			Biodiversity	Very high		Negligible	Slight adverse
Works within, adjacent, over or close to water bodies, watercourses, ponds or the fluvial floodplain	Increased localised flooding to the Proposed Scheme. Increased or redirected flood risk to other and risk to flood-sensitive receptors near to overloaded system and downstream.	The River Tud (including Norfolk Rivers IDB section)	Water supply and quality	High	Construction design and EMP (including temporary drainage strategy employing SuDS where appropriate). Monitoring plan must include water quality monitoring prior to, during and after construction (to be agreed with the Environment Agency). Environment Agency Flood Risk Activity Permit, Norfolk County Council Ordinary Watercourse Consent and Norfolk Rivers District IDB Consent required prior to commencement of	Negligible	Slight adverse
			Recreation	Medium		Negligible	Neutral
			Value to economy	Medium		Negligible	Neutral
			Conveyance of flow	High		Negligible	Slight adverse
			Biodiversity	High		Negligible	Slight adverse
		Unnamed ordinary watercourses (within the Tud WFD water body catchment)	Water supply and quality	Medium		Negligible	Neutral
			Value to economy	Medium		Negligible	Neutral
			Conveyance of flow	High		Negligible	Slight adverse
			Biodiversity	High		Negligible	Slight adverse

Construction Activity	Potential effects on direct and indirect receptors	Feature	Relevant attributes	Importance (value)	Mitigation	Magnitude of impact after mitigation	Significance of effect after mitigation
		River Tud floodplain	Conveyance of flow	High	construction activities.	Negligible	Slight adverse
Construction of proposed outfalls, Newgate House Culvert, New West Culvert, West Culvert Extension, and minor watercourse diversions associated with culverts, River Tud Crossing, and flood compensatory storage	Deterioration or loss of the aquatic environments and deterioration in water quality. Deterioration of downstream aquatic environment of indirect receptors.	The River Tud (including Norfolk Rivers IDB section)	Water supply and quality	High	Construction design and EMP. Adhere to CIRIA guidelines on control of water pollution on linear construction sites (C648) and environmental best practice on site (C741). Adherence to C786 – Culvert, Screen and Outfall Manual guidelines. Monitoring plan must include water quality monitoring prior to, during and after construction (to be agreed with the Environment Agency). Environment Agency Flood Risk Activity Permit, Norfolk County Council Ordinary Watercourse Consent and Norfolk Rivers District IDB Consent required prior to commencement of construction activities.	Negligible	Slight adverse
			Recreation	Medium		Negligible	Neutral
			Value to economy	Medium		Negligible	Neutral
			Biodiversity	High		Negligible	Slight adverse
		Unnamed ordinary watercourses (within the Tud WFD water body catchment)	Water supply and quality	Medium		Negligible	Neutral
			Value to economy	Medium		Negligible	Neutral
			Biodiversity	High		Minor adverse	Slight adverse
		The River Wensum	Water supply and quality	High		Negligible	Slight adverse
			Recreation	High		Negligible	Slight adverse
			Value to economy	Medium		Negligible	Neutral
			Biodiversity	Very High		Negligible	Slight adverse

Construction Activity	Potential effects on direct and indirect receptors	Feature	Relevant attributes	Importance (value)	Mitigation	Magnitude of impact after mitigation	Significance of effect after mitigation
Alteration of ground elevations and overland flow pathways, pond infilling and construction of above ground structures acting as a barrier to flow.	Changes in surface water flow pathways resulting in overloading of drainage systems and surface watercourses and drainage ditches. Increased or redirected flood risk to other and risk to flood-sensitive receptors near to overloaded system and downstream. Deterioration of downstream aquatic ecology.	The River Tud (including Norfolk Rivers IDB section)	Water supply and quality	High	Construction design and EMP (including a temporary surface water drainage strategy). Construct drainage in the early stages to maintain flood flow pathways. Ponds must be replaced prior to loss of existing pond (Refer to Chapter 8 (Biodiversity) (**TR010038/APP/6.1**) for detailed mitigation. Locations shown on Environmental Masterplan) (**TR010038/APP/6.8**)	Negligible	Slight adverse
			Recreation	Medium		Negligible	Neutral
			Value to economy	Medium		Negligible	Neutral
			Conveyance of flow	High		Negligible	Slight adverse
			Biodiversity	High		Negligible	Slight adverse
		Unnamed ordinary watercourses (within the Tud WFD water body catchment)	Water supply and quality	Medium		Negligible	Neutral
			Value to economy	Medium		Negligible	Neutral
			Conveyance of flow	High		Negligible to moderate beneficial (Hockering and Oak Farm)	Slight adverse to moderate beneficial (Hockering and Oak Farm)
			Biodiversity	High		Negligible	Slight adverse
		River Yare	Water supply and quality	Medium		Negligible	Neutral
			Value to economy	Medium		Negligible	Neutral

Construction Activity	Potential effects on direct and indirect receptors	Feature	Relevant attributes	Importance (value)	Mitigation	Magnitude of impact after mitigation	Significance of effect after mitigation
			Conveyance of flow	Medium		Negligible	Neutral
		Ponds	Water supply and quality	Medium		Negligible	Neutral
			Recreation	Medium		Negligible	Neutral
			Value to economy	Medium		Negligible	Neutral
			Biodiversity	Very high		Negligible	Slight adverse
		River Tud floodplain	Conveyance of flow	High		Negligible	Slight adverse
Drainage of additional hardstanding areas (closed drainage system that discharges to surface water).	Increase in the rate and volume of surface water runoff to water features and increased localised flooding to the Proposed Scheme. Increased or redirected flood risk to other and risk to flood-sensitive receptors near to overloaded system and downstream. Deterioration of downstream aquatic environments.	The River Tud (including Norfolk Rivers IDB section)	Water supply and quality	High	Construction design and EMP (including a temporary surface water drainage strategy).	Negligible	Slight adverse
			Recreation	Medium		Negligible	Neutral
			Value to economy	Medium		Negligible	Neutral
			Conveyance of flow	High		Negligible	Slight adverse
			Biodiversity	High		Negligible	Slight adverse
		Unnamed ordinary watercourses (within the	Water supply and quality	Medium		Negligible	Neutral

Construction Activity	Potential effects on direct and indirect receptors	Feature	Relevant attributes	Importance (value)	Mitigation	Magnitude of impact after mitigation	Significance of effect after mitigation
	Downstream consented discharges.	Tud WFD water body catchment)	Value to economy	Medium		Negligible	Neutral
			Conveyance of flow	High		Negligible	Slight adverse
			Biodiversity	High		Negligible	Slight adverse
		The River Wensum	Water supply and quality	High		Negligible	Slight adverse
			Recreation	High		Negligible	Slight adverse
			Value to economy	Medium		Negligible	Neutral
			Conveyance of flow	High		Negligible	Slight adverse
			Biodiversity	Very High		Negligible	Slight adverse
		River Tud floodplain	Conveyance of flow	High		Negligible	Slight adverse
Infilling of seven ponds due to the location of the Proposed Scheme	Loss of biodiversity habitat and ecology	Ponds	Biodiversity	Very high	One pond to replace each pond lost. The replacement ponds must be constructed before the existing ponds are lost. Refer to Chapter 8 Biodiversity (**TR010038/APP/6.1**)	Negligible	Slight adverse

Construction Activity	Potential effects on direct and indirect receptors	Feature	Relevant attributes	Importance (value)	Mitigation	Magnitude of impact after mitigation	Significance of effect after mitigation
					for detailed mitigation. Locations shown on Environmental Masterplan (**TR010038/APP/6.8**)		
Earthworks within the saturated aquifer, including excavations, ground improvement, utilities, pilings, and cuttings	Groundwater Levels and Flow Creation of a pathway for artesian groundwater to reach surface, causing groundwater flooding.	<u>Direct receptors</u> Broadland Rivers Chalk and Crag Secondary superficial aquifer <u>Indirect receptors</u> River Tud and associated Priority Habitats	Water supply/quality	Very High	A piling risk assessment shall be undertaken to inform the design, focusing on embedded mitigation to minimise the risk of impacts to groundwater. Best practice construction measures included within the EMP (**TR010038/APP/7.4**). Any works within a SPZ1 or 2 must obtain approval from EA and water level monitoring before, during and after construction.	Negligible	Slight adverse
			Soakaway	High		No change	Neutral
			Vulnerability	Very High		Negligible	Slight adverse
			Economic Value	Very High		Negligible	Slight adverse
			Conveyance of flow	Very High		Negligible	Slight adverse
			Biodiversity	Very High		Negligible	Slight adverse
Construction dewatering	<u>Direct Receptors</u> Alteration of the groundwater flow regime and reduction	<u>Direct receptors</u> Secondary superficial aquifer	Water supply/quality	High	Dewatering activities will be subject to approval from EA. Further investigations and assessments will	Negligible	Slight adverse
			Soakaway	High		No change	Neutral

Construction Activity	Potential effects on direct and indirect receptors	Feature	Relevant attributes	Importance (value)	Mitigation	Magnitude of impact after mitigation	Significance of effect after mitigation
	of groundwater levels within the zone of influence Indirect Receptors Reduction of groundwater flow and levels available for abstraction/baseflow	Indirect receptors Licensed abstractions Unlicensed abstractions River Tud and associated Priority Habitats	Vulnerability	Medium	be required as part of the licensing process, and likely to include water features surveys, monitoring before, during and after construction, and treatment of discharge water. Dewatering risks to be reassessed following supplementary ground investigation.	No change	Neutral
			Economic Value	High		Negligible	Slight adverse
			Conveyance of flow	High		Negligible	Slight adverse
			Biodiversity	High		Negligible	Slight adverse
Construction dewatering or emergency groundwater flooding discharge to watercourse	Introduction of contaminated/turbid water to watercourse	The River Tud (including Norfolk Rivers IDB section) River Wensum SSSI/SAC	Water supply and quality	High	Measures stipulated by the discharge consent, and included within the EMP (**TR010038/APP/7.4**).	No change	Neutral
			Dilution and removal of waste products	High		No change	Neutral
			Recreation	High		No change	Neutral
			Value to economy	Medium		No change	Neutral
			Conveyance of flow	High		No change	Neutral
			Biodiversity	High		No change	Neutral
Earthworks within the saturated aquifer,	Groundwater Quality	Direct receptors	Water supply/quality	Very High	A piling risk assessment shall be	Negligible	Slight adverse

Construction Activity	Potential effects on direct and indirect receptors	Feature	Relevant attributes	Importance (value)	Mitigation	Magnitude of impact after mitigation	Significance of effect after mitigation
including excavations, ground improvement, utilities, pilings, and cuttings	Direct Receptors Downdrag of contaminants from surface or between aquifers Contamination of groundwater by direct contact with construction materials Creation of contamination pathways Generation of suspended solids/turbidity within the saturated aquifer Indirect Receptors Transport of contaminants from aquifer to groundwater dependent abstractions, watercourses and habitats	Broadland Rivers Chalk and Crag Secondary superficial aquifer Indirect receptors Licensed abstractions Unlicensed abstractions River Tud and associated Priority Habitats River Wensum SSSI/SAC	Soakaway	High	undertaken to inform the design, focusing on embedded mitigation to minimise the risk of impacts to groundwater. Any works within a SPZ must obtain approval from EA and water quality monitoring before, during and after construction Road drainage soakaways no longer in use to be backfilled. Best practice construction measures included within the EMP (**TR010038/APP/7.4**).	No change	Neutral
			Vulnerability	Very High		Negligible	Slight adverse
			Economic Value	Very High		Negligible	Slight adverse
			Conveyance of flow	Very High		Negligible	Slight adverse
			Biodiversity	Very High		Negligible	Slight adverse

Table 13.9 Potential effects on groundwater and surface water receptors during operation of the Proposed Scheme

Operational activity	Potential effects on direct and indirect receptors	Feature	Relevant attributes	Importance (value)	Mitigation	Magnitude of impact after mitigation	Significance of effect after mitigation
Accidental leakage or spillages	Pollution of surface water features due to		Water supply and quality	High	None required due to spillages assessment	Negligible	Slight adverse

Operational activity	Potential effects on direct and indirect receptors	Feature	Relevant attributes	Importance (value)	Mitigation	Magnitude of impact after mitigation	Significance of effect after mitigation
	accidental spillage or leakage. Deterioration of downstream aquatic environments and abstraction water quality.	The River Tud (including Norfolk Rivers IDB section)	Recreation	Medium	results indicating all drainage areas would have <0.5% annual risk of pollution. Penstocks should be provided as best practice.	Negligible	Neutral
			Value to economy	Medium		Negligible	Neutral
			Biodiversity	High		Negligible	Slight adverse
		Unnamed ordinary watercourses (within the Tud WFD water body catchment)	Water supply and quality	Medium		Negligible	Neutral
			Value to economy	Medium		Negligible	Neutral
			Biodiversity	High		Negligible	Slight adverse
		The River Wensum	Water supply and quality	High	No direct discharge. None required due to spillages assessment results indicating all drainage areas would have <0.5% annual risk of pollution.	Negligible	Slight adverse
			Recreation	High		Negligible	Slight adverse
			Value to economy	Medium		Negligible	Neutral
			Biodiversity	Very High		Negligible	Slight adverse
		Ponds	Water supply and quality	Medium		Negligible	Neutral
			Recreation	Medium		Negligible	Neutral
			Value to economy	Medium		Negligible	Neutral

Operational activity	Potential effects on direct and indirect receptors	Feature	Relevant attributes	Importance (value)	Mitigation	Magnitude of impact after mitigation	Significance of effect after mitigation
			Biodiversity	High		Negligible	Slight adverse
	Pollution of groundwater due to accidental spillage or leakage. Deterioration of downgradient groundwater dependent terrestrial ecosystems and abstraction water quality.	Direct Receptors Secondary superficial aquifer Indirect receptors Broadland Rivers Chalk and Crag Licensed abstractions Unlicensed abstractions GWDTEs	Water supply and quality	High	None required due to spillages assessment results indicating all drainage areas would have <0.5% annual risk of pollution.	No change	Neutral
			Soakaway	High		No change	Neutral
			Vulnerability	Medium		No change	Neutral
			Economic value	High		No change	Neutral
			Conveyance of flow	High		No change	Neutral
			Biodiversity	High		No change	Neutral
Increase in pollutants from routine road runoff	Pollution of surface water features, including an increase in sediment load. Deterioration of downstream aquatic environments	The River Tud (including Norfolk Rivers IDB section)	Water supply and quality	High	Proposed drainage design. Filter drains (on catchment M1), swales and wetland (on catchment M2 and S1) must be provided to treat highway runoff. Enhancement measures including vegetated detention basins and additional wetlands shall be provided but are not required to mitigate environmental impact.	Negligible	Slight adverse
			Recreation	Medium		Negligible	Neutral
			Value to economy	Medium		Negligible	Neutral
			Biodiversity	High		Negligible	Slight adverse
		Unnamed ordinary watercourses (within the Tud WFD water body catchment)	Water supply and quality	Medium		Negligible	Neutral
			Value to economy	Medium		Negligible	Neutral

Operational activity	Potential effects on direct and indirect receptors	Feature	Relevant attributes	Importance (value)	Mitigation	Magnitude of impact after mitigation	Significance of effect after mitigation
			Biodiversity	High		Negligible	Slight adverse
		The River Wensum	Water supply and quality	High	No direct discharge. Proposed drainage design. Filter drains (on catchment M1), swales and wetland (on catchment M2 and S1) must be provided to treat highway runoff. Enhancement measures including vegetated detention basins and additional wetlands shall be provided but are not required to mitigate environmental impact.	Negligible	Slight adverse
			Recreation	High		Negligible	Slight adverse
			Value to economy	Medium		Negligible	Neutral
			Biodiversity	Very High		Negligible	Slight adverse
		Ponds	Water supply and quality	Medium		Negligible	Neutral
			Recreation	Medium		Negligible	Neutral
			Value to economy	Medium		Negligible	Neutral
			Biodiversity	High		Negligible	Slight adverse
	Pollution of groundwater as a result of infiltration below low flows streams	<u>Direct Receptors</u> Secondary superficial aquifer Indirect receptors Broadland Rivers Chalk and Crag Licensed abstractions Unlicensed abstractions GWDTEs	Water supply and quality	High	Proposed drainage design. Filter drains (on catchment M1), swales and wetland (on catchment M2 and S1), and therefore also protective of groundwater environment	Negligible	Slight adverse
			Soakaway	High		Negligible	Slight adverse
			Vulnerability	Medium		Negligible	Neutral
			Economic value	High		Negligible	Slight adverse
			Conveyance of flow	High		Negligible	Slight adverse

Operational activity	Potential effects on direct and indirect receptors	Feature	Relevant attributes	Importance (value)	Mitigation	Magnitude of impact after mitigation	Significance of effect after mitigation
			Biodiversity	High		Negligible	Slight adverse
Alteration of overland flow pathways due to road alignment and alteration of ground levels.	Changes in surface water flow pathways resulting in overloading of drainage systems and surface watercourses. Increased or redirected flood risk to other and risk to flood-sensitive receptors. Deterioration of downstream aquatic environments.	The River Tud (including Norfolk Rivers IDB section)	Water supply and quality	High	Proposed Scheme design - surface water flooding flow pathways maintained through 'dry culverts' designed to convey 1 in 100 year event including 65% climate change allowance in order to maintain connectivity of surface water flooding pathways.	Negligible	Slight adverse
			Recreation	Medium		Negligible	Neutral
			Value to economy	Medium		Negligible	Neutral
			Conveyance of flow	High		Negligible	Slight adverse
			Biodiversity	High		Negligible	Slight adverse
		Unnamed ordinary watercourses (within the Tud WFD water body catchment)	Water supply and quality	Medium		Negligible	Neutral
			Value to economy	Medium		Negligible	Neutral
			Biodiversity	High		Negligible	Slight adverse
		The River Tud floodplain	Conveyance of flow	High		Negligible	Slight adverse
Drainage of additional areas of hardstanding and alteration of ground elevations due to re-profiling	Increase in the rate and volume of surface water runoff to water bodies and watercourses and increased localised flooding to the Proposed Scheme.	The River Tud (including Norfolk Rivers IDB section)	Water supply and quality	High	Proposed new drainage designed to attenuate 1 in 100-year event including 40% climate change allowance to greenfield runoff rate.	Negligible	Slight adverse
			Recreation	Medium		Negligible	Neutral
			Value to economy	Medium		Negligible	Neutral

Operational activity	Potential effects on direct and indirect receptors	Feature	Relevant attributes	Importance (value)	Mitigation	Magnitude of impact after mitigation	Significance of effect after mitigation
	Increased or redirected flood risk to others and risk to flood-sensitive receptors near to overloaded system and downstream. Deterioration of downstream aquatic environments		Conveyance of flow	High	Modified existing drainage to be attenuated to existing rates or below (including 40% climate change allowance)	Negligible	Slight adverse
			Biodiversity	High		Negligible	Slight adverse
		Unnamed ordinary watercourses (within the Tud WFD water body catchment)	Water supply and quality	Medium		Negligible	Neutral
			Value to economy	Medium		Negligible	Neutral
			Conveyance of flow	High		Negligible	Slight adverse
			Biodiversity	High		Negligible	Slight adverse
		The River Wensum	Water supply and quality	High		Negligible	Slight adverse
			Recreation	High		Negligible	Slight adverse
			Value to economy	Medium		Negligible	Neutral
			Conveyance of flow	High		Negligible	Slight adverse
			Biodiversity	Very High		Negligible	Slight adverse
		River Tud floodplain	Conveyance of flow	High		Negligible	Slight adverse

Operational activity	Potential effects on direct and indirect receptors	Feature	Relevant attributes	Importance (value)	Mitigation	Magnitude of impact after mitigation	Significance of effect after mitigation
Infilling of seven ponds due to the location of the Proposed Scheme	Loss of biodiversity habitat and ecology	Ponds	Biodiversity	High	Provision of one pond to replace each pond lost due to the location of the Proposed Scheme. The replacement pond will be constructed before the existing pond is lost. Refer to Chapter 8 (Biodiversity) (**TR010038/APP/6.1**) for detailed mitigation. Locations shown on Environmental Masterplan (**TR010038/APP/6.8**)	Negligible	Slight adverse
New Newgate house Culvert (Hockering), New West Culvert (Oak Farm) and West Culvert Extension and new River Tud Crossing)	Potential loss of fluvial floodplain and restriction or redirection of the watercourses causing increased localised flooding to the Proposed Scheme. Increased or redirected flood risk to other and risk to flood-sensitive receptors near to overloaded system and downstream.	The River Tud (including Norfolk Rivers IDB section)	Water supply and quality	High	River Tud Crossing must be designed to peak flood level for 1 in 100-year plus 65% climate change allowance plus freeboard. Newgate House Culvert (Hockering) culvert to be designed for a 1 in 100-year fluvial event (including a 65% climate change allowance) with 600mm freeboard. Trash screen required to mitigate impacts of blockages. West Culvert Extension and New West Culvert (Oak Farm) to be extended using a similar	Negligible	Slight adverse
			Recreation	Medium		Negligible	Neutral
			Value to economy	Medium		Negligible	Neutral
			Conveyance of flow	High		Negligible	Slight adverse
			Biodiversity	High		Negligible	Slight adverse
		Unnamed ordinary watercourses (within the Tud WFD water body catchment)	Water supply and quality	Medium		Negligible	Neutral
			Value to economy	Medium		Negligible	Neutral

Operational activity	Potential effects on direct and indirect receptors	Feature	Relevant attributes	Importance (value)	Mitigation	Magnitude of impact after mitigation	Significance of effect after mitigation
			Conveyance of flow	High	culvert dimension to the existing to maintain throttle of flood flows. Trash screen required upstream to mitigation impacts of blockages.	Negligible to moderate beneficial (Hockering and Oak Farm)	Slight adverse to moderate beneficial (Hockering and Oak Farm)
			Biodiversity	High	Floodplain storage loss has been mitigated through compensatory floodplain storage.	Negligible	Slight adverse
		River Tud floodplain	Conveyance of flow	High		Negligible	Slight adverse
Discharge from proposed outfalls	Potential risk of erosion impacting on channel stability, causing structural damage and an increase sediment in downstream reaches. Deterioration of downstream aquatic environments.	The River Tud (including Norfolk Rivers IDB section)	Water supply and quality	High	Surface water runoff will be attenuated to greenfield rates at source using SuDS systems such as vegetated detention basins and wetlands. Proposed outfall design to include erosion protection measures.	Negligible	Slight adverse
			Recreation	Medium		Negligible	Neutral
			Value to economy	Medium		Negligible	Neutral
			Biodiversity	High		Negligible	Slight adverse
		Unnamed ordinary watercourses (within the Tud WFD water body catchment)	Water supply and quality	Medium		Negligible	Neutral
			Value to economy	Medium		Negligible	Neutral
			Biodiversity	High		Negligible	Slight adverse
		The River Wensum	Water supply and quality	High	No direct discharge. Surface water runoff will be attenuated to greenfield rates at source	Negligible	Slight adverse
			Recreation	High		Negligible	Slight adverse

Operational activity	Potential effects on direct and indirect receptors	Feature	Relevant attributes	Importance (value)	Mitigation	Magnitude of impact after mitigation	Significance of effect after mitigation
			Value to economy	Medium	using SuDS systems such as vegetated detention basins and wetlands. Proposed outfall design to include erosion protection measures.	Negligible	Neutral
			Biodiversity	Very High		Negligible	Slight adverse
New Newgate House Culvert (Hockering), New West Culvert (Oak Farm) and West Culvert Extension, and associated minor watercourse diversions due to culverting, River Tud Crossing and proposed outfalls	Change in channel morphology and reduction in hydromorphological complexity. Deterioration or loss of the aquatic environments and deterioration in water quality. Deterioration of downstream aquatic environment of indirect receptors.	The River Tud (including Norfolk Rivers IDB section)	Water supply and quality	High	Newgate House Culvert (Hockering) culvert to be designed with a natural sediment bed, and mammal ledge. Habitat restoration upstream of existing A47 on Oak Farm and Hockering tributary (Environmental Masterplan (**TR010038/APP/6.8**) Monitoring plan must include water quality monitoring (to be agreed with the Environment Agency). Outfalls to avoid impact on channel cross section profile. Riparian planting as indicated on the Environmental Masterplan (**TR010038/APP/6.8**). River Tud Crossing must be placed at least 5 metres away from the top of the river bank and the bridge deck designed to	Negligible	Slight adverse
			Recreation	Medium		Negligible	Neutral
			Value to economy	Medium		Negligible	Neutral
			Biodiversity	High		Negligible	Slight adverse
		Unnamed ordinary watercourses (within the Tud WFD water body catchment)	Water supply and quality	Medium		Negligible	Neutral
			Value to economy	Medium		Negligible	Neutral
			Biodiversity	High		Minor adverse	Slight adverse
		The River Wensum	Water supply and quality	High		Negligible	Slight adverse
			Recreation	High		Negligible	Slight adverse
			Value to economy	Medium		Negligible	Neutral
			Biodiversity	Very High		Negligible	Slight adverse

Operational activity	Potential effects on direct and indirect receptors	Feature	Relevant attributes	Importance (value)	Mitigation	Magnitude of impact after mitigation	Significance of effect after mitigation
					be no more than 30m in width.		
Long term disruption of groundwater flows as a result of below ground structures (piles, etc)	*Groundwater Levels and Flow* <u>Direct receptors</u> Impede groundwater flow and/or cause groundwater mounding if structures are continuous and perpendicular to groundwater flow. Creation of preferential pathways between aquifer units or between artesian groundwater bodies and surface <u>Indirect receptors</u> Reduction of groundwater flow to dependent abstractions, watercourses and habitats	<u>Direct receptors</u> Broadland Rivers Chalk and Crag Secondary superficial aquifer <u>Indirect receptors</u> River Tud and associated Priority Habitats Licensed abstractions Unlicensed abstractions	Water supply/quality	Very High	For the piling at the River Tud overbridge, as no groundwater is being removed from the catchment at this location, there will be no overall reduction in baseflow. Risk assessments will be revised following the full baseline groundwater level monitoring, addendum factual report, and 2021 supplementary ground investigations.	Negligible	Slight adverse
			Soakaway	High		No change	Neutral
			Vulnerability	Very High		No change	Neutral
			Economic Value	Very High		Negligible	Slight adverse
			Conveyance of flow	Very High		Negligible	Slight adverse
			Biodiversity	Very High		Minor	Slight adverse
Long term disruption of groundwater flows as a result of below ground structures	*Groundwater Quality* <u>Direct receptors</u> Downdrag of contaminants from surface or between aquifers Creation of contamination pathways	<u>Direct receptors</u> Broadland Rivers Chalk and Crag Secondary superficial aquifer <u>Indirect receptors</u> Licensed abstractions	Water supply/quality	Very High	A piling risk assessment will be undertaken to inform the design, focusing on embedded mitigation to minimise the risk of impacts to groundwater.	No change	Neutral
			Soakaway	High		No change	Neutral
			Vulnerability	Very High		No change	Neutral
			Economic Value	Very High		No change	Neutral

Operational activity	Potential effects on direct and indirect receptors	Feature	Relevant attributes	Importance (value)	Mitigation	Magnitude of impact after mitigation	Significance of effect after mitigation
	and increased vulnerability of the aquifers Pathway for artesian groundwater to reach surface, causing flooding <u>Indirect receptors</u> Transport of contaminants from aquifer to groundwater dependent abstractions, watercourses and habitats Flooding of habitats from artesian groundwater	Unlicensed abstractions River Tud and associated GWDTEs River Wensum SSSI/SAC	Conveyance of flow	Very High		No change	Neutral
			Biodiversity	Very High		No change	Neutral
Permanent dewatering of cutting slopes	<u>Direct Receptors</u> Permanent alteration of groundwater flow patterns Reduction of groundwater levels Loss of perched superficial aquifers <u>Indirect Receptors</u> Reduction of groundwater flow to dependent abstractions, watercourses and habitats	<u>Direct receptors</u> Secondary superficial aquifer <u>Indirect receptors</u> Unlicensed abstractions River Tud and associated GWDTEs	Water supply/quality	High	Risk assessments will be revised following the full baseline groundwater level monitoring, water features survey, addendum factual report, and 2021 supplementary GI at the detailed design stage. Water returned to the water environment via filter drains incorporated into the drainage system	Negligible	Slight adverse
			Soakaway	High		No change	Neutral
			Vulnerability	Medium		No change	Neutral
			Economic Value	High		Negligible	Slight adverse
			Conveyance of flow	High		No change	Neutral
			Biodiversity	High		No change	Neutral

Operational activity	Potential effects on direct and indirect receptors	Feature	Relevant attributes	Importance (value)	Mitigation	Magnitude of impact after mitigation	Significance of effect after mitigation
Drainage of routine road runoff infiltrating through filter drains	Pollution of groundwater due to routine road runoff Deterioration of downgradient groundwater dependent terrestrial ecosystems and abstraction water quality.	<u>Direct receptors</u> Secondary superficial aquifer <u>Indirect receptors</u> Chalk and SPZ1 Unlicensed abstractions River Tud and associated GWDTEs	Water supply/quality	Very High	Road drainage design to exclude discharges to groundwater in areas of shallow groundwater and SPZ1. Further water quality monitoring to confirm baseline groundwater quality.	No change	Neutral
			Soakaway	High		No change	Neutral
			Vulnerability	Medium		No change	Neutral
			Economic Value	Very High		No change	Neutral
			Conveyance of flow	High		No change	Neutral
			Biodiversity	High		No change	Neutral

Water Framework Directive Assessment

13.10.5. This section outlines the assessment of potential construction and operation related impacts on each of the water bodies' quantity and quality elements. It assessed whether these impacts could lead to non-compliance of the WFD and the ability of the relevant WFD water bodies to meet their current objectives.

WFD background and approach

13.10.6. The key objectives of the WFD, provided for in the area River Basin Management Plan (RBMP) (Environment Agency, 2018b), are as follows:

- To prevent deterioration of the status of surface waters and groundwater.
- To achieve objectives and standards for protected areas.
- To aim to achieve good status for all water bodies or, for heavily modified water bodies and artificial water bodies, good ecological potential and good surface water chemical status.
- To reverse any significant and sustained upward trends in pollutant concentrations in groundwater.
- The cessation of discharges, emissions and losses of priority hazardous substances into surface waters.
- Progressively reduce the pollution of groundwater and prevent or limit the entry of pollutants.

13.10.7. The assessment was carried out with due regard to the Planning Inspectorate Water Framework Directive Guidance (Planning Inspectorate, 2017). The assessment process is as follows:

- identification of water bodies that are potentially affected (directly or indirectly) or could be at risk as a result of the Proposed Development
- the baseline characteristics of the water bodies concerned
- a description of the Proposed Development and the aspects of the development considered within the scope of the WFD assessment
- the methods used to determine and quantify the scale of WFD impacts
- an assessment of the risk of deterioration, as Article 4.7 may apply where is a there is a risk the Proposed Development will prevent the achievement of good status or result in deterioration in status
- an explanation of any mitigation required and how its delivery is secured
- an explanation of any enhancements and/or positive contributions to the RBMP objectives proposed and how their delivery would be secured.

13.10.8. The Environmnent Agency and Norfolk County Council were consulted on issues related to flood risk, Water Framework Directive and geomorphology at meetings in March, June, August and November 2020 where discussions

focused on the requirements for the River Tud Crossing and the culverts and associated minor watercourse diversions at Oak Farm and south of Hockering. Outcomes from these consultations have helped inform the WFD assessment and mitigation. However, consultation is ongoing.

13.10.9. A screening assessment was undertaken to determine WFD water bodies that should be included in this assessment as part of the Scoping Report (September 2019) (**TR010038/APP/6.5**). Following this, a scoping assessment was undertaken for the receptors that are potentially at risk from the Proposed Scheme. This was outlined in the Scoping Report (September, 2019) and has been discussed in detail above. All surface water WFD and chemical quality elements are scoped into the WFD compliance assessment.

Proposed Scheme WFD assessment

13.10.10. Baseline information detailing surface water features, groundwater features and aquatic ecology can be found in in section 13.7.

13.10.11. Tud WFD water body (WBID: GB105034051000), Wensum DS Norwich WFD water body (GB105034055882), Yare (Tiffey to Wensum) WFD water body GB105034051281 and Broadland Rivers Chalk and Crag WFD groundwater body (WBID: GB40501G400300) have been considered in this assessment.

13.10.12. A summary of the WFD surface water and groundwater bodies within the study area, including their targets and objectives was obtained from the current Anglian RBMP, as shown by the Environment Agency's Catchment Data Explorer. This information was based on the 2019 status. The baseline condition of the various WFD elements are provided in section 13.7 and Tables 13-3 and 13-4.

13.10.13. The surface water and groundwater WFD catchments are within the Anglian River Basin District and their locations are identified in Figure 13.2 (WFD and IDB surface waterbodies) (**TR010038/APP/6.2**) and Figure 13.4 (WFD groundwater bodies) (**TR010038/APP/6.2**).

13.10.14. Geomorphological site walkovers were carried out in March 2018 and May 2020. The walkover surveys were undertaken to ground truth evidence of geomorphic change and/or instability that may be impacted by the Proposed Scheme, and to identify the dominant geomorphic processes occurring on each river reach to ensure baseline conditions are adhered to, or improved upon, as far as possible.

Effects of works

13.10.15. The assessment of the compliance of the Proposed Scheme with the WFD has been split into two sections: assessment of the effects and required mitigation

during construction (temporary works) and during operation on the WFD water bodies. These impacts have been in identified in section 13.8 and mitigation measures considered within the design of the Proposed Scheme have been discussed in section 13.9.

13.10.16. Locations of proposed habitat restoration can be seen in the Environmental Masterplan (**TR010038/APP/6.8**).

13.10.17. The assessment of impacts can be seen in Tables 13-8 and 13-9 for construction and operation, respectively. These tables indicate that there will not be any significant impacts caused to the water environment from the Proposed Scheme when the mitigation mentioned in section 13.9 is in place. Due to this, this WFD assessment concludes that the construction and operational activities affecting the Tud and indirectly the Wensum (DS Norwich) and Yare (Tiffey to Wensum) will be compliant with the requirements of the WFD. This assumes the mitigation is implemented and limits the overall effect of the Proposed Scheme to slight adverse and is localised. Due to this, construction and operational activities affecting the Tud and indirectly the Wensum (DS Norwich) and Yare (Tiffey to Wensum) are not considered to cause deterioration and should not prevent future attainment of WFD water body targets.

13.10.18. Table 13-10 provides a summary of the WFD assessment during the construction and operation of the Proposed Scheme.

Table 13.10 Summary of WFD water body assessment

Water body name ID	WFD aspect		Impacts on status or ability to meet target	Reference
Tud (GB105034051000)	Ecological	Supporting elements (surface water)	Slight short term construction impact due to spillage or works close to the water features, however, pollution prevention measures in the EMP and large degree of dilution in the river suggests this would not cause deterioration. Slight short term construction and long-term operational impact due to construction of outfalls. culverts and river crossing. No other construction related impact due to mitigation outlined in EMP. Slight operational impact.	See Table 13.8 and 13.9
		Biological		
		Hydromorphological supporting elements		
		Physico-chemical quality		
		Specific pollutants (including copper and zinc)		

Water body name ID	WFD aspect		Impacts on status or ability to meet target	Reference
	Chemical	Priority substances	No construction related impact due to mitigation outlined in EMP. No operational impact.	See Table 13.8 and 13.9
		Other pollutants		
		Priority hazard substances		
Wensum DS Norwich (GB105034055882)	Ecological	Supporting elements (surface water)	Not a direct receptor. No construction related impact due to mitigation outlined in EMP. No operational impact.	See Table 13.8 and 13.9
		Biological		
		Hydromorphological supporting elements		
		Physico-chemical quality		
		Specific pollutants (including copper and zinc)		
	Chemical	Priority substances	Not a direct receptor. No construction related impact due to mitigation outlined in EMP. No operational impact.	See Table 13.8 and 13.9
		Other pollutants		
		Priority hazard substances		
Yare (Tiffey to Wensum) (GB105034051281)	Ecological	Supporting elements (surface water)	Not a direct receptor. No construction related impact due to mitigation outlined in EMP. No operational impact.	See Table 13.8 and 13.9
		Biological		
		Hydromorphological supporting elements		
		Physico-chemical quality		
		Specific pollutants (including copper and zinc)		
	Chemical	Priority substances	Not a direct receptor. No construction related impact due to mitigation outlined in EMP. No operational impact.	See Table 13.8 and 13.9
		Other pollutants		
		Priority hazard substances		
Broadland Rivers Chalk and Crag (GB40501G400300)	Chemical	Chemical drinking water protected area	No construction related impact due to mitigation outlined in EMP and construction method statements and risk assessments.	See Table 13.8 and 13.9
		General chemical test		
		Chemical GWDTEs test		

Water body name ID	WFD aspect		Impacts on status or ability to meet target	Reference
		Chemical dependent surface water body status	No operational impact.	
		Chemical saline intrusion		
	Quantitative	Quantitative saline intrusion	No construction or operational related impact due to mitigation outlined in EMP and construction method statements and risk assessments.	See Table 13.8 and13.9
		Quantitative water balance		
		Quantitative GWDTEs test		
		Quantitative dependent surface water body status		

13.11. Monitoring

13.11.1. Inspections and audits along with general monitoring and reporting of effectiveness of control measures to be carried out throughout the construction programme would be incorporated into the EMP (**TR010038/APP/7.4**). The mitigation strategies implemented will be reviewed regularly to best suit the practices being undertaken on site.

13.11.2. There are proposed works directly over and in close proximity to the River Tud, a number of ordinary watercourses, and within Principal and Secondary aquifers. These receptors are at risk of potential adverse impacts due to construction activities. Monitoring of the River Tud, Oak Farm and Hockering ordinary watercourses and aquifers at risk from pollution and changes to groundwater levels and flow must be carried out prior to and during the construction phase. This includes visual assessments for oil and silt, groundwater level and quality monitoring, as well as watercourse monitoring using portable field indicator equipment. Whilst construction is in progress, selected watercourses must be monitored at locations up and downstream of the works, including the installation of continuous turbidity or total suspended solids monitor probes. Monitoring requirements shall be discussed and agreed with the Environment Agency prior to construction and these requirements shall be outlined in the Water monitoring and management plan in the EMP (**TR010038/APP/7.4**).

13.11.3. Any works within a groundwater SPZ 1 or 2 are likely to be subject to further monitoring and additional approval from Anglian Water Services. Monitoring requirements are to be reassessed once details of the SPZ for the new public water supply at East Tuddenham are made available.

13.12. Summary

13.12.1. The Proposed Scheme is not expected to give rise to significant adverse (moderate or greater) residual effects during the construction or operational phases with the adoption of mitigation discussed in section 13.9.

13.12.2. The outcome of this assessment is based on the mitigation measures described in this chapter which shall be secured through measures embedded in the design and the implementation of the EMP, especially its Table 3.1 Record of Environmental Actions and Commitments (**TR010038/APP/7.4**).

13.13. References

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