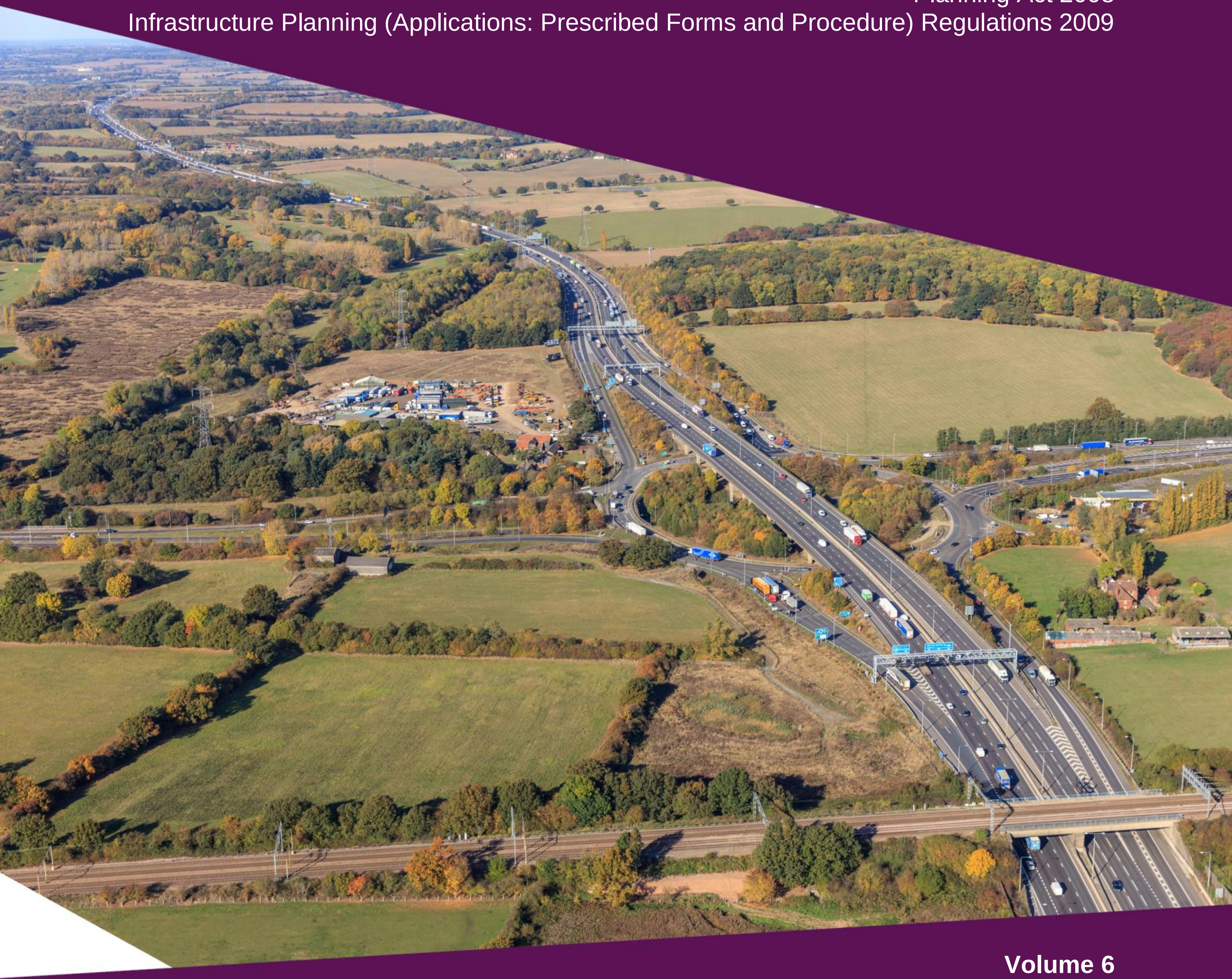
M25 junction 28 improvement scheme
TR010029
6.7 Water framework directive compliance assessment report

APFP Regulations 5(2)(a) and 5(2)(l)(iii)
Planning Act 2008
Infrastructure Planning (Applications: Prescribed Forms and Procedure) Regulations 2009



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Infrastructure Planning

Planning Act 2008

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

M25 junction 28 scheme
Development Consent Order 202[x]

6.7 WATER FRAMEWORK DIRECTIVE COMPLIANCE ASSESSMENT REPORT

Regulation Number:	Regulation 5(2)(a) and 5(2)(l)(iii)
Planning Inspectorate Scheme Reference:	TR010029
Application Document Reference:	TR010029/APP/6.7
Author:	M25 junction 28 improvement scheme project team, Highways England

Version	**Date**	**Status of Version**
1	May 2020	Application issue

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1. Introduction

1.1.1 Highways England (the "Applicant") is proposing a Scheme to improve traffic flow through the M25 junction 28 (the "Scheme") and to make the junction safer for drivers. These proposed works include modifications to the water environment.

1.1.2 This report is a Water Framework Directive (WFD) compliance assessment for a preliminary design of the Scheme and has been prepared in support of an application for a Development Consent Order (application document TR010029/APP/3.1). The WFD is a European directive that imposes legal requirements to protect and improve the water environment. A compliance assessment is undertaken to determine whether works that potentially affect the water environment meet the requirements of the directive.

1.1.3 The purpose of undertaking this WFD compliance assessment is to establish the nature and anticipated magnitude of the effects of Scheme components on the WFD quality elements of the water bodies affected by the Scheme.

1.1.4 At the time of writing this assessment reflects the design at the point of submission of the DCO application for the Scheme. An updated WFD assessment will need to accompany subsequent stages of design.

2. Scheme background

2.1 Process governing the Scheme

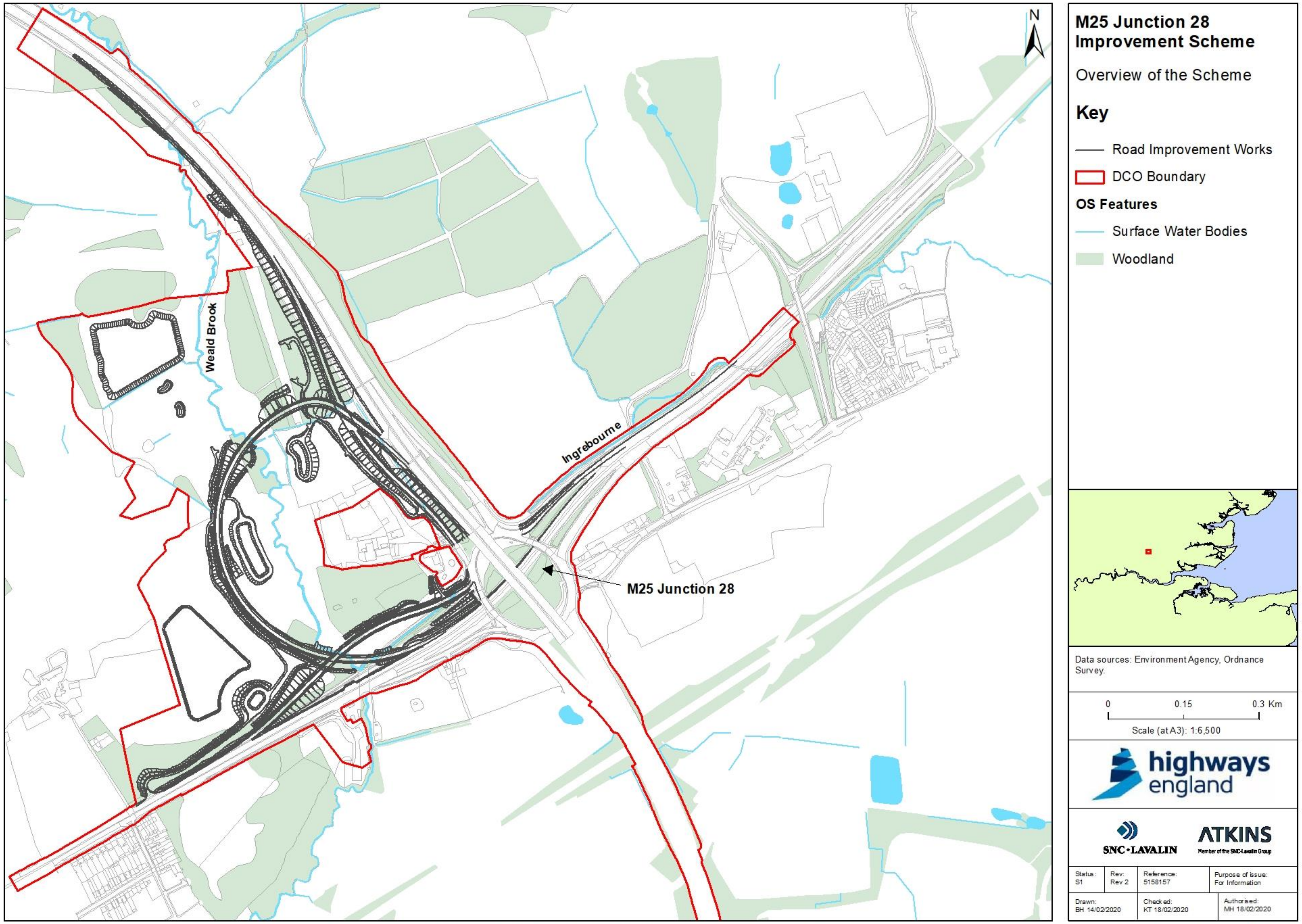
2.1.1 In December 2014, the Department for Transport (DfT) published its Road Investment Strategy (RIS) for the investment period 2015 and 2020, announcing £15 billion to invest in England's strategic road network. The RIS sets out a list of schemes that are to be delivered by Highways England over this investment period and identified M25 junction 28 as a key junction requiring improvement to address congestion and safety issues. In their second RIS (RIS2) for 2020 to 2025, published in March 2020, the DfT reiterate their support for improvements to M25 junction 28. The Scheme is described in RIS2 as an "*upgrade of the junction between the M25 and A12 in Essex, providing a free-flowing link from the northbound M25 to the eastbound A12"*.

2.1.2 Highways England is the strategic highway authority charged with modernising, maintaining and operating England's strategic road network. It is the 'overseeing organisation', responsible for delivering improvements to junction 28. This Scheme is being managed under the Project Control Framework (PCF), a phased approach to developing and delivering major road projects (Highways Agency, 2013). The Scheme is currently in Stage 3 of the PCF lifecycle, during which various aspects of the Scheme (including environmental assessment) are developed sufficiently to complete the preliminary design.

2.2 Scheme location

2.2.1 Junction 28 lies in the northeast quadrant of the M25 London Orbital Motorway in Essex. To the west of the junction is the London Borough of Havering, with the Borough of Brentwood immediately to the east. The junction provides the intersection between the M25, the key trunk route of the A12 (providing access to London, Chelmsford and Ipswich) and the A1023. An overview of the general configuration of the Scheme is set out in Figure 2.1.

Figure 2.1: Overview of Scheme



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2.3 Key features and objectives of the Scheme

2.3.1 An explanation of the Scheme objectives and a detailed description of the Scheme proposals can be found in the Scheme chapter (Chapter 2) of the Environmental Statement (ES) (application document TR010029/APP/6.1).

2.3.2 The Scheme comprises the following key works elements. These should be read in conjunction with Works plans (application documents TR010029/APP/2.3) and Schedule 1 of the Development Consent Order (application documents TR010029/APP/3.1):

- Highways works:
  - The creation of a new two lane loop road with hard shoulder, for traffic travelling from the M25 northbound carriageway onto the A12 eastbound carriageway, including the provision of three new bridges (Alder Wood bridge, Duck Wood bridge and Grove bridge) and an underpass (Grove Farm underpass) to carry the new loop road over existing infrastructure (Work No. 6).
  - Realignment of the existing A12 eastbound exit (off-slip) road (Work No. 2) to accommodate the new loop road including the provision of a new bridge (Maylands bridge) and the extension of the existing Grove culvert.
  - Improvements to the existing A12 eastbound and westbound carriageways and A12 eastbound entry (on-slip) road (Work Nos. 1, 3 and 4).
  - Realignment of the existing M25 northbound on-slip (Work No. 8).
  - Improvements to the existing Junction 28 roundabout, the existing M25 northbound carriageway and the M25 northbound off-slip (Work Nos. 5, 7 and 12).
  - New gantries over the M25 carriageway (Work Nos. 9, 10 and 11).
  - Alterations of existing private access and egresses and the provision of new private means of access to accommodate the new loop road (Work Nos. 13, 14, 15 and 16).
- Earthworks and drainage works:
  - Earthworks including the deposit of surplus construction materials on two identified sites (Work Nos. 17 and 18).
  - Three new attenuation ponds and associated drainage and access roads (Works Nos. 19A, 19B, 20A, 20B, 21A and 21B) and a new drainage outfall pipe (Work No. 22).
- Realignment of watercourses:
  - Realignment of the Weald Brook and the Ingrebourne River (Work Nos. 23A, 23B, 23C and 23D).
- Environmental mitigation:
  - Two new flood compensation areas (Work Nos. 24A and 24B) and the provision of new ecological compensation and mitigation areas (Work Nos. 25 and 26) and two new environmental ponds (Work Nos. 27 and 28).
- Utilities:

  - Diversion of an already underground high pressure gas pipeline and diversion underground of an existing overhead electric line (Work Nos. 29 and 30).
- Accommodation works:
  - Accommodation works to provide replacement facilities for Maylands Golf Course (Work No. 32).

2.4 The Scheme and the water environment

2.4.1 The Scheme is located substantially within the floodplain of the Ingrebourne River and Weald Brook, and at the confluence between the two watercourses.

2.4.2 There are no European designated areas affected by the Scheme.

2.4.3 Evolution of the Scheme design has recognised the importance of its environmental setting.

2.4.4 Developing a design that balances functionality with positive environmental outcomes is a key objective of the Scheme. This is achieved by incorporating mitigation measures presented in section 1.

2.5 Scheme alternatives

2.5.1 During development of the Scheme a wide range of alternative solutions for resolving the traffic problems at junction 28 have been identified, developed and assessed. This process is set out in the Assessment of alternatives chapter (Chapter 3) of the ES (application document TR010029/APP/6.1).

2.5.2 A range of strategic options were initially considered (for instance options to change or reduce demand for the junction or enhance public transport). The strategic option focussing on localised highway improvements was preferred because it was seen to be most strongly aligned to addressing the local problem identified, and could be delivered within the RIS programme.

2.5.3 Options 5B, 5C and 5F (three variants of a cloverleaf junction) were the preferred options from the long list of highway improvement options because they were seen to perform best in the traffic, environmental and economic assessments. The three options had similar implications for the overall environment due to similar footprints. Option 5F was taken forward because it offered the best balance on transport performance, environment, economics and social factors, had the highest weighted Value Management Score. It was also noted to be the preferred option within feedback provided following public consultation.

3. WFD background and approach to the junction 28 compliance assessment

3.1 WFD background

3.1.1 The WFD (Council Directive 2000/60/EC) aims to protect and enhance the quality of the water environment across all European Union member states. The WFD requires member states to classify the current condition or 'status or potential' of surface water and groundwater bodies and set a series of objectives for maintaining or improving condition. The WFD is implemented through a process of river basin management planning, as set out in River Basin Management Plans (RBMPs) that are updated once every six years.

3.1.2 The WFD requires all-natural surface water bodies to achieve both Good Chemical Status (GCS) and Good Ecological Status (GES). Artificial and Heavily Modified Water Bodies (A/HMWBs) may be prevented from reaching GES due to the modifications necessary to maintain their 'use', e.g. navigation. They are, however, required to achieve Good Ecological Potential (GEP), through the implementation of a series of mitigation measures.

3.1.3 The WFD also requires Good status (both qualitative and quantitative) to be achieved for all groundwater bodies, the prevention of the deterioration in groundwater status and the reversal of significant and sustained upward trends in pollutant concentrations in groundwater.

3.1.4 In addition, the WFD requires compliance with objectives and standards for protected areas specifically listed in the River Basin Management Plan (RBMP) for the protection of surface water and groundwater or for the conservation of habitats and species directly dependent on water.

3.1.5 Status is reported at 'water body' scale, with individual water bodies forming part of larger River Basin Districts (RBD), for which RBMPs have been developed. The process of river basin management planning includes the preparation of programmes of measures for achieving the environmental objectives of the WFD and these act as the main reporting mechanism to the European Commission and the public.

3.1.6 Each RBMP documents the analysis, monitoring, objective-setting and consideration of measures required to maintain or improve status at a water body scale for both surface water and groundwater bodies. The first RBMPs were published in 2009 followed by a Cycle 2 update published in 2015.

3.2 WFD compliance assessments

3.2.1 A WFD compliance assessment is required for new developments and schemes to demonstrate that proposals will not result in a deterioration in status (or potential) of any water body (defined in this report as Test A) or prevent the water body from meeting Good status (or potential) in the future (2021 or 2027) (defined in this report as Test B).

3.2.2 If Tests A and B above cannot be satisfied, Article 4.7 of the Directive sets out specific situations and conditions whereby derogations are permitted.

3.2.3 The compliance assessment presented in this document accompanies a preliminary design prepared at stage 3 of the Highways England PCF Process

(Highways England, 2013). The assessment is made based on this preliminary design (as set out in the Scheme layout plans application document TR010029/APP/2.7), assuming:

- The mitigation already 'embedded' in this preliminary design (as presented in the Scheme layout plans (application document TR010029/APP/2.7) and summarised in section 5.2 below) is implemented.
- Additional specific mitigation (as set out in section 5.3) is implemented.
- Generic guidance on the principles of WFD compliant design (as summarised in section 5.4) is adhered to in subsequent detailed design of those Scheme components anticipated to affect the water environment.

3.3 WFD compliance assessment method for the Scheme

Introduction

3.3.1 The Planning Inspectorate Advice Note 18 (The Planning Inspectorate, 2017) recommends that applicants seek the views of appropriate agencies early in the application process to agree: a) the need for a WFD assessment; and b) the method, scope and screening criteria to be employed when undertaking that assessment. Further consultation is recommended as the potential impact of the development is better understood to develop mitigation that achieves compliance, and, if needed, to agree matters relating to Article 4.7 derogation.

3.3.2 Highways England and its representatives have consulted with the Environment Agency (EA) on matters relating to the WFD through the options appraisal stage (PCF2) for this Scheme, and during the preliminary design stage (PCF3). This consultation included teleconference meetings with the EA on 13 March 2017, 12 August 2019, 24 September 2019 and 22 October 2019 as well as face to face meetings on 30 October 2017, 6 November 2018 and 16 April 2019. A site meeting was also carried out with the EA on 23 May 2019. The EA have also commented on the September 2017, August 2019 and January 2020 draft WFD assessments for the Scheme, issued to them in March, 2019, August 2019 and January 2020 (Environment Agency, 2019a, 2019b and 2020). Outcomes from these consultations have informed the WFD compliance assessment.

WFD compliance assessment method

3.3.3 Very early in the application process representatives of Highways England discussed methods of WFD compliance assessment with members of the EA's national Geomorphology Team (who have particular responsibility for WFD compliance assessment). The focus of discussion was large Highways England RIS schemes in southeast England that were expected to affect multiple water bodies. The EA suggested that the WFD compliance assessment carried out for HS2 (HS2, 2016) presented a useful template of best practice. Its thorough matrix-based approach allows analysis and record of the effect of each scheme component on all WFD quality elements. It captures the core outcomes of a compliance assessment whilst being transparent and simple to interpret. Assessments can be readily updated, creating a clear audit trail of WFD compliance as a scheme progresses through its lifecycle from options assessment to design, environmental permitting and implementation. This approach was used as a template for the WFD compliance assessment carried out for the Scheme and reported here (see below and Appendix B).

3.3.4 A precautionary risk-based approach, based on HS2 (2016), was undertaken for the assessment. The Scheme was assessed for its effect on achieving the two key environmental objectives set out in paragraph 3.2.1 (Tests A and B), conservatively accounting for uncertainty of potential impacts (often determined by the level of information available at preliminary design stage).

3.3.5 The matrix approach used allows the effect of individual scheme components on individual WFD quality elements to be assessed and recorded. The matrix also allows aggregated effects to be recorded; i.e. the effects of multiple scheme components in a single water body, aggregated as the overall effect of the Scheme on water body status (in accordance with the "one out, all out" philosophy of the WFD[1]).

3.3.6 A "Red, Amber, Green" (RAG) coding system was used in a precautionary risk-based approach. Definitions for the colour coding were assigned to indicate the level of risk of objective non-compliance within each water body, accounting for a) mitigation already "embedded" into the preliminary design (as summarised in section 5.2) and b) additional mitigation to be integrated into later phases of the design (as set out in sections 5.3 and 5.4). The definitions were as follows:

- **Dark blue**: beneficial effect of a scale sufficient to increase status class for the water body (certain)
- **Light blue**: beneficial effect resulting in a localised improvement, but insufficient to increase status class at water body scale (certain)
- **Green**: no measurable change to (or effect on) water body (certain)
- **Yellow**: minor localised adverse and/or temporary effect when balanced against mitigation – insufficient to affect an element at a water body scale (certain)
- **Amber**: an adverse effect is possible when balanced against mitigation – the extent of effect is uncertain, and there remains a potential to affect water body status
- **Red**: adverse effect of sufficient scale to impact on a quality element at a water body scale (certain)

3.4 Screening criteria and scope for the Scheme WFD compliance assessment

Screening

3.4.1 A precautionary approach has been taken to screening Scheme components for inclusion into the assessment, as follows:

- **Surface water** – As an initial step, all Scheme components intersecting with surface water features presented on OS VectorMap® District (Ordnance Survey, 2017) were identified. From this intersect dataset we selected WFD assessed water bodies and their natural tributaries (the Ingrebourne River and Weald Brook) to screen into the WFD compliance assessment[2]. This is a

[1] Under the 'one out, all out' principle, status is determined by the quality element with the worst status. As an example, the worst status biological or supporting quality element will determine the ecological status of a water body.
[2] The remaining minor drainage ditches (as local scale features) were passed to the Biodiversity chapter (Chapter 7) of the ES (document reference TR010029/APP/6.1) for assessment. Hence, between the WFD Compliance Assessment and the ES, the effect of all Scheme components intersecting with surface water features presented on OS VectorMap® are considered.

precautionary screen because only minor drainage ditches are excluded from the assessment.

- **Groundwater** – since there are no WFD groundwater bodies underlying the Scheme, the effect of Scheme components on this water body type has been screened out of the assessment.
- **Lake** – since there are no WFD lake water bodies within or near the Scheme boundary, the effect of Scheme components on this water body type has been screened out of the assessment.

3.4.2 Screening out of ground and lake water bodies from the WFD compliance assessment has been agreed with the EA (Environment Agency, 2019a).

Scoping

3.4.3 A precautionary approach to scoping has also been undertaken for the receptors (primarily WFD quality elements) that are potentially at risk from the Scheme. It is precautionary because we only scope out WFD quality elements (e.g. groundwater) and protected areas we are certain are not affected by the scheme, see bullets below:

- **Surface quality elements** - all surface water WFD biological, physico-chemical and hydromorphological quality elements are scoped in to the WFD compliance assessment. They are assessed for each of the surface water bodies in the second cycle of the Thames RBMP (Environment Agency, 2018).
- **Specific pollutants, priority substances and priority hazardous substances WFD quality elements** - are scoped in to this WFD compliance assessment. There are two potential sources of pollution associated with the Scheme that could affect these quality elements:
  - **Road runoff -** the WFD compliance assessment relies on output from the Highways England (formerly Highways Agency) Water Resource Assessment Tool (HAWRAT, Highways Agency, 2009) to assess impacts of these WFD quality elements in road runoff on the water environment of receiving water bodies. Collaborative research between the EA and Highways England agreed on a group of 'significant pollutants' routinely found in road runoff to form the basis of the HAWRAT assessment (see Table 3.1 and paragraph 5.9 of Highways Agency, 2009).
  - **Leachate from landfill** - the Scheme, in particular Balancing Pond No 1[3], will disturb a historic landfill called Brook Street Landfill Site, located immediately to the northwest of Grove Farm. There is a potential risk of contaminants from this landfill leaching to WFD surface water bodies. Further information can be found under 'Baseline conditions' in the Geology and Soils chapter (Chapter 10) of the ES (application document TR010029/APP/6.1).
- **Groundwater quality elements -** as there are no WFD groundwater bodies beneath the Scheme, groundwater quality elements are scoped out of the assessment.

[3] Balancing pond 1 is referred to as Scheme component ING4 and WB6, see map in Appendix A.

- **WFD protected areas** – as there are no European designated areas affected by the scheme (Highways England, 2017), protected areas are scoped out of the assessment.

4. Scheme WFD compliance assessment

4.1 Introduction

4.1.1 This section, together with assessment matrices in Appendix B, sets out the WFD compliance assessment for the Scheme.

4.2 Information sources for WFD compliance assessment

General data sources

4.2.1 Information on the status and objectives of water bodies potentially impacted by the Scheme (Figure 2.1) was taken from the EA Catchment Data Explorer (Environment Agency, 2018). The Thames RBMP (Environment Agency, 2015), together with information provided by the EA, were referenced for details on programmes of measures.

Biological and supporting elements

4.2.2 Assessment of the impact of Scheme components on biological and supporting quality elements was undertaken based on information gathered by:

- Surveys undertaken on the potentially impacted water bodies:
  - River corridor survey carried out on the Ingrebourne River and Weald Brook by ecologists on 2 October 2017 and reported in Appendix C. Note that macrophytes were observed and recorded in this survey.
  - Ecological and geomorphological walkover surveys carried on the Ingrebourne River and Weald Brook on 15 February 2019 and 23rd May 2019 - reported in Appendix D.
  - Electric fishing and aquatic macroinvertebrate surveys undertaken in September 2017. Full details can be found in the Biodiversity chapter (Chapter 7) of the ES (application document TR010029/APP/6.1).
- Consultation meetings / telephone conferences with the EA as set out in paragraph 3.2.3, in particular a site visit with the EA on 23 May 2019.
- Desk study using high resolution aerial photographs, topographic survey and environmental spatial data sets (e.g. Ordnance Survey river networks, environmental designations).

Specific pollutants and chemical elements

<u>Road runoff</u>

4.2.3 The impact of WFD specific pollutants, priority substances and priority hazardous substances, generated by road surfaces, on surface waters have been assessed using the Highways Agency's Water Risk Assessment Tool (HAWRAT). This tool has been specifically developed to determine: a) whether road runoff generates an environmental risk and b) if measures are needed to mitigate that risk.

4.2.4 The toxicity thresholds used in HAWRAT were developed through a national collaborative research programme between Highways England and the EA to prevent adverse ecological effects in the receiving water bodies. The thresholds are consistent with those adopted for the derivation of Environmental Quality

Standards (EQSs) under the WFD. Additional Runoff Specific Thresholds (RSTs) are also used in the assessment to investigate the potential for short term peaks in pollutants to impact aquatic ecology. Copper and zinc standards are the key indicators used to assess the range of likely pollutants within the runoff.

4.2.5 This WFD compliance assessment uses the results from HAWRAT to assess potential for the Scheme to comply with substances from the range of specific pollutants, hazardous substances and priority hazardous substances set under the WFD – copper and zinc are both specific pollutants. A full description of the water quality assessment is included in section 8.6 of the Road Drainage and Water Environment chapter (Chapter 8) of the ES (application document TR010029/APP/6.1). The assessment has been based on the preliminary drainage design for the Scheme which can be seen on the Scheme layout plans (application document TR010029/APP/2.7).

Brook Street landfill site

4.2.6 Construction of Balancing Pond No 1 will disturb Brook Street landfill site. There is a risk of contaminants from this landfill leaching to the Weald Brook and Ingrebourne River. The results of the preliminary ground investigation, reported under the 'Baseline conditions' section of the Geology and Soils chapter (Chapter 10) of the ES (application document TR010029/APP/6.1), are used to make an initial assessment of the likelihood of contamination to surface water bodies from this source. This WFD compliance assessment will be revisited upon receipt of, and in the light of the results of, future ground investigations. Until further investigations are complete a precautionary approach has been taken in assessing the risk of surface water body contamination from this source by assuming a minor localised adverse effect.

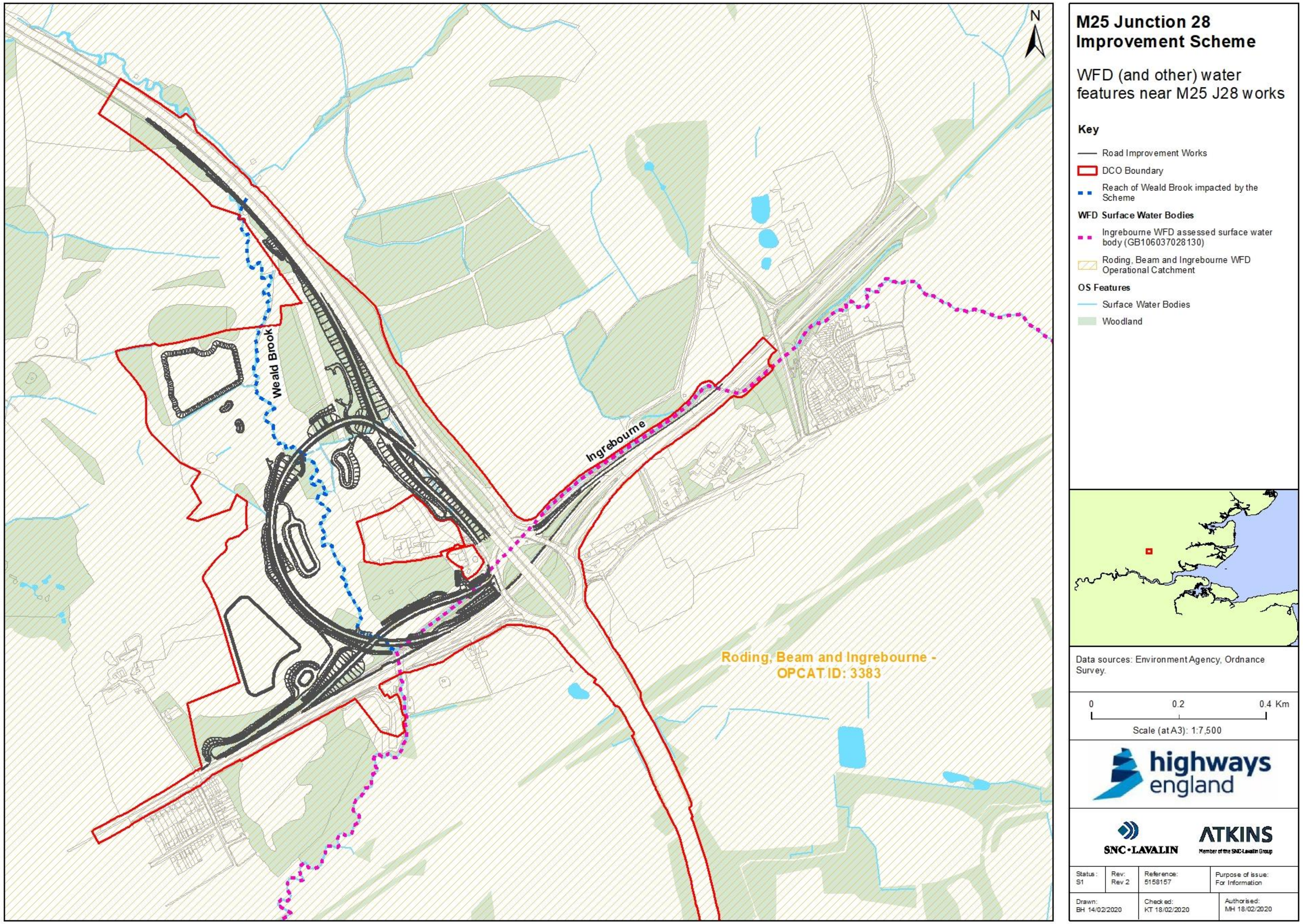
Groundwater quality elements

4.2.7 No further information was collected on groundwater quality elements after they had been scoped out of the assessment (see section 3.4).

Protected areas

4.2.8 No further information was collected on protected areas after they had been scoped out of the assessment (see section 3.4).

Figure 4.1: WFD water bodies (and other surface water features) affected by the Scheme



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4.3 WFD water bodies potentially affected by junction 28

4.3.1 The location of the water bodies (and other surface water features) potentially affected by the Scheme are shown in Figure 2.1 and described below.

River water bodies

4.3.2 The Scheme lies in the Thames WFD River Basin District (RBD 6) within the Roding, Beam and Ingrebourne WFD Operational Catchment (OPCAT ID 3383) and Management Catchment (MCAT ID 3071).

4.3.3 The Scheme affects a reach of the Ingrebourne River WFD assessed surface water body (GB106037028130).

4.3.4 Scheme components have been screened in to the assessment that affect surface water features beyond the Ingrebourne WFD assessed water body. These other surface water features are:

- A reach of a tributary to the Ingrebourne River (the Weald Brook).
- Drainage ditches within the Scheme Development Consent Order (DCO) boundaries.

Lakes water bodies

4.3.5 WFD lake water bodies are scoped out of the assessment (see section 3.4).

Groundwater bodies

4.3.6 WFD groundwater bodies are scoped out of the assessment (see section 3.4).

Protected areas

4.3.7 Protected areas are scoped out of the assessment (see section 3.4).

4.4 Baseline WFD status (and objectives)

Introduction

4.4.1 The only assessed WFD water body affected by the Scheme is the Ingrebourne River. Its baseline WFD status and objectives are set out below.

Ingrebourne River

4.4.2 The Ingrebourne River (GB106037028130), a river water body, is not designated as artificial or heavily modified. Table 4.1 shows the status of the water body in cycle 2 (2016) and the objectives that have been set by the EA for the water body to work towards.

4.4.3 The ecological status of the Ingrebourne River for 2016 (cycle 2) is moderate. This is driven by a moderate status for: a) invertebrates b) macrophytes and phytobenthos combined and c) physico-chemical quality elements. However, note that supporting physico-chemical quality elements was allocated a moderate status due to phosphate being assigned poor status [4].

[4] The assessment process allows the status of supporting elements to draw ecological status no lower than moderate, therefore, even if a physico-chemical quality element such as phosphate is assigned poor status, the lowest the overall physico-chemical quality element status can be is moderate.

4.4.4 The 2016 (cycle 2) status for chemical elements of the water body is good. This is driven by priority substances and priority hazardous substances. The EA determine that other pollutants do not require assessment.

4.4.5 The objective set by the EA for this water body is moderate, which was achieved by 2015. It is considered technically infeasible for the water body to achieve Good status primarily because of heavy phosphorous loading from the continuous discharge of sewage treatment works in the catchment. Other reasons for the water body not achieving good status are:

- Intermittent point source sewage discharges
- Urbanisation, impoundments, flood protection structures and ecological barriers due to physical modification
- Urban diffuse pollution
- Point source urban misconnections
- Poor nutrient management due to agricultural and rural land diffuse pollution sources

4.4.6 Although the current (2016, cycle 2) objective set by the EA for this water body is moderate, these objectives are re-assessed on each cycle of the Thames RBMP and it may be that this moderate objective is reviewed and replaced with a good objective during the next RBMP cycle. Therefore, it is still important to implement measures in the water body that will work towards improving the status of all elements to good.

Table 4.1: Ingrebourne River WFD water body classification

Water body name	Ingrebourne River	
Water body ID	GB106037028130	
National Grid Reference	TQ5591487843	
River Basin District	Thames (6)	
Management Catchment	Roding, Beam and Ingrebourne (3071)	
Operational Catchment	Roding, Beam and Ingrebourne (3383)	
Artificial or HMWB	Not designated artificial or heavily modified	
Classification	**2016 Cycle 2**	**Objectives**
Overall water body	Moderate	Moderate by 2015
Ecological	Moderate	Moderate by 2015
Biological quality elements	Moderate	Moderate by 2015
Fish	Good	Good by 2015
Invertebrates	Moderate	Moderate by 2015
Macrophytes and Phytobenthos combined	Moderate	Moderate by 2015
Hydromorphological supporting elements	Supports Good	Supports Good by 2015

Water body name	Ingrebourne River	
Water body ID	GB106037028130	
National Grid Reference	TQ5591487843	
River Basin District	Thames (6)	
Management Catchment	Roding, Beam and Ingrebourne (3071)	
Operational Catchment	Roding, Beam and Ingrebourne (3383)	
Artificial or HMWB	Not designated artificial or heavily modified	
Classification	**2016 Cycle 2**	**Objectives**
Hydrological regime	Supports Good	Supports Good by 2015
Morphology	Supports Good	Not Stated
Physico-chemical quality elements	Moderate	Moderate by 2015
Ammonia (Phys-Chem)	Good	Good by 2015
Biochemical dissolved Oxygen (BOD)	Good	Not Stated
Dissolved Oxygen	Good	Good by 2015
pH	High	Good by 2015
Phosphate	Poor	Bad by 2015
Temperature	High	Good by 2015
Specific pollutants	High	High by 2015
Copper	High	High by 2015
Iron	High	Not Stated
Manganese	High	Not Stated
Triclosan	High	High by 2015
Zinc	High	High by 2015
Chemical	Good	Good by 2015
Priority substances	Good	Good by 2015
Lead and its compounds	Good	Good by 2015
Nickel and its compounds	Good	Good by 2015
Other Pollutants	Does not require assessment	Does not require assessment
Priority Hazardous Substances	Good	Good by 2015
Brominated diphenylether (BDPE) Calc	Not Stated	Good by 2015
Benzo (b) and (k) fluoranthene	Good	Good by 2015
Benzo(a)pyrene	Good	Good by 2015

Water body name	Ingrebourne River	
Water body ID	GB106037028130	
National Grid Reference	TQ5591487843	
River Basin District	Thames (6)	
Management Catchment	Roding, Beam and Ingrebourne (3071)	
Operational Catchment	Roding, Beam and Ingrebourne (3383)	
Artificial or HMWB	Not designated artificial or heavily modified	
Classification	**2016 Cycle 2**	**Objectives**
Cadmium and its compounds	Good	Good by 2015
Di(2-ethylhexyl)phthalate (Priority hazardous)	Good	Good by 2015
Mercury and its compounds	Good	Good by 2015
Nonylphenol	Good	Good by 2015

4.5 Site and desk investigations to determine baseline condition

Introduction

4.5.1 This section summarises the baseline condition of water features affected by the Scheme using information gathered by site and desk investigations as described in paragraph 4.2.2.

4.5.2 Key data sources for this baseline assessment are a River Corridor Survey (see report in Appendix C) and a combined geomorphological and ecological survey (see report in Appendix D). These were carried out specifically to gain an understanding of the baseline ecological and hydromorphological characteristics of watercourses and to ascertain their potential response to the Scheme. During the surveys, details were recorded on the general morphological functioning, ecology and aquatic habitats of the existing water environment. Bed and bank characteristics (materials, forms and features) were recorded, including typical channel dimensions, marginal and aquatic vegetation. Notes were also taken on habitat potential and flow types. All surveys were undertaken by experienced geomorphologists and ecologists.

Summary baseline assessment

4.5.3 Information gathered from site and desk investigations were used to break the sections of the Ingrebourne River and Weald Brook affected by the Scheme into a series of geomorphologically homogeneous reaches. A conservation score based on the criteria set out in Table 4.2 was used to summarise the baseline condition of each reach, as shown as part of further analysis undertaken, the results of which are set out under the heading ‘Net effect of Scheme on riverine biodiversity’ in section 4.5.4. Conservation Status is a commonly used metric in catchment scale geomorphological assessment (Sear et al., 2010).

Table 4.2: Reach conservation status

Susceptibility to disturbance	Score	Definition
High	8-10	Conforms most closely to natural, unaltered state and will often exhibit signs of free meandering and possess well-developed bedforms (point bars and pool-riffle sequences) and abundant bank side vegetation
Moderate	5-7	Shows signs of previous alteration but still retains many natural features, or may be recovering towards conditions indicative of the higher category
Low	2-4	Substantially modified by previous engineering works and likely to possess an artificial cross-section (e.g. trapezoidal) and will probably be deficient in bedforms and bankside vegetation.
Channelised	1	Awarded to reaches whose bed and banks have hard protection (e.g. concrete walls or sheet piling)
Culverted	0	Totally enclosed by hard protection
Navigable	N/A	Classified separately due to their high degree of flow regulation and bank protection, and their probable strategic need for maintenance dredging.

4.5.4 Approximately 1,900 m of ephemeral ditches are potentially affected by the Scheme. These are land drainage ditches that are likely to remain dry throughout much of the year. However, they provide useful aquatic habitat during wet periods. Although the effects of the Scheme on these features will not affect the status of the Ingrebourne River WFD water body, they are included in this assessment because of their potential local value.

4.6 Effect of permanent works

Introduction

4.6.1 Assessment of the compliance of the Scheme with the WFD divides into three parts. Assessment of the effect of permanent works on the Ingrebourne River WFD water body is covered in this section (section 4.6). The effects of temporary works on the Ingrebourne River WFD water body are covered in the next section (section 4.7). Finally, cumulative effects of the Scheme on both the Ingrebourne River WFD water body and other WFD water bodies is covered in section 4.8.

4.6.2 Assessments of the compliance of each permanent Scheme component with the requirements of the WFD are presented below in the sub-sections headed ‘Ingrebourne River’ and ‘Weald Brook’. These are summaries of the full matrix based assessments set out in Appendix B. The Scheme components screened into these assessments are marked on the map in Appendix A and listed in Table 4.3.

4.6.3 The assessments cover both Test A (no deterioration) and Test B (protecting future attainment of GES). They present the effect of Scheme components on WFD quality elements using the colour coding described in paragraph 3.3.6. Assessments are aggregated based on the WFD principle of “one out, all out” to eventually determine the effect of the Scheme at a water body scale.

Ingrebourne River

Overview

4.6.4 This WFD compliance assessment concludes that the Scheme components affecting the Ingrebourne River will be compliant with the requirements of the WFD. This assumes: a) the mitigation already 'embedded' in the preliminary design (as summarised in section 5.2) is implemented and b) additional mitigations (as set out in sections 5.3 and 5.4) limits the overall effect of the Scheme to minor adverse and localised. On this basis, **the Scheme components affecting the Ingrebourne are not considered to cause deterioration at the water body scale (thus passing Test A) and should not prevent future attainment of GES (Test B).**

4.6.5 The WFD compliance assessment splits the Ingrebourne WFD water body to review the River Ingrebourne and the Weald Brook separately, even though they are part of the same WFD water body. This has been done so the impacts and mitigation to these two quite different watercourses are assessed appropriately.

4.6.6 Figure 4.2 is a visual summary of the WFD compliance assessment for the Scheme components affecting the Ingrebourne River. A full assessment can be found in the matrix in Appendix B.

Test A Potential to cause deterioration of current WFD Ecological Status

4.6.7 Grove culvert extension (ING1) and the section of Grove Bridge crossing the Ingrebourne River (ING3) drive the minor localised adverse effect of the Scheme on the Ingrebourne River. These two Scheme components result in a loss of open channel, marginal and riparian vegetation; in turn reflected as minor localised adverse effect on a) the macrophyte and phytobenthos quality element (shading reducing photosynthetic activity); b) the macroinvertebrate quality element (loss of habitat resulting from reduction in / loss of aquatic and riparian vegetation) and, in particular in the case of ING1, c) morphological and hydrological complexity (less dynamic flow, more uniform river morphology, loss of sediment continuity and loss of riparian zone) contributing to overall habitat loss. Although substantial mitigation is proposed in the form of a) embedded measures to address the effect of these Scheme components (W01, W10 and W11 - Table 5.1) and b) additional mitigation (principally W13, but also W14 and W15 in section 5.3), it is considered that these Scheme components will have a minor localised adverse effect on the Ingrebourne River.

4.6.8 The other Scheme components affecting the water body are considered to have a neutral effect on WFD compliance, as discussed below:

- Accounting for proposed embedded measures to mitigate the effects of riparian habitat loss on the hydro-morphology and biological quality elements (W01 and W09 in Table 5.1), the relocation of the A12 Slip (ING2) is considered to have a neutral effect on WFD quality elements.
- There is a strategy in place to address contamination of the Ingrebourne River resulting from Construction of Balancing Pond 1 and associated disturbance to landfill (WB6). Should further ground investigations indicate leaching from Brook Street Landfill Site is likely, Balancing Pond No.1 will be lined (W16). This will address leaching of contaminants into the Ingrebourne River.

- Road runoff discharge to the existing drainage network (WB7) will have a neutral effect on all WFD elements. Based on information available at the time of reporting, a design for road drainage has been developed to achieve compliance with relevant EQS, RST toxicity and sediment standards as tested with HAWRAT (included in the Road Drainage and Water Environment chapter (Chapter 8) in the ES, application document TR010029/APP/6.1) (W12). Ditch and filter drains are the proposed mitigation for surface water quality mitigation (W12). Where possible, sediment catch-pits are proposed for sediment mitigation (W12). Runoff generated by non-highway surfaces, such as embankments, is collected and conveyed to natural waters by pre-embankment drains.

Test B Potential to prevent future attainment of GES

4.6.9 A feasibility study was undertaken to determine if the Scheme could contribute to delivery of RBMP Measure 22480. This measure is described as "Re-meander 550 m section of straightened section of the Ingrebourne upstream of the M25 Brook Street junction (junction 28) by installing deflectors or re-meander where space allows". The study demonstrated that, whilst the Scheme would not prevent this measure being implemented, all three options for the Scheme to assist its delivery were considered not viable for different reasons, which included not delivering effective mitigation, technical infeasibility (e.g. constraints imposed on the proposed measure by road drainage and a high pressure gas pipeline crossing) and poor value for money. See Appendix F for more information.

4.6.10 Delivery of the Scheme will also not compromise other planned RBMP Measures in the water body, nor the potential for other quality elements to help achieve GES[5]. Hence the Scheme is not considered to prevent future attainment of GES.

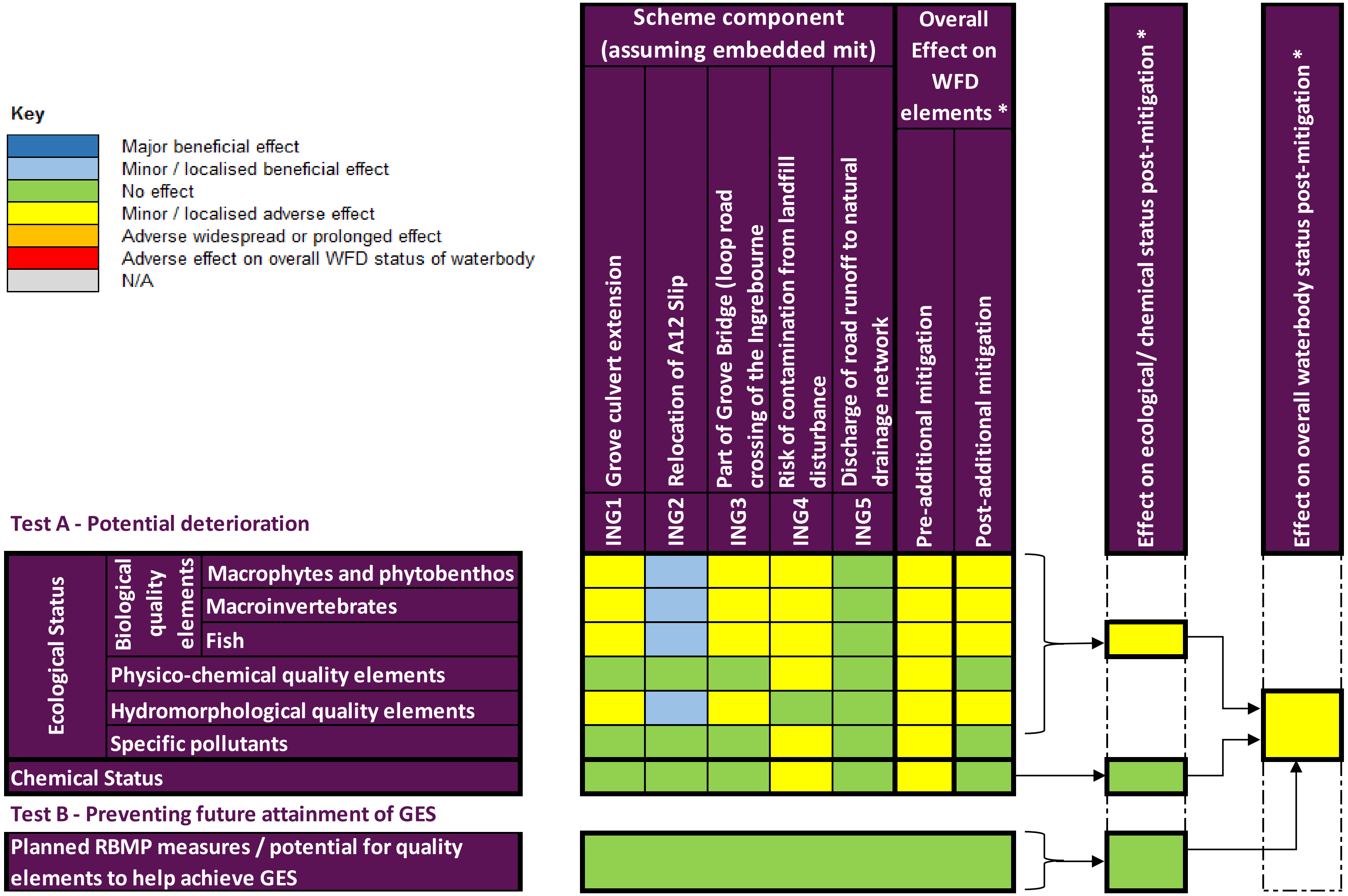
Table 4.3: Scheme components scoped into WFD compliance assessment

Code	Title	Description
ING1	Grove culvert extension	Extension to an existing culvert 190m in length by a further 80m to accommodate new slip road approach to junction 28 from A12. Loss of c. 80m of natural channel, riparian zone and floodplain.
ING2	Relocation of A12 Slip	Relocation of A12 slip from adjacent to A12 to a standalone retained wall structure on right bank of the Ingrebourne River floodplain. Loss of floodplain, constriction of floodplain.
ING3	Grove Bridge (loop road crossing of the Ingrebourne River and floodplain)	Crossing structure with low soffit. Embankments encroaching into floodplain. Pronounced shading of channel. Bank protection may be required. Loss/constriction of floodplain and riparian zone.
ING4	Construction of Balancing Pond 1 and associated disturbance to landfill	Disturbance of Brook Street Landfill site at Grove Farm within 500m of Ingrebourne River. Potential for contamination of watercourse.
ING5	Discharge of road runoff to natural drainage network	Treatment of runoff from road surfaces discharging into the Ingrebourne River and its tributaries to achieve compliance with EQS and RST toxicity standards.

[5] As an example, the minor localised adverse effect currently attributed to 'Discharge of road runoff to natural drainage network' (ING5) is not considered to prevent attainment of GES in the Ingrebourne River at a water body scale.

Code	Title	Description
WB1	Grove Bridge (loop road crossing of the Weald Brook and floodplain)	Crossing structure with low soffit. Embankments encroaching into floodplain. Pronounced shading of channel. Bank protection may be required. Loss/constriction of floodplain and riparian zone.
WB2	Construction of loop road over current alignment of Weald Brook	Construction of loop road over current alignment of Weald Brook. Realignment of channel.
WB3	Maylands Bridge (A12 slip road crossing)	A12 slip road overbridge crossing of Weald Brook and floodplain. Bridge structure with higher soffit (than ING3 and WB1), possible minor encroachment of embankment into floodplain on right bank. Shading of channel and riparian zone.
WB4	Duck Wood Bridge (northern loop crossing of Weald Brook and floodplain)	Loop road overbridge of Weald Brook and floodplain. Realignment of sinuous section of natural channel. Shading of channel and riparian zone possible, minor loss of riparian zone.
WB5	Weald Brook culvert extension (extension on M25 Weald Brook crossing)	c 8m culvert extension to accommodate carriageway widening for slip road. Loss of c. 8m channel, riparian zone and floodplain.
WB6	Construction of Balancing Pond 1 and associated disturbance to landfill	Disturbance of Brook Street Landfill site at Grove Farm within 500m of Weald Brook and near ditches that drain to the Weald Brook. Potential for contamination of watercourse.
WB7	Discharge of road runoff to natural drainage network	Treatment of runoff from road surfaces discharging into the Weald Brook and its tributaries to achieve compliance with EQS and RST toxicity standards.

Figure 4.2: Summary of WFD compliance assessment for Ingrebourne River



* Each of these assessments takes the category with the worst effect recorded on the scheme components contained within their assessment

Weald Brook

Overview

4.6.11 This WFD compliance assessment concludes that Scheme components affecting the Weald Brook will be compliant with the requirements of the WFD. This assumes: a) the mitigation already ‘embedded’ in the preliminary design (as summarised in section 5.2) is implemented and b) additional mitigations (as set out in sections 5.3 and 5.4) will limit the overall effect of the Scheme to minor adverse and localised. **On this basis, the Scheme components affecting the Weald Brook are not considered to cause deterioration at the water body scale (thus passing Test A) and should not prevent future attainment of GES (Test B).**

4.6.12 Figure 4.3 is a visual summary of the WFD compliance assessment of the effect of each Scheme component on the Weald Brook WFD quality elements. A full assessment can be found in the matrix in Appendix B.

Test A Potential to cause deterioration of current WFD Ecological Status

4.6.13 Four Scheme components drive the minor localised adverse effect of the Scheme on the Weald Brook, as set out in the bullets below:

- The low soffit and straightened channel planform associated with the Grove Bridge crossing the Weald Brook (WB1) will cause shading, loss of riparian zone and more uniform channel morphology. In turn this leads to reduced photosynthetic activity, less abundant and diverse macrophytes and phytobenthos communities and reduced habitat for macroinvertebrates and fish. Although substantial embedded measures are proposed to mitigate the effect of this Scheme component (W02, W10 and W11 in Table 5.1), it is considered that minor localised adverse effects will still occur.
- Maylands Bridge (WB3) has similar effects on the WFD quality elements of Weald Brook to those of Grove Bridge (WB1). However, a much higher soffit and wider span lessens the severity of these effects (W10). Embedded measures are proposed to mitigate the effect of this Scheme components (W02 and W11 in Table 5.1), but it is considered that minor localised adverse effects will still occur.
- Duck Wood Bridge (WB4) has a similar, if less pronounced, effect on the WFD quality elements of Weald Brook to those of Grove Bridge (WB1). A higher soffit and wider span slightly lessen the severity of these effects (W10). However, a central bridge pier forces the realignment of a naturally sinuous channel reach to a much straighter planform. Embedded measures are proposed to mitigate the effect of this Scheme component (W02 and W11 in Table 5.1), but it is considered that minor localised adverse effects will still occur.
- The Weald Brook culvert extension (WB5) causes the loss of approximately 8 m of channel, riparian zone and floodplain leading to a limited loss of hydromorphological diversity and biological habitat and diversity. Accounting for proposed mitigation in the form of a) embedded measures W01, W02 and W08 (Table 5.1) and b) additional mitigation W14 and W15 (section 5.3), it is considered that this Scheme component will have a minor localised adverse effect on the Weald Brook.

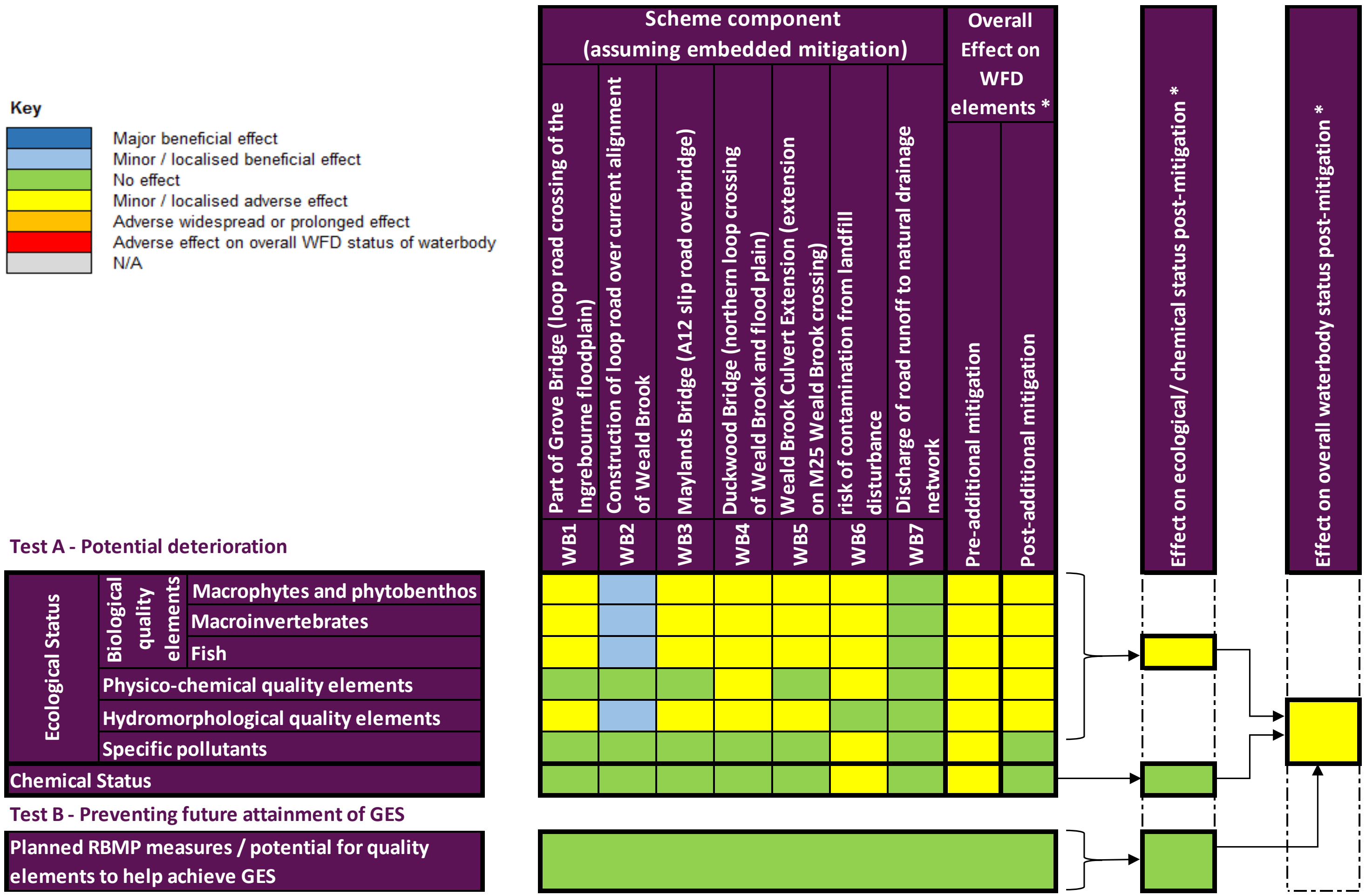
4.6.14 The other Scheme components affecting the water body are anticipated to have a neutral effect, as discussed below.

- The realignment of the Weald Brook due to the construction of the loop road (WB2) is assessed as having a neutral effect on the water environment. This is because the realignment presents an opportunity to restore the channel to a condition closer to its natural state, providing an improvement in hydro-morphological diversity and therefore the number and diversity of habitats available for macrophytes and phytobenthos, macroinvertebrates and fish.
- There is a strategy in place to address contamination of the Ingrebourne River resulting from Construction of Balancing Pond 1 and associated disturbance to landfill (WB6). Should further ground investigations indicate leaching from Brook Street Landfill Site is likely, Balancing Pond No.1 will be lined (W16). This will address leaching of contaminants into the Weald Brook.
- Road runoff discharge to the existing drainage network (WB7) will have a neutral effect on all WFD elements. Based on information available at the time of reporting, a design for road drainage has been developed to achieve compliance with relevant EQS, RST toxicity and sediment standards as tested with HAWRAT (included in the Road Drainage and Water Environment chapter (Chapter 8) in the ES, application document TR010029/APP/6.1) (W12). A combination of dry attenuation ponds and ditches are the proposed mitigation for surface water quality mitigation. Sediment catch-pits are proposed for sediment mitigation. Runoff generated by non-highway surfaces, such as embankments, is collected and conveyed to natural waters by pre-embankment drains.

Test B Potential to prevent future attainment of GES

4.6.15 Delivery of the Scheme will not compromise other planned RBMP Measures in the water body nor the potential for other quality elements to help achieve GES. Hence the Scheme is not considered to prevent future attainment of GES.

Figure 4.3: Summary of WFD compliance assessment for the Scheme on the Weald Brook



* Each of these assessments takes the category with the worst effect recorded on the scheme components contained within their assessment

Net effect of Scheme on riverine environment

Introduction

4.6.16 The Scheme includes many components that affect the water environment and many measures to address these effects. This section summarises a separate assessment that has been undertaken to check whether the net effect of these Scheme components, in combination with proposed mitigation measures, generates a net benefit to riverine habitat.

4.6.17 A full description of this assessment is presented in Appendix E.

Method of assessment

4.6.18 The basis of the assessment is a comparison of the product of habitat extent and habitat quality in: a) the baseline condition and b) the Scheme scenario. Habitat quality is measured using the conservation score index presented in Table 4.2. Habitat extent is measured as length of river channel.

4.6.19 The EA advocates that adverse effects on riverine habitat should be addressed solely through measures that replace or improve 'like for like' riverine habitat. Because of this the assessment focusses solely on riverine habitat (i.e. the river channel and its riparian zone). It only considers the effect of the Scheme on this habitat type and mitigation that directly addresses these effects (e.g. river realignment to generate more natural river habitat). The measures considered in the assessment are ticked in the column headed 'mitigation' in Table 5.1. Mitigation measures to non-riverine habitat (e.g. floodplain lowering), as ticked in the column headed 'enhancement' in the same table, are not considered in the assessment. This is a precautionary approach because it does not account for the benefit that such enhancements will bring to the water environment as part of the Scheme.

4.6.20 The assessment also considers the effect of mitigation that the EA have agreed to implement in the wider Ingrebourne WFD catchment with financial support from Highways England (see section below headed 'Outcome of assessment').

Outcome of assessment

4.6.21 The outcome of the assessment is summarised in Table 4.4. This shows that the net effect of the Scheme components combined with proposed mitigation to the riverine environment within the DCO boundary generates a net deficit in riverine habitat of -0.23.

4.6.22 Investigations were undertaken in consultation with the EA to determine whether this deficit could be addressed through the implementation of further mitigation to riverine habitat within the DCO boundary. Further mitigation on the Weald Brook within the DCO boundary (on the reach north of Duck Wood Bridge) was not considered to be beneficial because of the relatively natural state of the existing watercourse. The investigation therefore focussed on the Ingrebourne River within the DCO boundary the north-east of junction 28, a reach that had been identified by the EA as having potential for improvement as set out within RBMP Measure 22480. The feasibility study for implementing mitigation in this reach is presented in Appendix F. The study considered three options for implementation of mitigation to assist in the achievement of RMBP Measure 22480, and concluded that none were viable. A separate assessment of the net riverine habitat benefit generated by the most attractive of these options from the perspective of riverine habitat restoration (the upstream realignment) assigned a net benefit to riverine habitat of 0.55 to this option (see Appendix E).

Table 4.4: Outcome of riverine habitat assessment

Receptors	Baseline	Proposed	Difference
Ingrebourne River (within DCO boundary)	1.31	1.12	-0.20
Weald Brook (within DCO boundary)	9.97	9.94	-0.04
Watercourses within DCO boundary	11.29	11.05	-0.23
Minimum off site mitigation requirement			0.23
Minimum net effect of Scheme on riverine habitat			neutral
Notes 1. The figures in this table represent the product of habitat quality and river reach length as a metric referred to as 'length weighted conservation score' – see paragraph 4.6.18. 2. Small inconsistencies in summing figures arise in the table above due to rounding error.			

Mitigation measures outside of the DCO boundary

4.6.23 The EA advocate that loss of riverine habitat should be addressed through measures that replace or improve 'like for like' riverine habitat. Highways England and the EA have reached a common understanding that the only viable option for delivering 'like for like' measures to mitigate the deficit net effect of the Scheme on riverine habitat is through works outside of the DCO boundary (W13). This is confirmed in the Statement of Common Ground with the EA (application document TR010029/APP/8.1). The two organisations have also agreed that these measures can be most effectively delivered by the EA, as part of their programme of works within the Ingrebourne WFD water body with financial support from Highways England.

4.6.24 Using the riverine habitat benefit assessment presented in the previous section as a guide, these works should deliver a minimum net riverine habitat benefit of 0.23 to ensure the Scheme has a neutral effect on riverine habitat within the Ingrebourne WFD water body. They should target a net riverine habitat benefit of 0.55: an equivalent to benefit generated by the 'upstream realignment' set out in the Feasibility Study in Appendix F.

4.6.25 Highways England is committed to ensuring that the financial support required to enable delivery of these measures by the Environment Agency is provided to the Environment Agency prior to the commencement of construction of the Scheme and the parties are developing a legal agreement to document this commitment.

4.7 Effect of temporary works

4.7.1 Temporary activities during construction potentially affecting WFD water bodies include the following:

- **Runoff from construction sites to surface water bodies** – Management of runoff from construction sites prior to discharge to surface water body.
- **Disturbance of invasive non-native species (INNS)** – Construction activities can result in the spread of INNS along surface water bodies and their riparian zone.
- **Vegetation management** – Clearance of riparian and in channel vegetation during construction.
- **De-watering** – Local changes to groundwater levels associated with pumping out of subterranean works areas (e.g. deep foundations) and disposal of pumped water to surface water bodies.
- **Runoff from construction sites to groundwater** – Untreated runoff from construction sites discharges through permeable surface geology direct to an aquifer.

4.7.2 Temporary construction activities are considered to have a neutral effect at the water body scale. This assumes that the guidance on temporary works set out in section 5.4 under the heading ‘Temporary activities during construction’ are observed.

4.8 Cumulative effects

4.8.1 An assessment of the cumulative effects of the Scheme is set out in Chapter 15 of the ES (application document TR010029/APP/6.1). This considers cumulative effects with other developments during both the construction and operational phases of the Scheme. It reports no significant cumulative effects associated with road drainage and the water environment.

5. Mitigation

5.1 Introduction

5.1.1 This section summarises measures proposed to mitigate the effects of the Scheme on the water environment. The term mitigation is used in its broadest sense, to include not only direct mitigation for the effects of the Scheme, but also compensation and enhancement.

5.1.2 Three categories have been used to describe mitigation measures:

- **Embedded mitigation**: mitigation already explicitly represented in the preliminary design
- Additional mitigation:
  - **Specific** – a limited number of specific measures not explicitly captured in the preliminary design as embedded mitigation.
  - **Generic guidance** – for detailed design of scheme components in a way designed to achieve WFD compliance.

5.1.3 Additional mitigations in the form of both specific measures and generic guidance are recorded in the Register of Environmental Actions and Commitments (REAC) for the Scheme (application document (TR010029/APP/7.3), which in turn forms part of the Outline Construction and Environmental Management Plan (CEMP) (application document (TR010029/APP/7.2). These documents are the mechanisms that secure mitigation being a) progressively embedded into the Scheme as it evolves through detailed design, and b) implemented during construction.

5.1.4 As the Scheme evolves, discussions with the EA are ongoing to develop a package of mitigation that provides mitigation for the effect of the Scheme on the water environment and, where opportunity and financial constraints allow, delivers enhancements to the natural environment.

5.2 Embedded mitigation

Introduction

5.2.1 Table 5.1 summarises mitigation embedded into the preliminary design of the Scheme. These measures are referred to by their codes in both Appendix B and Section 4.6. Scheme components (e.g. bridges and the A12 Slip) can be seen in the Scheme layout plans (application document TR010029/APP/2.7). The geographically specific measures can be seen on the preliminary environmental design plans (application document TR010029/APP/6.2, Figure 2.2).

5.2.2 A preliminary design specification for floodplain lowering on the Ingrebourne River and Weald Brook (W03 to W05) can be found in Appendix E.

5.2.3 Long term maintenance and management plans for river and floodplain features (including measures W03-W06) are set out in the Outline Landscape and ecological management and monitoring plan (LEMP) (application document TR010029/APP/6.3, Appendix 7.16).

Table 5.1: Summary of embedded mitigation and enhancement

Code	Title	Description	Mitigation	Enhancement
W01	Ingrebourne realignment	Realignment of c 200 m of existing straight channel to new sinuous course between Grove Farm and the Weald Brook confluence. Including the restoration of more naturally functioning channel.	✓	
W02	Weald Brook realignment	Realignment of two sections of existing straight channel to new sinuous courses on the lower Weald Brook (85 m and 250 m in length). Including the restoration of more natural functioning channel.	✓	
W03	Ingrebourne floodplain lowering	Lowering of c 3,500 m^2 of floodplain, creation of backwaters on the Ingrebourne between Grove Farm and the Weald Brook confluence.		✓
W04	Weald Brook floodplain lowering upstream	Lowering of c 2,100 m^2 of floodplain, a flood compensation area and creation of a backwater to Weald Brook, just upstream of Duck Wood Bridge (WB4).		✓
W05	Weald Brook floodplain lowering downstream	Lowering of c 7,800 m^2 of floodplain in combination with a flood compensation area adjacent to Grove Bridge and Maylands Bridge (WB1, WB3 and ING3).		✓
W06	Maintenance of riparian trees on Weald Brook	Long term maintenance works to manage riparian trees along the Weald Brook in a way that creates varied light intensity on the channel and riparian zone of the river.		✓
W07	Unlined drainage ditches	As part of the scheme significant lengths of unlined ephemeral drainage ditch will be created to manage 'clean' runoff from non-pavement surfaces. These ditches will generate habitat that mitigates for loss of existing ephemeral drainages ditches to the Scheme[6].		✓
W08	Depressed inverts and natural river beds on culvert extensions	A natural river bed will be incorporated into the design of culverts carrying the Weald Brook under the M25 (Weald Brook Culvert extension, WB5) and the Ingrebourne beneath J28 (Grove Culvert extension, ING1).	✓	

[6] For further detail see short section in Appendix E under "Non riverine elements of the water environment".

Code	Title	Description	Mitigation	Enhancement
W09	A12 slip constructed on retaining wall	The effects of the scheme will be reduced by minimising the footprint on the floodplain by supporting the A12 slip road on a retaining wall (ING2) instead of a large embankment structure.	✓	
W10	Widespan bridge structures	Within the restrictions defined by other constraints, proposed structures have been set as high and wide as feasible to limit adverse geomorphological impacts, conveyance and shading effects. These structures are Grove Bridge (WB1 and ING3), Maylands Bridge (WB3) and Duck Wood Bridge (WB4).	✓	
W11	Minimisation of hard bank protection at river crossings	Channel crossings and realignments have been planned to limit the need for hard bank protection to reduce potential impacts on the biological and hydro-morphological quality elements. This affects the following structures: Grove Bridge (ING3) over the Ingrebourne and Duck Wood Bridge (WB4).	✓	
W12	Management of road runoff before discharge to the natural drainage system	A drainage system designed to meet WFD toxicity standards at points of discharge to natural waters (Road Drainage and the Water Environment chapter (Chapter 8) in the ES).	✓	

5.3 Additional mitigation (specific)

5.3.1 This category captures specific measures that Highways England is committed to delivering as part of the Scheme but are not captured in the preliminary design as embedded mitigation. These are recorded in the REAC (application document TR010029/APP/7.3) for development in later phases of design. They comprise:

- W13 – Mitigation works, outside of the DCO boundary, delivered by the EA as part of their programme of works within the Ingrebourne WFD water body.
- W14 – Measures to prevent excessive scour or “wash-out” of bed material immediately downstream of Grove culvert extension (ING1) and Weald Brook culvert extension (WB5). Measures likely to include construction of artificial riffle feature downstream of culvert or selective use of bed and bank protection.

- W15 – Measures to facilitate mammal passage through Grove culvert extension (ING1) and Weald Brook culvert extension (WB5) during higher than normal flows. The form of such measures needs to be determined at detailed design, but often comprise a shelf along which mammals can move, together with ramps for mammal access and egress.
- W16 – Measure to line Balancing Pond No.1. Only required if further Ground Investigations indicate a risk of the leaching of contaminants from the Brook Street Landfill to watercourses.

5.4 Additional mitigation (generic guidance)

Introduction

5.4.1 This section contains generic guidance on minimising the impact of Scheme components on WFD quality elements with a view to securing compliance of the Scheme with the WFD. The guidance covers components common to the Scheme and will be used to inform the detailed design process.

Components of the permanent Scheme

Single span bridges

5.4.2 Single span structures are the preferred type of crossing because they minimise impact on the water environment if designed appropriately.

5.4.3 They should be designed and constructed in such a way as to minimise disruption to the river and riparian zone. Abutments should be set well back from the bank edge to allow the river to function naturally and to maintain a wildlife corridor along the banks. Where practically possible the bridge deck should run perpendicular to the watercourse (to reduce shading). Bed and bank protection should only be used where a real risk to life or critical infrastructure is apparent. A single span structure should not create a barrier to fish and other wildlife, or disrupt navigation or recreation (SEPA, 2010).

5.4.4 Single span structures are not always technically feasible, particularly on wide rivers (where it may be necessary to place additional abutments in the watercourses). They can take longer to construct. They may also be more expensive than other crossing types as specialist construction techniques may be required.

5.4.5 Further guidance on the engineering of river crossings is available in SEPA (2010).

Culverts

5.4.6 Culverts present a higher risk (than single span structures) of: a) disrupting natural hydraulic and sediment transport processes, b) acting as a barrier to fish passage and movement of other wildlife and c) damaging the bed and banks of a river during construction. They are therefore not a preferred method of watercourse crossing from the perspective of protecting and improving the water environment.

5.4.7 Culverts are, however, generally cheaper and easier to build than single span structures because their construction process tends to be less complex. In some instances, they may be the only feasible technical solution. Hence, they can be consented by regulators (such as the EA) for crossing smaller, low sensitivity watercourses if their adverse impact on the water environment is minimised.

5.4.8 A culvert designed solely for hydraulic performance will not be consented by regulators. Guidance must be sought on how to reduce their adverse impact on the water environment. Useful references include:

- Chapter 8 of Fluvial Design Guide (EA, 2010)
- Chapter 4 of Culvert design and operation guide (C689) (Ciria, 2010)
- Water Framework Directive Mitigation Measures Manual (EA, 2013)
- Advice on minimising impact on fish passage in the Fish Pass Manual (EA, 2010a)
- SEPA's advice on river crossings and position statement on culverting (SEPA 2010, 2015)

5.4.9 Key considerations to help achieve environmentally sensitive culvert design include:

- Minimise length, for instance by incorporating wingwalls into the design.
- Minimise impact of the structure on natural flow and sediment process during construction and operation. For instance, an open arc structure that avoids disturbing the natural bed of the river is preferred to a box culvert.
- Do not size on hydraulic (flood) requirements alone. Additional capacity will be required for environmental uses (e.g. mammal shelves and ensuring natural flow / sediment process). Flow rates and depths during normal and low flows will need to be conducive to wildlife requirements such as fish passage.
- Natural bed substrate will be required, so the invert of the culvert will need to be set well below natural bed level at both ends. Embedment depths will depend on local geomorphological processes but are commonly around 300mm.

Channel widening, deepening, straightening or realigning

5.4.10 Widening, deepening, straightening or realigning of naturally functioning channels will be opposed by regulators (e.g. the EA) because it will result in loss of a range of river habitats and, by disrupting natural processes, may result in degradation of further downstream (or upstream) habitat.

5.4.11 However, watercourse channels adjacent to roads have often been modified by previous road building or drainage schemes. Hence, in some instances, the realignment of a channel can present an opportunity to restore channels to a more natural state of ecological function in line with WFD objectives.

5.4.12 Where widening, deepening, straightening or realigning of naturally functioning channels cannot be avoided, modification will need to be carried out in a manner that minimises long term impact. The regulator will need to consent the work and is likely to insist on environmental enhancements elsewhere to mitigate or offset adverse effects on the water environment.

5.4.13 Guidance should be sought on any works that result in the modification of a river channel. The guidance section of the River Restoration Centre website (RRC, 2014) is an excellent starting point for developing effective river restoration designs.

5.4.14 Key considerations in developing environmentally sensitive modifications to river channels are:

- Avoid modifying a channel that is already functioning naturally.
- Where channel modification is required, develop a design that works with natural processes, and hence allows the river to function naturally in the long-term.
- Be aware that a natural river is likely to require space to function properly (e.g. to allow for re-meandering or backwaters). Allow for this space requirement in the design of other components of the Scheme and land purchases / agreements.
- As a general principle, the length of a realigned channel should exceed or match the length of channel prior to modification.
- There are designers and contractors who specialise in river restoration. Designs developed by such specialists are more likely to be consented by the regulator.

Bank and bed reinforcement

5.4.15 Hard bed and bank reinforcement will be opposed by the regulator, except at locations where it can be demonstrated that it prevents potential loss of life or is necessary to protect critical infrastructure. Designs that work with natural processes (and hence avoid the need for protection) are preferred. Softer, bioengineered solutions will in many cases afford appropriate protection and be a cheaper/more sustainable design.

5.4.16 Bank and bed erosion are parts of the natural functioning of a river.

5.4.17 Further guidance on the environmental aspects of bank protection is available in EA (2013) and SEPA (2008).

Drainage of road runoff (to surface water)

5.4.18 Collaborative research between the EA and Highways England developed a risk-based tool (HAWRAT) for a) assessing the effect on the water environment of relevant WFD specific pollutants, priority substances and priority hazardous substances, generated by road surfaces b) testing the effectiveness of mitigation (Highways Agency, 2009). This tool should be used as the basis for the design of road drainage.

5.4.19 SuDS are the preferred approach to managing pollution risk associated with road runoff and should be implemented where technically feasible. All drainage systems should be designed in accordance with industry standards, with particular emphasis on appropriate pollution prevention and control measures (CIRIA, 2015).

Temporary activities during construction

Runoff from construction sites to surface and groundwater bodies

5.4.20 Construction generates significant risks of pollution to surface and groundwater bodies. These need to be fully mitigated by suitable control of construction practices such as adherence to the Pollution Prevention Guidance (PPG) Notes, specifically PPG 5: Works and Maintenance in or near Water and PPG 6: Construction and Demolition Sites (EA, 2014 & 2014a, withdrawn).

5.4.21 All PPGs that were previously maintained by the EA are currently under review and a new set of guidance notes are presently being issued as Guidance for Pollution Prevention (GPP) documents. These include GPP5 for works and maintenance in or near water (which replaces PPG5).

Disturbance of invasive non-native species

5.4.22 Construction activities in, over and adjacent to water bodies significantly increase the risk of the spread of INNS associated with aquatic and riparian habitats. Risks will need to be managed effectively during the construction period through the implementation of biosecurity control, such as check-clean-dry procedures for plant, equipment and the workforce. The GB non-native species secretariat website (http://www.nonnativespecies.org) provides a key source of information for the identification of risks, appropriate control and management systems and disposal.

5.4.23 The EA should also be consulted to ascertain the status and distribution of invasive species in surface water bodies. Consideration needs to be given to the potential to create pathways for invasive species movement within/between water bodies, through for example, the removal of existing barriers e.g. artificial structures such as weirs and culverts.

Vegetation management

5.4.24 There is often the requirement to manage vegetation (both riparian and aquatic) during construction activities in, over and adjacent to water bodies. Vegetation clearance should only be undertaken following an ecological constraints assessment of the potential for vegetated habitats to support protected species (e.g. nesting birds, reptiles) and to determine the intrinsic ecological value of the habitat, plus the risk posed by INNS.

5.4.25 Consideration should be given within the construction programme and design to translocate vegetation to an appropriate receptor site and/or improve conditions for target communities in line with regulatory drivers such as the WFD and the NERC Act's (2006) proposed list of species/habitat of principle importance.

6. Conclusion and recommendations

6.1 Conclusions

6.1.1 This WFD compliance assessment concludes that the M25 junction 28 improvement scheme is compliant within the requirements of the WFD. None of the components that make up the Scheme are considered to cause deterioration at the water body scale (thus passing Test A). All should not prevent future attainment of GES (Test B).

6.1.2 This conclusion is based on the preliminary design for the Scheme as presented on the Scheme layout plans (application document TR010029/APP/2.7). Critically it also assumes the following:

- The mitigation already ‘embedded’ in this preliminary design (as presented on the Scheme layout plans and summarised in section 5.2) is implemented.
- Additional specific mitigation (as summarised in section 5.3) is implemented as developed and agreed with the EA.
- Generic guidance on the principles of WFD compliant design (as summarised in section 5.4) is adhered to in subsequent detailed design of Scheme components affecting the water environment.

6.1.3 Implementation of mitigation on the ground is secured through four mechanisms. First, embedded mitigation is safe-guarded because it is explicitly represented in the preliminary design. Second, both embedded mitigation and additional mitigation (in the form of specific mitigation and generic guidance) is secured by inclusion in the REAC for the Scheme (application document TR010029/APP/7.3). Third, implementation of specific additional measure W13 (works outside of the DCO boundary) is secured by means of a legal agreement between Highways England and the Environment Agency. Finally, long term maintenance and management plans for river and floodplain features are set out in the Outline LEMP (/APP/6.3, Appendix 7.16).

6.1.4 The measures summarised in 6.1.2 include both mitigations for the effects of the Scheme on the water environment and enhancements to the water environment (see categorisation in Table 5.1). The enhancements also further the Scheme’s compliance with the WFD.

6.1.5 The Scheme is not expected to exert any adverse cumulative effects on WFD quality elements in water bodies beyond those affected directly by the Scheme.

6.1.6 This WFD compliance assessment has been undertaken using an approach recommended by the EA for its transparency, thoroughness and auditability. A precautionary approach has been adopted to scoping and screening Scheme components and WFD quality elements for the assessment.

6.2 Recommendations

6.2.1 The following key recommendations are made:

- Highways England to support the EA to ensure that the EA programme of works within the Ingrebourne WFD water body delivers appropriate measures to mitigate the deficit in riverine habitat associated with the Scheme (mitigation measure W13, see section 5.3).
- Consultation with regulators (principally the EA) continues regularly throughout the design process to ensure that the Scheme is designed to be compliant with the objectives of the WFD and that feasible opportunities for improvements to the water environment are integrated into the Scheme.
- The design principles set out in section 5 are shared widely with all members of the design team involved in the development of Scheme components affecting the water environment.
- Specialists in sustainable design of river crossings, realignments, floodplain habitat improvements and management of bed/bank erosion continue to be consulted during the evolution of the design of Scheme components that have potential to modify the water environment.
- This WFD compliance assessment is updated as more detailed information about the Scheme becomes available. This is most likely to be at detailed design.

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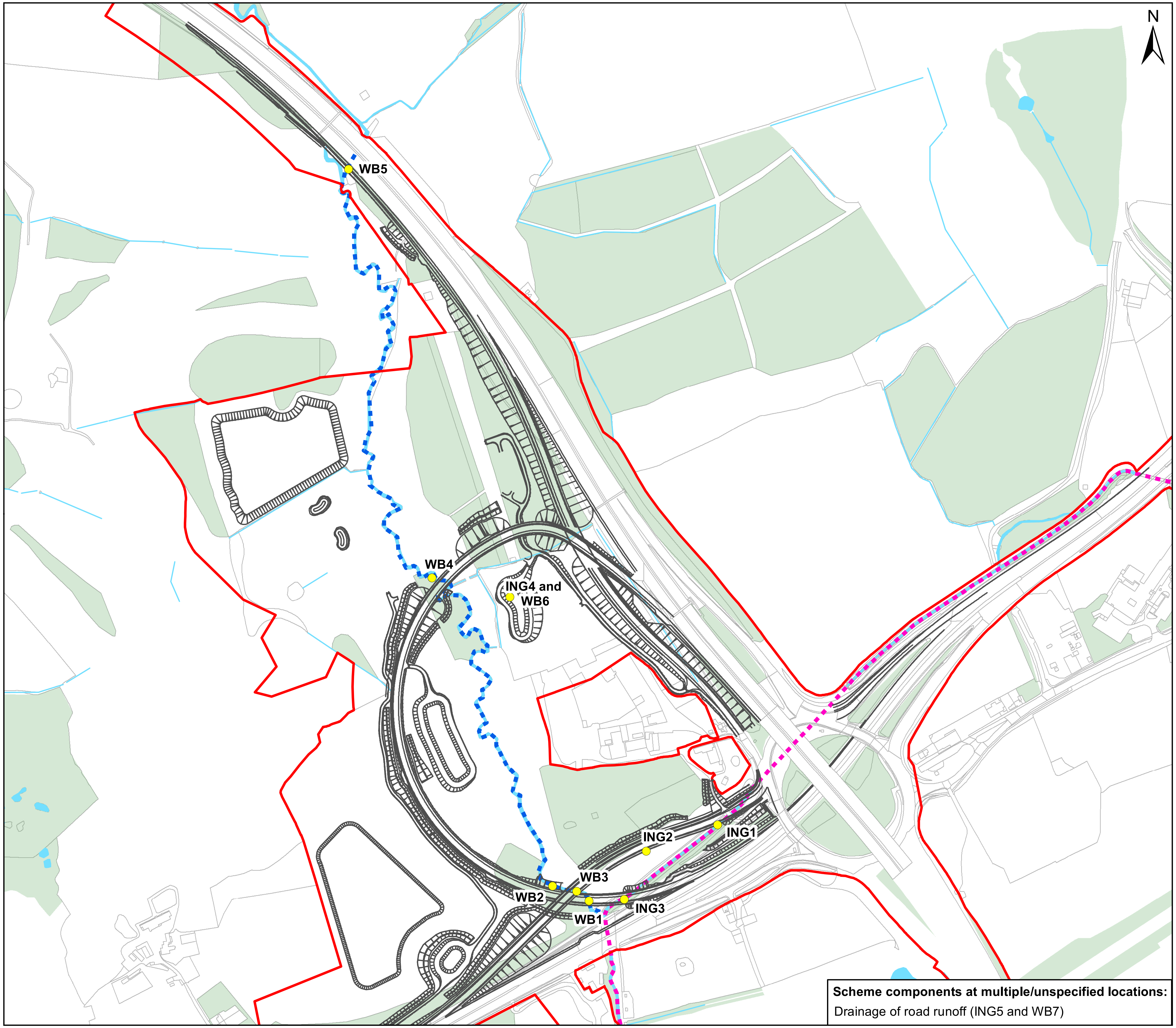
Appendices

Appendix A. Effect of the Scheme on the water environment



M25 Junction 28 Improvement Scheme

Scheme Components screened into the WFD Compliance Assessment of The Scheme

Key

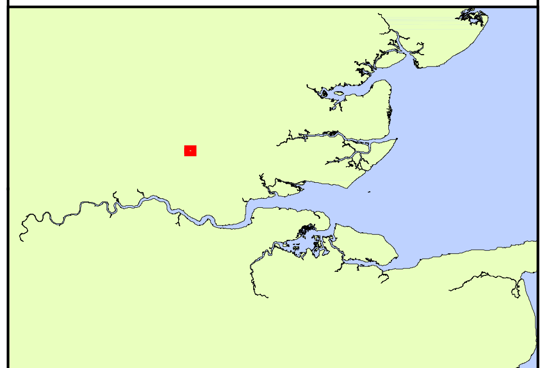
- Scheme Components
- Road Improvement Works
- DCO Boundary
- Reach of Weald Brook impacted by the Scheme

WFD Surface Water Bodies

- Ingrebourne WFD assessed surface water body (GB106037028130)

OS Features

- Surface Water Bodies
- Woodland



Data sources: Environment Agency, Ordnance Survey.

0 0.1 0.2 Km

Scale (at A3): 1:5,000

highways england

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Appendix B. WFD compliance assessment matrices

B.1 Ingrebourne River

B.2 Weald Brook

WFD Assessed Water body	Code	ING1	ING2	ING3	ING4	ING5
Ingrebourne GB106037028130	**Scheme component**	Grove culvert extension	Relocation of A12 Slip	Grove Bridge (loop road crossing of the Ingrebourne River and floodplain)	Construction of Balancing Pond 1 and associated disturbance to landfill	Discharge of road runoff to natural drainage network
	Watercourse Type	WFD assessed water body	WFD assessed water body	WFD assessed water body	WFD assessed water body	WFD assessed water body
	Location	TQ 56613 92335	TQ 56515 92299	TQ 56487 92235	Multiple locations	Multiple locations
	Description	Extension to an existing culvert 190m in length by a further 80m to accommodate new slip road approach to junction 28 from A12. Loss of c. 80m of natural channel, riparian zone and floodplain.	Relocation of A12 slip road from adjacent to A12 to a standalone retained wall structure on right bank of the Ingrebourne River floodplain. Loss of floodplain and constriction of floodplain.	Crossing structure with low soffit. Embankments encroaching into floodplain. Pronounced shading of channel. Bank protection may be required. Loss/constriction of floodplain and riparian zone.	Disturbance of Brook Street Landfill site at Grove Farm within 500m of Ingrebourne River. Potential for contamination of watercourse.	Treatment of runoff from road surfaces discharging into the Ingrebourne River and its tributaries to achieve compliance with EQS and RST toxicity standards.

Key

Colour	Meaning
dark blue	major beneficial effect
light blue	minor / localised beneficial effect
green	no effect
yellow	minor / localised adverse effect
orange	adverse widespread or prolonged effect
red	adverse effect on overall WFD status of water body

This assessment has been undertaken on the basis that a) all mitigation measures embedded in the Scheme (see drawings in Appendix A) are implemented and b) additional proposed mitigation measures set out in section 5 of the main report are also implemented.

Test A Potential to cause deterioration of current WFD Ecological Status

			Current Status	Status objective	Effect of Scheme component on WFD element* (ING1)	Effect of Scheme component on WFD element* (ING2)	Effect of Scheme component on WFD element* (ING3)	Effect of Scheme component on WFD element* (ING4)	Effect of Scheme component on WFD element* (ING5)	Overall effect of Scheme on WFD element	Additional Proposed Mitigation Measures	Residual effect of Scheme on WFD element**	Effect of Scheme on ecological / chemical status	Overall effect of Scheme on water body status
ECOLOGICAL STATUS	Biological quality elements	Macrophytes and phytobenthos	Moderate	Moderate by 2015	The extension of the current culvert by c. 80m to accommodate a new slip road, will result in the loss of c. 80m of open channel. Loss of open channel, marginal and riparian vegetation will have an impact upon a) the macrophyte and phytobenthos quality element as shading will stop photosynthetic activity in parts of the channel and reduce it in others so growth of macrophytes and phytobenthos will be reduced considerably in that section of the river; b) the macroinvertebrate quality element due to the loss of habitat resulting from reduction in / loss of aquatic and riparian vegetation; and c) a permanent loss of habitat for fish. It will also fragment the habitat of the channel upstream and downstream of the culvert further, creating a bigger barrier to the movement of biological elements such as the migration of fish. Measures W1 and W8 are considered to substantially mitigate for the effect of this culvert extension through river realignment, depressed inverts and natural beds on culvert extensions. Accounting for this mitigation the culvert is anticipated to have a minor, localised adverse effect.	The loss and constriction of the floodplain is not anticipated to have an impact on the macrophytes and phytobenthos, macroinvertebrates or fish within the channel, considering the mitigations set out below. By constructing a retaining wall rather than an embankment (W9) the loss of the riparian zone and floodplain is minimised. W1 is considered to further mitigate for the effect through river realignment. Overall this will have a localised beneficial effect on these quality elements.	Permanent shading of the channel and riparian zone will result in a localised adverse effect on macrophytes and phytobenthos through a reduction in photosynthetic activity. The consequent reduction in habitats and food sources will reduce the abundance and diversity of invertebrates and fish. The bridge does not form a material barrier to fish migration. This effect is minimised by the use of a widespan bridge structure instead of a culvert (W10). Measures W1 and W11 are considered to further mitigate for the effect of the scheme component through river realignment and the minimisation of bank protection at this crossing through careful design. Accounting for this mitigation the bridge crossing is anticipated to have a minor, localised adverse effect.	The proposed construction of balancing pond No 1 will disturb the Brook Street Landfill site. Disturbance could lead to the leaching of contaminants from the landfill into the watercourse. Changes in water quality would impact on the habitats for all the biological elements. It would be likely that the diversity of the elements would decrease as only some species would be suited to that type of environment. The results of a Preliminary Ground Investigation are reported under the Baseline conditions section of Chapter 10 of the Environmental Statement (Geology and Soils). This concluded that the risks to controlled waters from contamination within the landfill, associated with the proposed development, are considered to be low. Further investigations in the form of a full Ground Investigation and associated assessment are required to confirm this preliminary conclusion. Until these further investigations are complete we have taken a precautionary approach to assume a minor localised adverse effect on the water body.	Based on currently available information a design for road drainage has been developed to achieve compliance with relevant EQS / RST toxicity and sediment standards as tested with HAWRAT. Ditch and filter drains are the proposed mitigation for surface water quality mitigation. Where possible, sediment catch-pits are proposed for sediment mitigation. Runoff generated by non-highway surfaces, such as embankments, is collected and conveyed to natural waters by pre-embankment drains (W12). Compliance with the EQS / RST toxicity and sediment standards will contribute to safeguarding the number and diversity of a) macrophytes and phytobenthos b) the habitats available for macroinvertebrates and c) fish populations, particularly at early stages of life when they are vulnerable to suffocation. No effect.	Although one scheme component is assessed as having a localised beneficial effect and one a neutral effect on the biological quality elements, all others generate a minor, localised adverse effect. The worst case, minor, localised adverse effect, is carried through.	The following additional mitigations are proposed for the Ingrebourne WFD water body: Measure W13 - improvements to off-site watercourses Measure W14 - to prevent excessive scour or "wash-out" of bed material immediately downstream of Grove culvert extension (ING1). Measure likely to include construction of artificial riffle feature downstream of culvert or selective use of bed and bank protection. Measure W15 - to facilitate mammal passage through Grove culvert extension (ING1) during higher than normal flows. The form of such measures needs to be determined at detailed design, but often comprise a shelf along which mammals can move, together with ramps for mammal access and egress. Proposed mitigation for ING4, if further investigations suggest leaching from Brook Street Landfill Site is likely, is to line Balancing Pond No.1 (W16). This will address leaching of contaminants into the Ingrebourne.	Even accounting for the effects of the additional mitigation, minor, localised adverse effects to biological quality elements will still remain.	Minor localised adverse effect	**Minor localised adverse effect**
		Macroinvertebrates	Moderate	Moderate by 2015										
		Fish	Good	Good by 2015										
	Physico-chemical quality elements	Physico-chemical quality elements comprise total phosphorus, salinity, dissolved oxygen, pH, acid neutralising capacity.	Moderate	Moderate by 2015	A culvert extension is not considered to have an effect on the physico-chemical condition of the channel. No effect.	The loss and constriction of floodplain is not considered to adversely effect the physico-chemical condition of the channel. No effect.	The introduction of embankments / bank protection is not considered to effect the physico-chemical condition of the channel. No effect.	Potential contaminants from the Brook Street Landfill Site leaching into the Ingrebourne could have an adverse effect on the physico-chemical quality elements in the water body, such as phosphorus and pH. Until further investigations (see biological quality elements) are complete we have taken a precautionary approach and assumed a minor, localised adverse effect on the water body.	See background information in first paragraph of biological quality elements. Compliance with EQS / RST toxicity and sediment standards will generate physico-chemical conditions more conducive to supporting healthy biological quality elements. No effect.	Four of the scheme components are assessed as having a neutral effect on physico-chemical quality elements. However, ING4 is assessed as having a minor, localised adverse effect on physico-chemical quality elements due to the potential for leaching of contaminants from landfill. The worst case (minor, localised adverse effects) is carried through.		Because of measure W16 to mitigate potential effect of leaching from Brook Street Landfill, neutral effect carried through.		
	Hydro-morphological quality elements	Hydro-morphological quality elements: Hydrological Regime (e.g. quantity and dynamics of flow and connection to groundwater) and Morphology (e.g. river continuity, river depth and width variation, structure and substrate of river bed, and structure of riparian zone). However, for a HMWB the assessment of this quality element needs to account for the designated use of the water body.	Good	Good by 2015	The culvert extension by c.80m will reduce the morphological and hydrological complexity (less dynamic flow, more uniform river morphology, loss of river continuity and loss of riparian zone). These changes will be permanent and over a long stretch of channel. See text on mitigation in second paragraph of biological quality elements. Accounting for this mitigation the culvert is anticipated to have a minor, localised adverse effect.	The loss and constriction of the floodplain could adversely affect the hydro-morphological condition of the riparian zone and floodplain. See text on mitigation in second paragraph of biological quality elements. Accounting for this mitigation this scheme component will have a localised beneficial effect.	Channel straightening immediately underneath the bridge, loss of riparian zone due to shading and the constriction of the floodplain could adversely affect the hydro-morphological condition of the channel. See text on mitigation in second paragraph of biological quality elements. Accounting for this mitigation the bridge crossing is anticipated to have a minor, localised adverse effect.	Potential contaminants from the Brook Street Landfill Site leaching into the Ingrebourne is not expected to have an adverse effect on the hydro-morphological quality elements. The contaminants leaching are not expected to increase the silt input to the watercourse or impact on the quantity or dynamics of flow. Considered to have no effect.	See background information in first paragraph of biological quality elements. Compliance with toxicity standards will generate hydro-morphological conditions more conducive to supporting healthy biological quality elements. Controlling silt inputs from the road will limit additional fines in the aquatic sediment system. No effect.	There are three scheme components that have a neutral or positive effect on the hydro-morphological quality element (ING2, ING4 and ING5). However, the remainder are considered to have a minor, localised adverse effect. The worst case (minor, localised adverse effect) is carried through.		Even accounting for the effects of the additional mitigation, minor, localised adverse effects to hydro-morphological quality elements will still remain.		
	Specific pollutants	As listed in Annex VIII of the Water Framework Directive.	Good	Good by 2015	Physical modification of water feature will not cause deterioration to the Specific Pollutant quality elements. No effect.			The risk of contaminants from the landfill leaching to the Ingrebourne could adversely effect Specific Pollutants. Until the further investigations (see biological quality elements) are complete, a potential minor localised effect on Specific Pollutants is assumed.	See background information in first paragraph of biological quality elements. No effect - compliance with EQS and RST toxicity standards.	Four of the scheme components are assessed as having a neutral effect on specific pollutants. However, ING4 is assessed as having a minor, localised adverse effect due to the potential for leaching of contaminants from landfill. The worst case (minor, localised adverse effects) is carried through.		Because of measure W16 to mitigate potential effect of leaching from Brook Street Landfill, neutral effect carried through.		
CHEMICAL STATUS	Priority substances and/or priority hazardous substances	As listed in the Environmental Quality Standards Directive, (2008/105/EC).	Good	Good by 2015	Physical modification of water feature will not cause deterioration to Chemical Status. No effect.			The risk of contaminants from the landfill leaching to the Ingrebourne could lead to the reduction in water quality within the water body, affecting chemical status. Until the further investigations (see biological quality elements) are complete, a potential minor localised effect on chemical status is assumed.	See background information in first paragraph of biological quality elements. No effect - compliance with EQS and RST toxicity standards.	Four of the scheme components are assessed as having a neutral effect on Chemical Status. However, ING4 is assessed as having a minor, localised adverse effect due to the potential for leaching of contaminants from landfill. The worst case (minor, localised adverse effects) is carried through.		Because of measure W16 to mitigate potential effect of leaching from Brook Street Landfill, neutral effect carried through.	No Effect	

Test B Potential to prevent future attainment of Good Ecological Status

	Effect of Scheme component on WFD element	Overall effect of Scheme on proposed measure
	Delivery of the Scheme will not compromise other planned RBMP Measures in the water body, nor the potential for other quality elements to help achieve GES. Hence the Scheme is not considered to prevent future attainment of GES. Of particular relevance is RMBP Measure 22480. This measure is described as "Re-meander 550m section of straightened section of the Ingrebourne upstream of the M25 Brook Street junction (Jcn. 28) by installing deflectors or re-meander where space allows.". A feasibility study was done on this section of river, and due to the constraints of the topography this has been decided against and so will not be going ahead. However, the scheme will not be affecting the future potential for work to be completed at this location and therefore does not prevent future attainment of Good Ecological Status.	No effect

*assumes that mitigations embedded in the Scheme are implemented.
** assumes additional mitigation measures are also implemented.

Water body: **Weald Brook** Part of the WFD Assessed Water body catchment **Ingrebourne GB106037028130**	

Code	WB1	WB2	WB3	WB4	WB5	WB6	WB7
Scheme component	Grove Bridge (loop road crossing of the Weald Brook and floodplain)	Construction of loop road over current alignment of Weald Brook	Maylands Bridge (A12 slip road crossing)	Duck Wood Bridge (northern loop crossing of Weald Brook and floodplain)	Weald Brook culvert extension (extension on M25 Weald Brook crossing)	Construction of Balancing Pond 1 and associated disturbance to landfill	Discharge of road runoff to natural drainage network
Watercourse	Main River	Main River	Main River	Main River	Main River	Main River	Main River
Location	TQ 56437 92231	TQ 56387 92251	TQ 56420 92244	TQ 56236 92667	TQ 56106 93233	Multiple locations	Multiple locations
Description	Crossing structure with low soffit. Embankments encroaching into floodplain. Pronounced shading of channel. Bank protection may be required. Loss/constriction of floodplain and riparian zone.	Construction of loop road over current alignment of Weald Brook. Realignment of channel.	A12 slip road overbridge crossing of Weald Brook and floodplain. Bridge structure with higher soffit (than ING3 and WB1), possible minor encroachment of embankment into floodplain on right bank. Shading of channel and riparian zone.	Loop road overbridge of Weald Brook and floodplain. Realignment of sinuous section of natural channel. Shading of channel and riparian zone possible, minor loss of riparian zone.	c 8m culvert extension to accommodate carriageway widening for slip road. Loss of c. 8m channel, riparian zone and floodplain.	Disturbance of Brook Street Landfill site at Grove Farm within 500m of Weald Brook and near ditches that drain to the Weald Brook. Potential for contamination of watercourse.	Treatment of runoff from road surfaces discharging into the Weald Brook and its tributaries to achieve compliance with EQS and RST toxicity standards.

Key

Colour	Meaning
dark blue	major beneficial effect
light blue	minor / localised beneficial effect
green	no effect
yellow	minor / localised adverse effect
orange	adverse widespread or prolonged effect
red	adverse effect on overall WFD status of water body

This assessment has been undertaken on the basis that a) all mitigation measures embedded in the Scheme (see drawings in Appendix A) are implemented and b) additional proposed mitigation measures set out in section 5 of the main report are also implemented.

Test A Potential to cause deterioration of current WFD Ecological Status

			Current Status	Status objective	Effect of Scheme component on WFD element* (WB1)	Effect of Scheme component on WFD element* (WB2)	Effect of Scheme component on WFD element* (WB3)	Effect of Scheme component on WFD element* (WB4)
ECOLOGICAL STATUS	Biological quality elements	Macrophytes and phytobenthos Macroinvertebrates Fish	None - not a WFD water body Within Ingrebourne WFD water body catchment (GB106037028130)		Permanent shading of the channel and riparian zone will result in a localised adverse effect on macrophytes and phytobenthos through a reduction in photosynthetic activity. The consequent reduction in habitats and food sources will reduce the abundance and diversity of invertebrates and fish. The bridge does not form a material barrier to fish migration. This effect is minimised by the use of a widespan bridge structure instead of a culvert (W10). Measures W2 and W11 are considered to further mitigate for the effect of the scheme component through river realignment and the minimisation of bank protection at this crossing through careful design. Accounting for this mitigation the bridge crossing is anticipated to have a minor, localised adverse effect.	Realignment of the Weald Brook to accommodate the loop road. The northern part of the realignment presents an opportunity to restore the channel to a condition closer to natural state. A more heterogeneous hydromorphology supports a more diverse range of habitats for macrophytes, phytobenthos, macroinvertebrates and fish. This scheme component is anticipated to have a minor localised beneficial effect.	Limited shading of the channel and riparian zone will result in a localised adverse effect on macrophytes and phytobenthos through a reduction in photosynthetic activity. The consequent reduction in habitats and food sources will reduce the abundance and diversity of invertebrates and fish. The bridge does not form a barrier to fish migration. This effect is minimised by the use of a high bridge structure that spans the floodplain associated with higher frequency events (W10). Measures W2 and W11 are considered to further mitigate for the effect of the scheme component through river realignment and the minimisation of bank protection at this crossing through careful design. Accounting for this mitigation the bridge crossing is anticipated to have a minor, localised adverse effect.	Partial shading of the channel and riparian zone will result in a localised adverse effect on macrophytes and phytobenthos through a reduction in photosynthetic activity. The consequent reduction in habitats and food sources will reduce the abundance and diversity of invertebrates and fish. The bridge does not form a barrier to fish migration. This effect is minimised by the use of a widespan bridge structure instead of a culvert (W10). Measures W2 and W11 are considered to further mitigate for the effect of the scheme component through river realignment and the minimisation of bank protection at this crossing through careful design. Accounting for this mitigation the bridge crossing is anticipated to have a minor, localised adverse effect.
	Physico-chemical quality elements	Physico-chemical quality elements comprise total phosphorus, salinity, dissolved oxygen, pH, acid neutralising capacity.			The introduction of embankments / bank protection is not considered to effect the physico-chemical condition of the channel.	The realignment of the Weald Brook is not anticipated to have a material effect on the physico-chemical quality elements. No effect.	High level bridge structure is not considered to effect the physico-chemical condition of the channel.	A more uniform channel planform may cause minor, localised detriment to physico-chemical quality elements. See text on mitigation in second paragraph of biological quality elements. Accounting for this mitigation the bridge crossing is anticipated to have a minor, localised adverse effect.
	Hydro-morphological quality elements	Hydro-morphological quality elements: Hydrological Regime (e.g. quantity and dynamics of flow and connection to groundwater) and Morphology (e.g. river continuity, river depth and width variation, structure and substrate of river bed, and structure of riparian zone). However, for a HMWB the assessment of this quality element needs to account for the designated use of the water body.			Channel straightening immediately underneath the bridge, loss of riparian zone due to shading and the constriction of the floodplain could adversely affect the hydro-morphological condition of the channel. See text on mitigation in second paragraph of biological quality elements. Accounting for this mitigation the bridge crossing is anticipated to have a minor, localised adverse effect.	Realignment of the Weald Brook to accommodate the loop road. The northern part of the realignment presents an opportunity to restore the channel to a condition closer to natural state including a more heterogeneous hydromorphology. This scheme component is anticipated to have a minor localised beneficial effect.	Channel straightening immediately underneath the bridge and compromise of riparian zone due to shading could adversely affect the hydro-morphological condition of the channel. See text on mitigation in second paragraph of biological quality elements. Accounting for this mitigation the bridge crossing is anticipated to have a minor, localised adverse effect.	Channel realignment will markedly reduce the morphological and hydrological complexity (less dynamic flow, more uniform river morphology, less complex sediment processing and loss of riparian zone). See text on mitigation in second paragraph of biological quality elements. Accounting for this mitigation the bridge crossing is anticipated to have a minor, localised adverse effect.
	Specific pollutants	As listed in Annex VIII of the Water Framework Directive.			Physical modification of water feature will not cause deterioration to the Specific Pollutant quality elements.			
CHEMICAL STATUS	Priority substances and/or priority hazardous substances	As listed in the Environmental Quality Standards Directive, (2008/105/EC).			Physical modification of water feature will not cause deterioration to Chemical Status.			

			Effect of Scheme component on WFD element* (WB5)	Effect of Scheme component on WFD element* (WB6)	Effect of Scheme component on WFD element* (WB7)	Overall effect of Scheme on WFD element
ECOLOGICAL STATUS	Biological quality elements	Macrophytes and phytobenthos Macroinvertebrates Fish	The extension of the current culvert by c. 8m to accommodate a new slip road, will result in the loss of c. 8m of open channel. Loss of open channel, marginal and riparian vegetation will have an impact upon a) the macrophyte and phytobenthos quality element as shading will stop photosynthetic activity in parts of the channel and reduce it in others so growth of macrophytes and phytobenthos will be reduced; b) the macroinvertebrate quality element due to the loss of habitat resulting from reduction in / loss of aquatic and riparian vegetation; and c) a loss of habitat for fish. Measures W2 and W8 are considered to mitigate for the effect of this culvert extension through river realignment and depressed inverts and natural beds on culvert extensions. Accounting for this mitigation the culvert is anticipated to have a minor, localised adverse effect.	The proposed construction of balancing pond No 1 will disturb the Brook Street Landfill site. Disturbance could lead to the leaching of contaminants from the landfill into the watercourse. Changes in water quality would impact on the habitats for all the biological elements. It would be likely that the diversity of the elements would decrease as only some species would be suited to that type of environment. The results of a Preliminary Ground Investigation are reported under the Baseline conditions section of Chapter 10 of the Environmental Statement (Geology and Soils). This concluded that the risks to controlled waters from contamination within the landfill, associated with the proposed development, are considered to be low. Further investigations in the form of a full Ground Investigation and associated assessment are required to confirm this preliminary conclusion. Until these further investigations are complete we have taken a precautionary approach to assume a minor localised adverse effect on the water body.	Based on currently available information a design for road drainage has been developed to achieve compliance with relevant EQS / RST toxicity and sediment standards as tested with HAWRAT. A combination of dry attenuation ponds and ditches are the proposed mitigation for surface water quality mitigation. Sediment catch-pits are proposed for sediment mitigation. Runoff generated by non-highway surfaces, such as embankments, is collected and conveyed to natural waters by pre-embankment drains (W12). Compliance with the EQS / RST toxicity and sediment standards will contribute to safeguarding the number and diversity of a) macrophytes and phytobenthos b) the habitats available for macroinvertebrates and c) fish populations, particularly at early stages of life when they are vulnerable to suffocation. No effect.	There are two scheme components that have a neutral or positive effect on the biological quality elements (WB2 & WB7). However, the remainder are considered to have a minor, localised adverse effect. The worst case (minor, localised adverse effect) is carried through.
	Physico-chemical quality elements	Physico-chemical quality elements comprise total phosphorus, salinity, dissolved oxygen, pH, acid neutralising capacity.	A culvert extension is not considered to have an effect on the physico-chemical condition of the channel. No effect.	Potential contaminants from the Brook Street Landfill Site leaching into Weald Brook could have an adverse effect on the physico-chemical quality elements in the water body, such as phosphorus and pH. Until further investigations (see biological quality elements) are complete we have taken a precautionary approach and assumed a minor, localised adverse effect on the water body.	See background information in first paragraph of biological quality elements. Compliance with EQS/RST toxicity and sediment standards will generate physico-chemical conditions more conducive to supporting healthy biological quality elements. No effect.	Five of the scheme components are assessed as having no effect on the physico-chemical quality elements of the water body. However, two are assessed as having a minor, localised adverse effect. The worst case (minor, localised adverse effects) is carried through.
	Hydro-morphological quality elements	Hydro-morphological quality elements: Hydrological Regime (e.g. quantity and dynamics of flow and connection to groundwater) and Morphology (e.g. river continuity, river depth and width variation, structure and substrate of river bed, and structure of riparian zone). However, for a HMWB the assessment of this quality element needs to account for the designated use of the water body.	The culvert extension by c.8m will reduce the morphological and hydrological complexity (less dynamic flow, more uniform river morphology, reduction in river continuity and loss of riparian zone). See text on mitigation in second paragraph of biological quality elements. Accounting for this mitigation the culvert is anticipated to have a minor, localised adverse effect.	Potential contaminants from the Brook Street Landfill Site leaching into the Weald Brook is not expected to have an adverse effect on the hydro-morphological quality elements. The contaminants leaching are not expected to increase the silt input to the watercourse or impact on the quantity or dynamics of flow. Considered to have no effect.	See background information in first paragraph of biological quality elements. Compliance with toxicity standards will generate hydro-morphological conditions more conducive to supporting healthy biological quality elements. Controlling silt inputs from the road will limit additional fines in the aquatic sediment system. No effect.	There are three scheme components that have a neutral or positive effect on the hydro-morphological quality element (WB2, WB6 & WB7). However, the remainder are considered to have a minor, localised adverse effect. The worst case (minor, localised adverse effect) is carried through.
	Specific pollutants	As listed in Annex VIII of the Water Framework Directive.	Physical modification of water feature will not cause deterioration to the Specific Pollutant quality elements.	The risk of contaminants from the landfill leaching to the Weald Brook could adversely effect Specific Pollutants. Until the further investigations (see biological quality elements) are complete, a potential minor localised effect on Specific Pollutants is assumed.	See background information in first paragraph of biological quality elements. No effect - compliance with EQS and RST toxicity standards.	Six of the scheme components are reported as having no effect on specific pollutants. One scheme component is assessed as having a minor, localised adverse effect on specific pollutants due to contamination of the water quality from landfill leaching (WB6). The worst case (minor, localised adverse effect) is carried through.
CHEMICAL STATUS	Priority substances and/or priority hazardous substances	As listed in the Environmental Quality Standards Directive, (2008/105/EC).	Physical modification of water feature will not cause deterioration to Chemical Status.	The risk of contaminants from the landfill leaching to Weald Brook could lead to the reduction in water quality within the water body, affecting chemical status. Until the further investigations (see biological quality elements) are complete, a potential minor localised effect on chemical status is assumed.	See background information in first paragraph of biological quality elements. No effect - compliance with EQS and RST toxicity standards.	Six of the scheme components are reported as having no effect on chemical status. One scheme component is assessed as having a minor, localised adverse effect on chemical status due to contamination of the water quality from landfill leaching (WB6). The worst case (minor, localised adverse effect) is carried through.

			Additional Proposed Mitigation Measures	Residual effect of Scheme on WFD element**	Effect of Scheme on ecological / chemical status	Overall effect of Scheme on water body status
ECOLOGICAL STATUS	Biological quality elements	Macrophytes and phytobenthos Macroinvertebrates Fish	The following additional mitigations are proposed for the Weald Brook water body: Measure W14 - to prevent excessive scour or "wash-out" of bed material immediately downstream of Weald Brook culvert extension (WB5). Measure likely to include construction of artificial riffle feature downstream of culvert or selective use of bed and bank protection. Measure W15 - to facilitate mammal passage through Weald Brook culvert extension (WB5) during higher than normal flows. The form of such measures needs to be determined at detailed design, but often comprise a shelf along which mammals can move, together with ramps for mammal access and egress. Proposed mitigation for WB6, if further investigations suggest leaching from Brook Street Landfill Site is likely, is to line Balancing Pond No.1 (W16). This will address leaching of contaminants into the Weald Brook.	Even accounting for the effects of the additional mitigation, minor, localised adverse effects to biological quality elements will still remain.	Minor localised adverse effect	**Minor localised adverse effect**
	Physico-chemical quality elements	Physico-chemical quality elements comprise total phosphorus, salinity, dissolved oxygen, pH, acid neutralising capacity.		Even accounting for the effects of the additional mitigation, minor, localised adverse effects to physico-chemical quality elements will still remain.		
	Hydro-morphological quality elements	Hydro-morphological quality elements: Hydrological Regime (e.g. quantity and dynamics of flow and connection to groundwater) and Morphology (e.g. river continuity, river depth and width variation, structure and substrate of river bed, and structure of riparian zone). However, for a HMWB the assessment of this quality element needs to account for the designated use of the water body.		Even accounting for the effects of the additional mitigation, minor, localised adverse effects to hydro-morphological quality elements will still remain.		
	Specific pollutants	As listed in Annex VIII of the Water Framework Directive.		The proposed mitigation for WB6 should reduce the effect from minor localised adverse effect to no effect by stopping the leaching of contaminants. No effect.		
CHEMICAL STATUS	Priority substances and/or priority hazardous substances	As listed in the Environmental Quality Standards Directive, (2008/105/EC).		The proposed mitigation for WB6 should reduce the effect from minor localised adverse effect to no effect by stopping the leaching of contaminants. No effect.	No effect	

Test B Potential to prevent future attainment of Good Ecological Status

		Effect of Scheme component on WFD element	Overall effect of Scheme on proposed measure	
	Delivery of the Scheme will not compromise other planned RBMP Measures in the water body, nor the potential for other quality elements to help achieve GES. Hence the Scheme is not considered to prevent future attainment of GES. Note there are no RMBP measures assigned to this section of Weald Brook			

*assumes that mitigations embedded in the Scheme are implemented.
** assumes additional mitigation measures are also implemented.

Appendix C. River corridor survey

Technical note

Project:	M25 J28 Improvement	Client:	Highways England
Subject:	River Corridor Surveys	From:	[redacted]
Date:	8 Nov 2017	Reviewed:	[redacted]

Introduction

The purpose of this report is to detail the findings of the River Corridor Surveys (RCSs) undertaken on the Weald Brook and Ingrebourne River, near Brentwood Essex on 2 November 2017. These surveys were undertaken as part of the M25 junction 28 improvement scheme (the Scheme) for Highways England and provides baseline ecological and geomorphological data for the reaches surveyed.

These watercourses, in the south west corner of junction 28 of the M25 (junction with the A12) were identified as being potentially impacted by the improvement scheme. In addition to RCS other ecological surveys and assessments have been undertaken (including aquatic macro-invertebrate survey and electric fishing), details of which can be found in the Aquatic Survey Report, Appendix 7.6 of the Environmental Statement.

This report details the four RCSs undertaken on the Weald Brook and Ingrebourne River with the aim to provide baseline information to assess potential impacts from the Scheme.

Background

The survey area is located in the north west corner of junction 28 of the M25. The Ingrebourne River flows into the survey area underneath the M25 from its source in Brentwood, approximately 3 km to north east. The Weald Brook enters the survey area from the north west, originating in Navestock Common and South Weald Common approximately 3 km away. The confluence of the two rivers is in the south-eastern corner of the survey area, shortly before it flows beneath the A12 in a south easterly direction. Figure 1 shows the location of the Weald Brook and River Ingrebourne.

These watercourses are part of the Ingrebourne River Water Framework Directive (WFD) waterbody (Waterbody ID GB106037028130) and are not designated as artificial or heavily modified. The current overall WFD status for this waterbody is Moderate (Good for chemical elements, Moderate for biological elements)[1]. The Ingrebourne River flows for 40 km before joining the River Thames at Rainham.

Underlaying geology within the survey area is London Clay (consisting of clay, silt and sand) with superficial deposits alluvium (with clay, silt and sand)[2]. No statutory designated sites of nature conservation interest are within the river corridor, although it is as part of the locally designated Ingrebourne Valley Site of Metropolitan Importance for Nature Conservation[3] and the Manor Local Nature reserve (also known as Dagnam Park) is approximately 500 m west of the Weald Brook. The nature reserve comprises acid and neutral grassland along with ancient and secondary woodland.

Method

The RCS's were undertaken as per the methodology within the National Rivers Authority "River Corridor Surveys – Technical Handbook No 1"[4]. For this scheme, three 500 m reaches were identified using Ordnance Survey mapping for the Weald Brook. Only 270 m of the Ingrebourne River were surveyed between the culvert beneath the M25 and the confluence with the Weald Brook. The reaches surveyed for this Scheme are shown in Figure 2 and summarised in Table 1.

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[1] Environment Agency Catchment Data Explorer website http://environment.data.gov.uk/catchment-planning/WaterBody/GB106039017890 accessed November 2017.
[2] British Geological Society website, accessed November 2017.
[3] Within Greater London, Sites of Importance for Nature Conservation (SINCs) are sub-divided into Sites of Metropolitan Importance (SMI); Sites of Borough Importance (SBI) - Grade 1 or Grade 2; and Sites of Local Importance (SLI).
[4] NRA Technical Handbook 1 - River Corridor Surveys. (1991). National Rivers Authority.

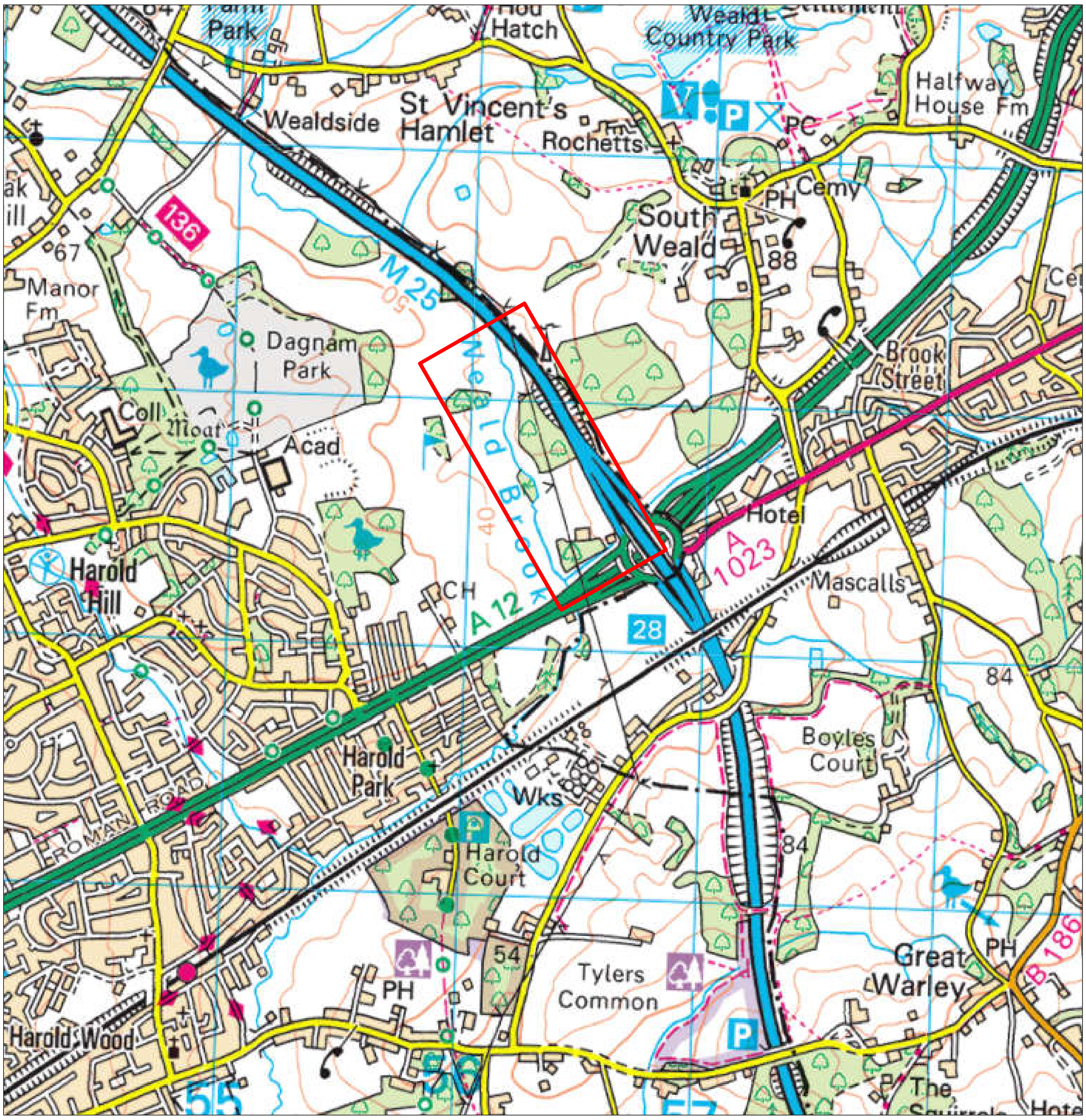
Technical note

Table 1. List of reaches surveyed

Watercourse	Reach	Upstream NGR	Downstream NGR	Length
River Ingrebourne	1	TQ 56660 92385	TQ 56458 92211	270 m
Weald Brook	1	TQ 56108 93235	TQ 56132 92856	500 m
	2	TQ 56132 92856	TQ 56288 92572	500 m
	3	TQ 56288 92572	TQ 56458 92211	500 m

The survey methodology is a habitat based approach, recording details of the more dominant vegetation and physical structures identified within the reach, rather than comprehensive species accounts. This information is gathered and recorded in the form of a map using a set of standard symbols and abbreviations. The RCS maps produced for each reach are presented in this technical note with accompanying keys to identify the ecological and geomorphological features present (see Annex 1 for a key to the symbols and Annex 2 for plant species and abbreviations used in production of the maps), along with a summary description of the reach and information taken from a desk study prior to undertaking the survey.

Technical note



Contains Ordnance Survey data. © Crown copyright and database rights 2017 Ordnance Survey

Figure 1. Location of Ingrebourne Brook and Weald Brook nr. Romford (survey area in red)

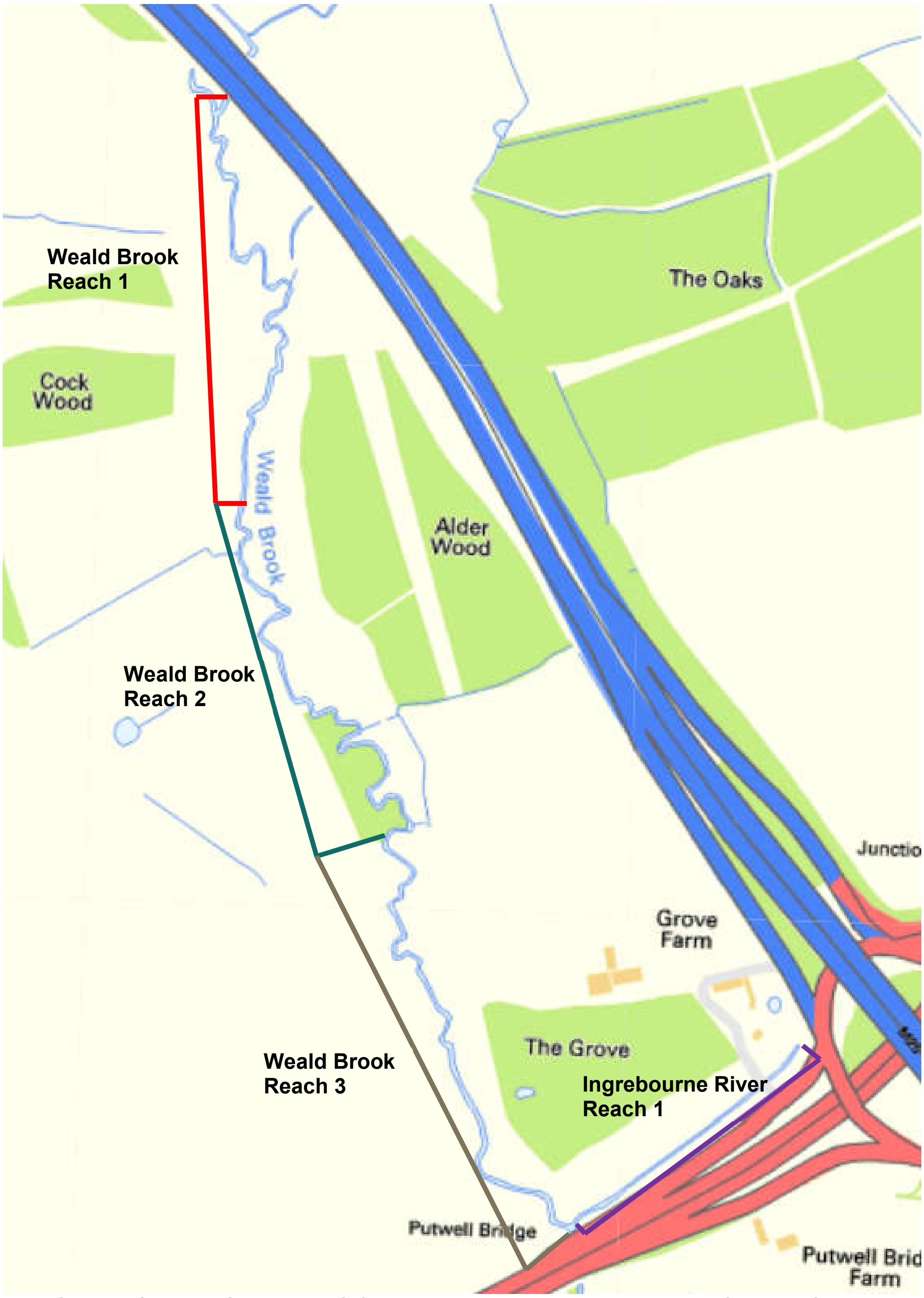


Figure 2. Reaches of the Weald Brook and Ingrebourne River surveyed

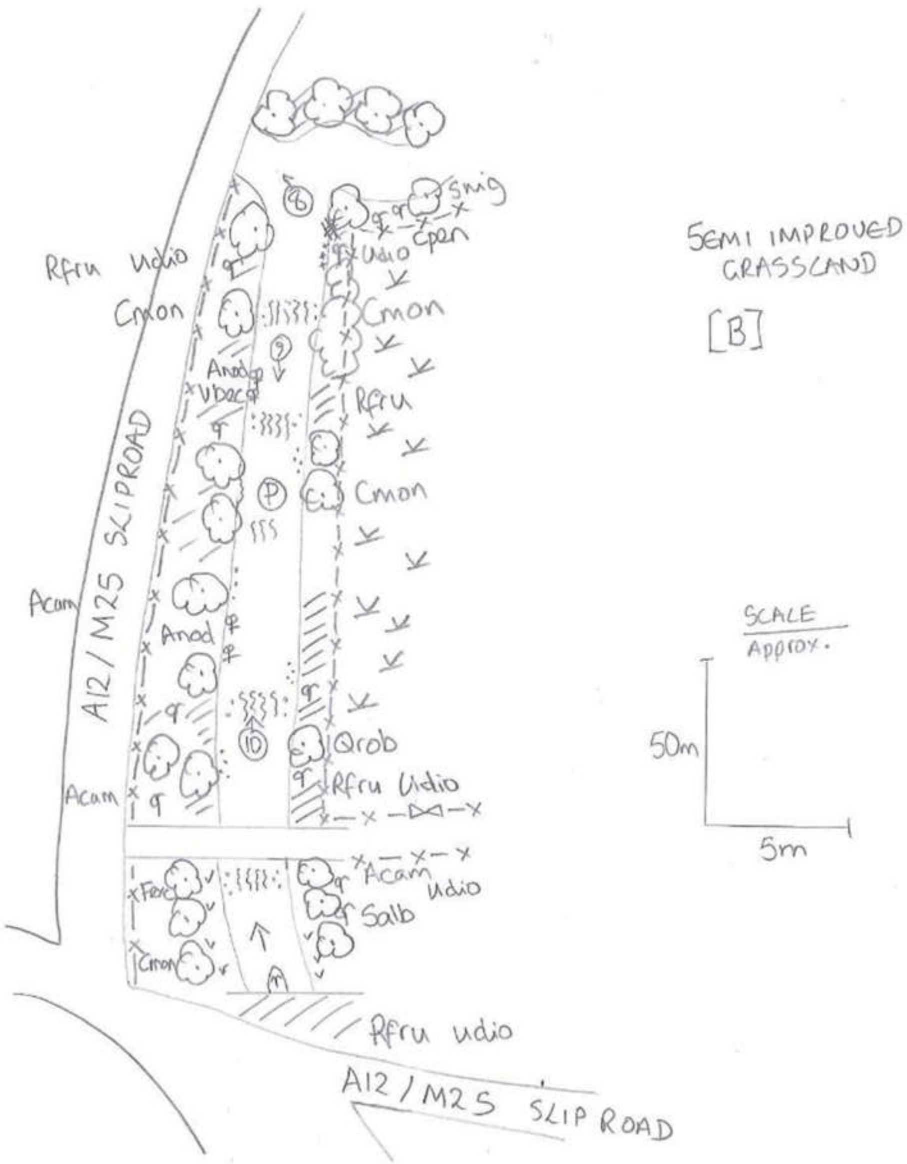
Technical note

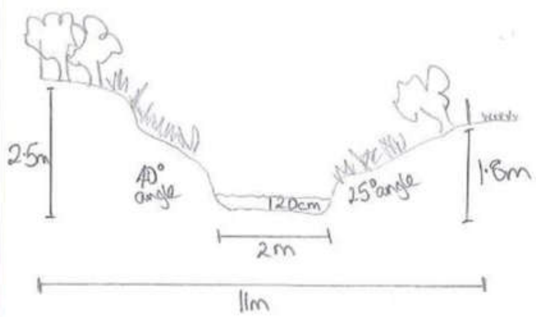
Survey data – River Ingrebourne Reach 1

River Corridor Survey Map

River:	Section:	NGR u/s: / NGR d/s:		Date:
INGREBOURNE	1	NGR u/s: TQ 56660 92385 NGR d/s: TQ 56458 92211	[redacted]	2/11/17

NOT 500M = THIS SECTION 270M.





Depth:	20cm
Flow:	Low
Level:	low
Clarity:	Clear
Substrate:	GRAVEL / SAND / SILT

Technical note

Summary description of River Ingrebourne Reach 1

Broad nature

The Ingrebourne River in this reach has been historically straightened to run adjacent to the A12/M25 slip road. At the most upstream point the river flows beneath the M25 from a north-easterly direction through a double box culvert. As it flows adjacent to the slip road, it is shaded by a variety of tree species and hedgerows. While there is very little sinuosity within the channel, there are five riffles through the reach and areas of erosion and deposition occurring along the margins. The dominant flow type recorded was smooth glide. At the downstream end of the surveyed reach is the confluence with the Weald Brook which has resulted in a slow flowing, deeper section with increased sedimentation.

Dimensions

The wetted width of the channel varied little through the reach, and was at most 2.5 m wide with areas of riffles or gravel deposits being approximately 1.5m wide. Average depth throughout the reach was approximately 0.2 m with deeper areas at the downstream end, of approximately 0.4 m.

Substrate

Water clarity was good at the time of survey, with the bed visible throughout the survey reach. The substrate was predominantly gravel and pebble with some areas of silt, particularly in slow flowing areas such as the downstream end close to the confluence with the Weald Brook.

Bank structure and vegetation

An embankment flanks the left bank (A12/M25 slip road) for the entire length of the reach which is approximately 2.5 m high. There is an embankment along the right bank which at the upstream end is approximately the same height as the left. An access road crosses the river approximately 40 m from the upstream end of the reach. From here the embankment gradually reduces in height to bank top at the confluence. The left bank is steep, at approximately 40°. Downstream of the access road, the right bank is shallower at approximately 25°. Both banks are vegetated with a mixture of grass, tall herbs, shrubs and trees. The bank height is approximately 0.4 m on both banks. Bank material was earth with potential signal crayfish burrows identified at the downstream end.

Side channels / structures

An access road crosses the river approximately 40 m from the upstream end of the reach. At the downstream end the river is joined by the Weald Brook.

Instream / marginal vegetation

Aquatic vegetation within this reach was limited to fool's water-cress (*Apium nodiflorum*) and brooklime (*Veronica beccabunga*) in the margins, with most of the channel devoid of vegetation. Filamentous algae was also recorded. In places, the bankside vegetation such as grasses and herbs overhung the river channel.

Bank vegetation

Bankside vegetation was dominated by a mix of trees and shrubs, including field maple (*Acer campestre*), oak (*Quercus robur*) and alder (*Alnus glutinosa*), with extensive areas of hawthorn (*Crataegus monogyna*) hedgerows, particularly on the left bank. Where light and space was available below trees, the understory consisted of predominantly of bramble (*Rubus fruticosus*), nettle (*Urtica dioica*) and other tall herbs. A small amount of Himalayan Balsam (*Impatiens glandulifera*) was present at the culvert under the M25.

Adjacent land use

The left hand bank was flanked by the A12/M25 slip road, the right bank by semi-improved grassland/pasture.

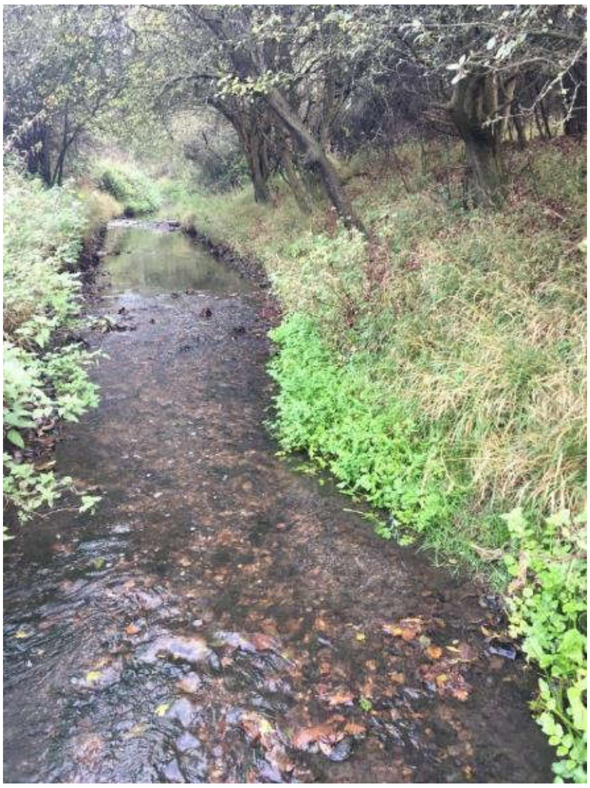
Management recommendations and enhancement opportunities

This channel has a mix of habitats suitable for a variety of fish and aquatic macro-invertebrate species, with a number of riffles, tree roots and marginal vegetation present throughout.

However, it has been historically straightened and would benefit from restoration, including restoring sinuosity (e.g. through berm installation), creating backwaters and introduction of woody debris. Increasing the light entering the channel by selective removal of bankside trees and hedgerows is likely to act to improve ecological condition through improved distribution and abundance of in-stream vegetation.

Photos

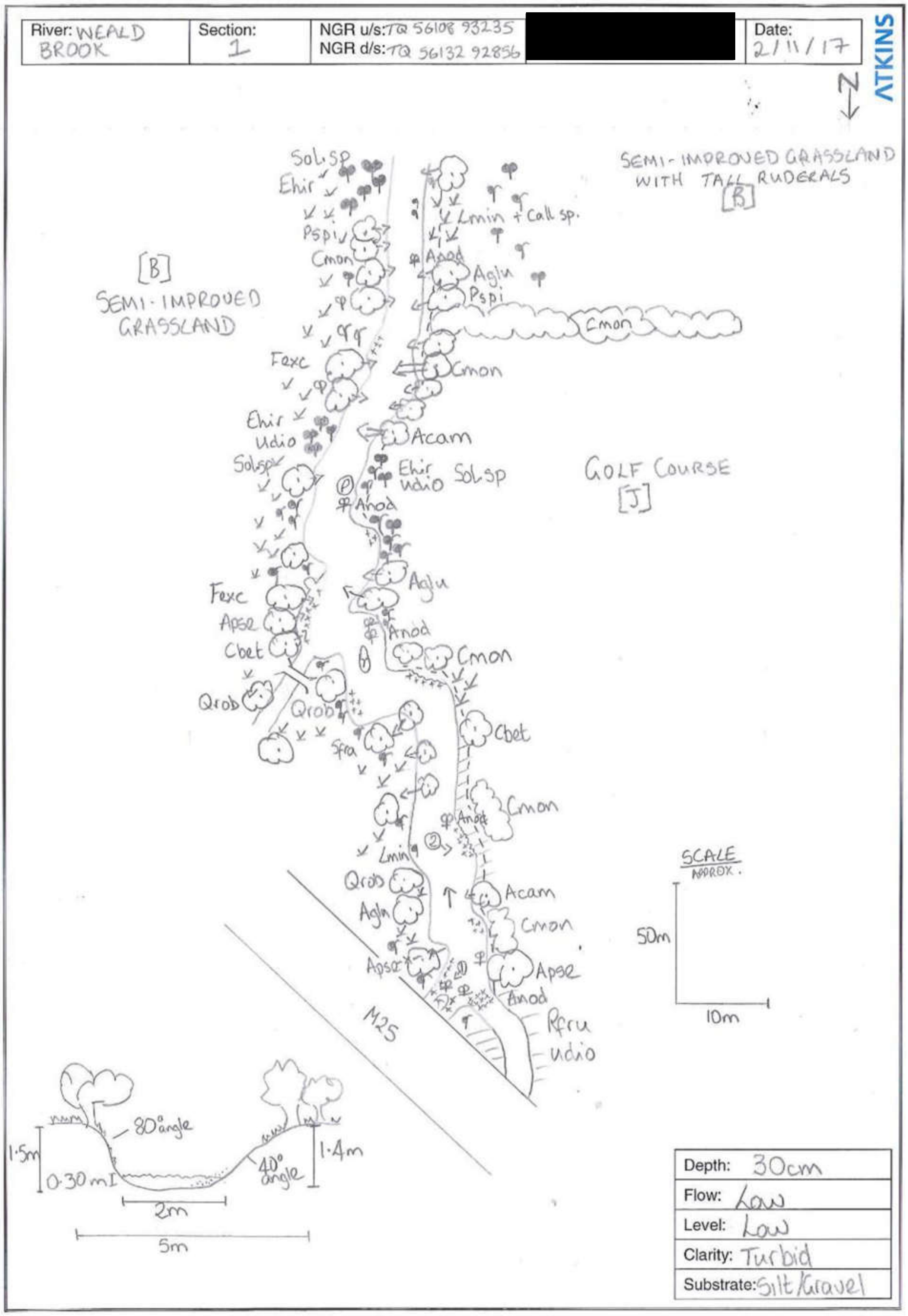
Photo locations are indicated on the RCS map with the following symbol ①→

Photo 8	Photo 9
	
Photo 10	
	

Technical note

Survey data – Weald Brook – Reach 1

River Corridor Survey Map



Summary description of Weald Brook Reach 1

Broad nature

This reach was heavily shaded by mature trees and scrub along both banks, primarily consisting of alders and hawthorn. The watercourse flows from the north-east beneath the M25. The channel is wide at the most upstream end (approximately 3 m), with a vegetated mid-channel bar. The bed substrate at this location appears reinforced with cobble, although downstream the substrate quickly changes to silt with occasional areas of gravel. This reach meanders through a golf course on the right bank and rough pasture and scrub on the left bank with large amounts of woody debris and fallen trees within the channel. The wetted width is variable through the reach as a result of woody debris accumulations and silt deposition. Where the bankside canopy is open, small areas of aquatic vegetation are present.

Dimensions

The average bank top width was approximately 2 m with the wetted width varying greatly between 0.5 m and 1.5 m. Average depth was approximately 0.3 m with shallower areas caused by woody debris and silt deposition. There was no perceptible flow through much of the reach, with smooth flow evident in narrow sections of the channel.

Substrate

The reach was heavily sedimented with frequent silt marginal bars and occasional gravel/pebble accumulations. At the upstream end, where the river flows from beneath the M25, the bed is reinforced with cobbles.

Bank structure

Both banks consist of earth and are both approximately 1.5 m high. The right bank has a more gentle slope towards the golf course, while the left hand bank is at approximately 80°.

Side channels / structures

A small side channel is present at the most upstream end. It was discharging a small flow volume to the Weald Brook at the time of survey despite being blocked by debris. A larger side channel is present approximately half way down the reach, which is crossed by a footbridge. There is a large amount of woody debris and fallen trees within the reach which create natural obstructions to water flow and add habitat complexity.

Instream / marginal vegetation

Due to heavy shading, there was very little instream or marginal vegetation. Occasionally, where there was a break in the canopy shading, there were small patches of fool's water-cress, duck weed (*Lemna minor*), starwort (*Callitriche* species) and celery-leaved buttercup (*Ranunculus sceleratus*).

Bank vegetation

Large mature trees occurred along both banks (including dead specimens), with many overhanging the channel. Dominant tree species included hawthorn, ash (*Fraxinus excelsior*), field maple, oak, alders and sycamore (*Acer pseudoplatanus*). A dense understory consisted of nettle, willowherb (*Epilobium hirsutum*), goldenrod (*Solidago* species) and bramble. A small amount of Himalayan balsam was present at the culvert under the M25.

Adjacent land use

Beyond the mature trees and tall herbs, a golf course was on the right bank, with rough pasture at the most downstream end. Rough pasture with tall herbs occurred along the entire length of the left bank.

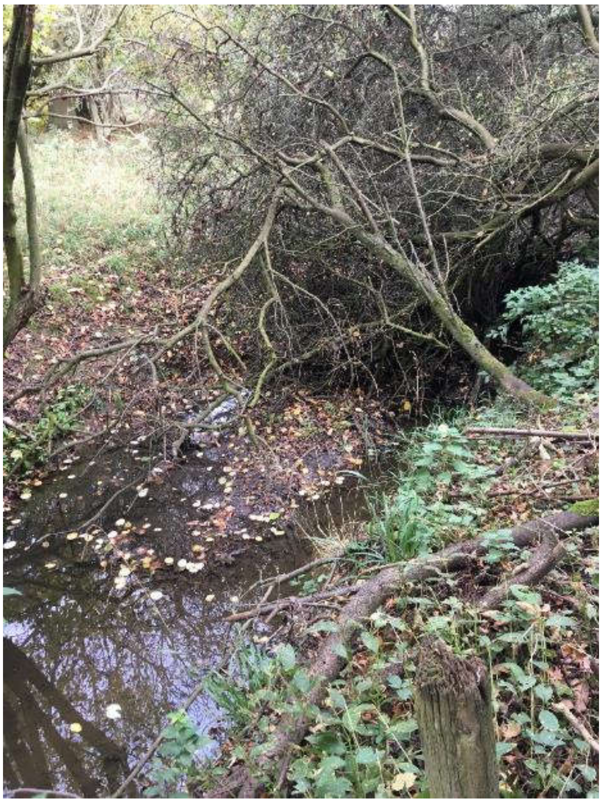
Management recommendations and enhancement opportunities

This reach is heavily shaded by bankside trees, hedgerows and scrub. Removing occasional trees from the bank top could improve the amount of in-channel and marginal vegetation present.

Technical note

Photos

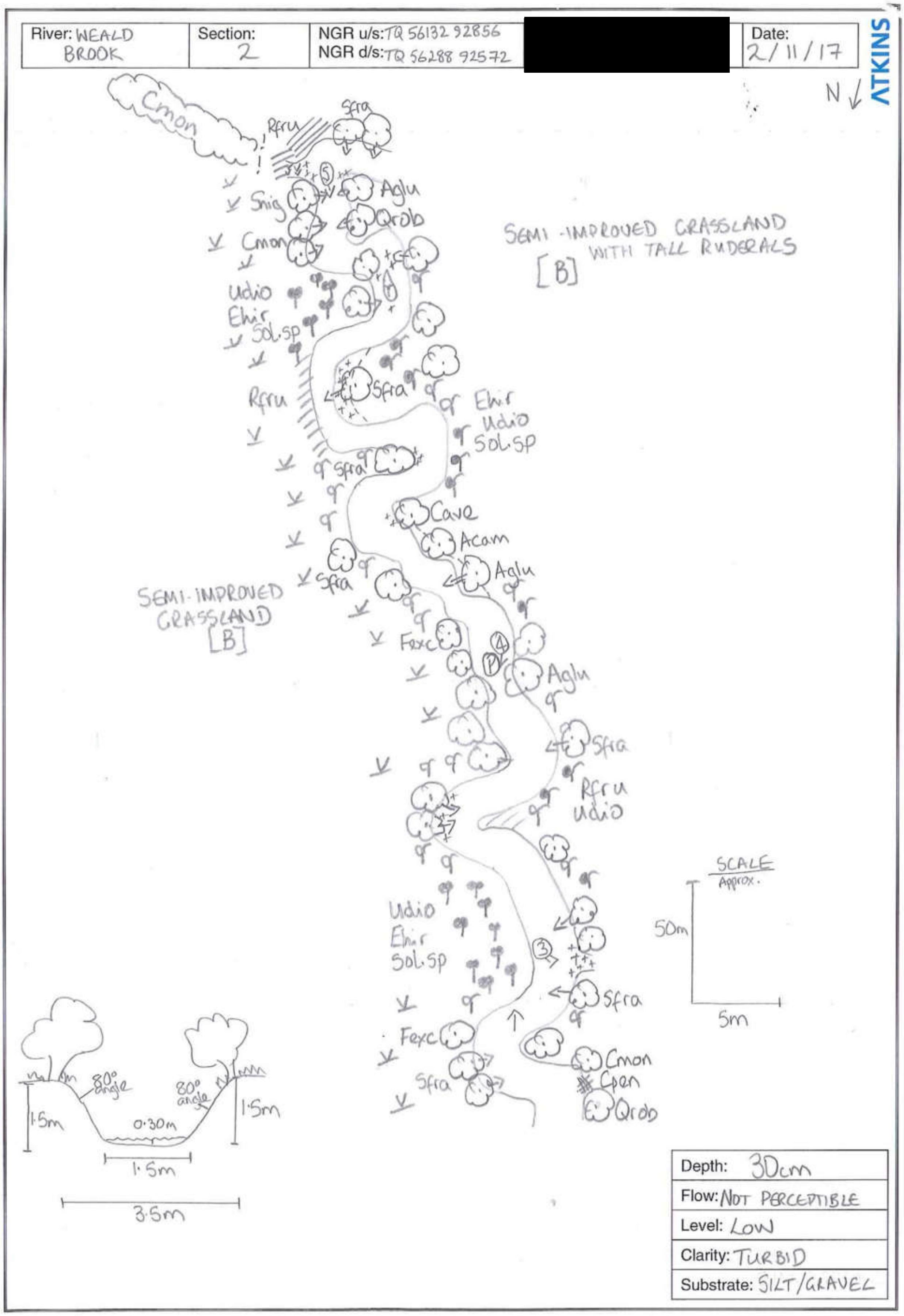
Photo locations are indicated on the RCS map with the following symbol ①→

Photo 1	Photo 2
	

Technical note

Survey data – Weald Brook Reach 2

River Corridor Survey Map



Technical note

Summary description of the Weald Brook Reach 2

Broad nature

This reach was heavily shaded by mature trees and scrub along both banks, primarily consisting of crack-willow (*Salix fragilis*), with field maple, alders and hawthorn. The watercourse flows north to south through a naturally sinuous channel. The bed substrate consists of large amounts of silt with occasional gravel. Many of the trees overhang the channel with occasional instances of mature trees growing in the channel. The bank top width is narrower than upstream reach, at an average of 1.5 m. Wetted width ranged from 0.1 m to 2.5 m. Adjacent land use on both banks consisted of rough pasture with large stands of goldenrod and nettle.

Dimensions

The average bank to bank width was approximately 1.5 m with the wetted width varying greatly due to wide meanders and in-channel trees, between 0.1 m and 2.5 m. Average depth was approximately 0.3 m with shallower areas caused by woody debris and silt deposition. There was no perceptible flow through much of the reach, with smooth flow evident in narrower sections of the channel.

Substrate

The reach was heavily sedimented with frequent silt marginal bars and very occasionally gravel/pebble deposits.

Bank structure

Both banks consist of earth and are both approximately 1.5 m high. Both banks have a steep slope, at approximately 80°.

Side channels / structures

Three side channels were identified during the survey, all were dry at the time of survey, but are likely to act as field drainage discharge points during wet periods. There is a large amount of woody debris, fallen trees and in-channel trees within the reach, which create natural obstructions to water flow and add habitat complexity.

Instream / marginal vegetation

Due to heavy shading from trees no in-stream or marginal vegetation was present. A vegetated mid-channel bar was present with terrestrial grasses and herbs.

Bank vegetation

Large mature trees occurred along both banks (including dead specimens), with many overhanging the channel. The dominant tree species in this reach was crack-willow, with hawthorn, field maple and alders. A dense understory consisted of nettle, goldenrod, willowherb and bramble.

Adjacent land use

Rough pasture with tall herbs, ran the entire length of the left bank. Extensive stands of goldenrod and nettle were present on the left bank.

Management recommendations and enhancement opportunities

This reach is heavily shaded by bankside trees, hedgerows and scrub. Removing occasional trees could improve the amount of in-channel and marginal vegetation present.

Technical note

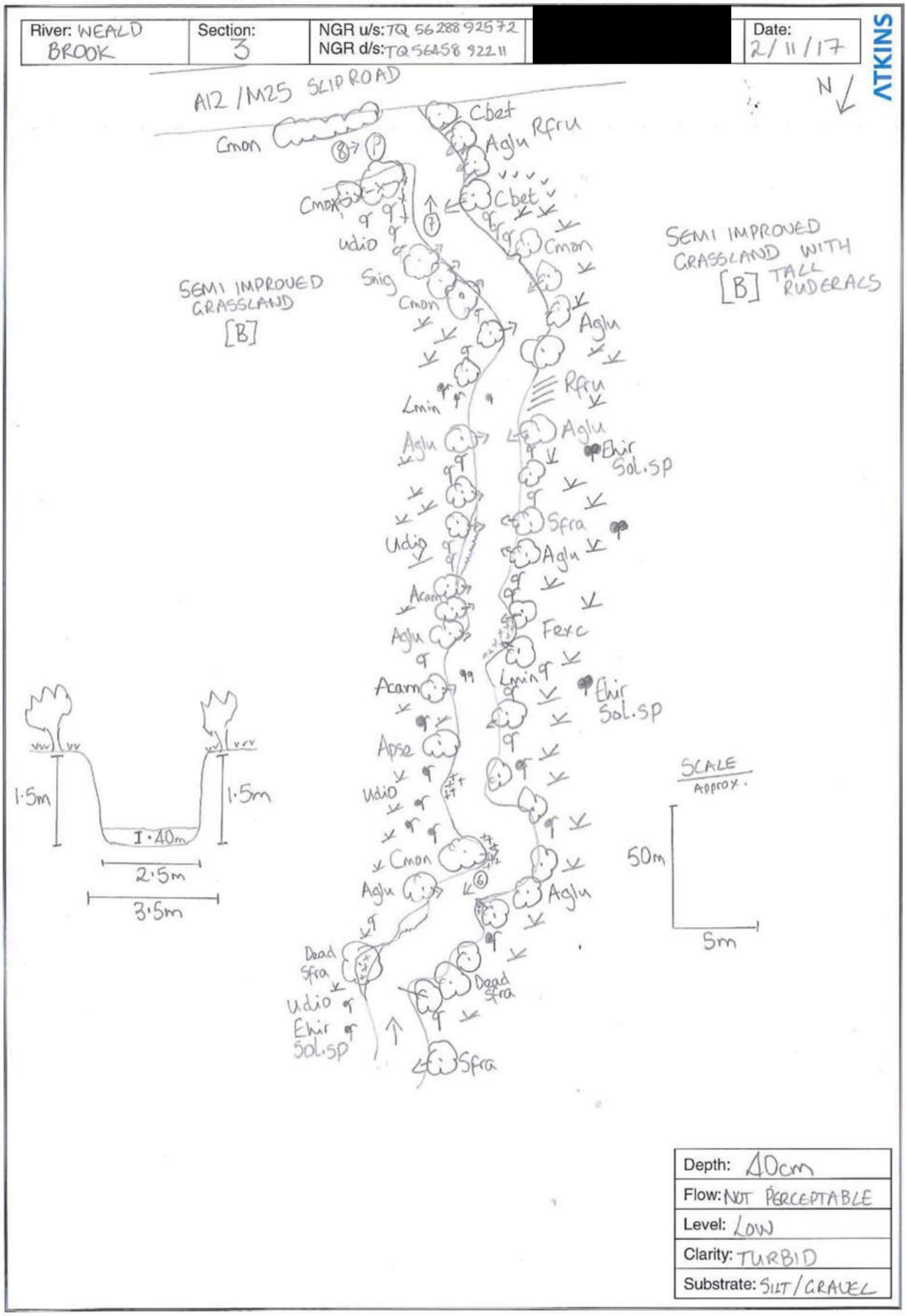
Photos

Photo locations are indicated on the RCS map with the following symbol ①→

Photo 3	Photo 4
	
Photo 5	
	

Survey data – Weald Brook Reach 3

River Corridor Survey Map



Technical note

Summary description of the Weald Brook Reach 3

Broad nature

In common with Reach 1 and Reach 2 this reach was also heavily shaded by mature trees and scrub along both banks, primarily consisting of alders, hawthorn and hornbeam (*Carpinus betulus*). The channel in this reach becomes less sinuous in the downstream direction, due in part to the impoundment caused by the confluence with the Ingrebourne River at the downstream end. Upstream, the channel is more sinuous with the wetted width varying due to silted side bars. Downstream the watercourse is deeper and consistently wider. Where the bankside canopy is open, small areas of aquatic vegetation were recorded.

Dimensions

At the most upstream end, the wetted width varies between and 1 m and 2 m with a depth of approximately 0.25 m. Soon the wetted width fills the entire channel which widens to approximately 2.5m with a depth of approximately 0.4m. There was no perceptible flow through this reach.

Substrate

The reach was heavily sedimented with occasional silt marginal bars. Moving downstream, the turbid water prevented visibility of the bed but it is presumed that silt substrate remains dominant.

Bank structure

Both banks consist of earth and are both approximately 1.5 m high and approximately 80°. Some liverworts were present on the bank face in the downstream section of the reach.

Side channels / structures

No side channels were present, other than the confluence with the River Ingrebourne. Woody debris in the upstream section creates some natural obstructions to water flow.

Instream / marginal vegetation

Where there was a break in the canopy shading, there were small patches of duck weed.

Bank vegetation

Large mature trees occurred along both banks (including dead specimens), with many overhanging the channel. Dominant tree species included hornbeam, alder and hawthorn. Upstream a dense mix of tall grass and herbs was present beneath and between trees on both banks. Growth became less dense further downstream.

Adjacent land use

Rough pasture with tall herbs, ran the entire length of both banks.

Management recommendations and enhancement opportunities

It is likely that heavy shading by the mature broadleaved woodland has limited the presence of any in-channel and marginal aquatic macrophytes. The removal of occasional trees and/or scrub to allow more light into the channel could encourage aquatic macrophytes to establish within this reach.

Photos

Photo locations are indicated on the RCS map with the following symbol ①→

Photo 6	Photo 7

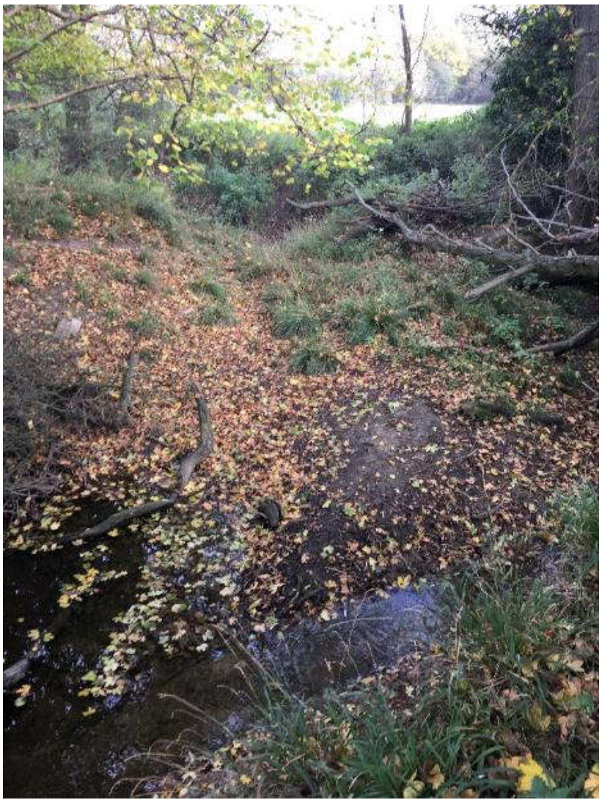
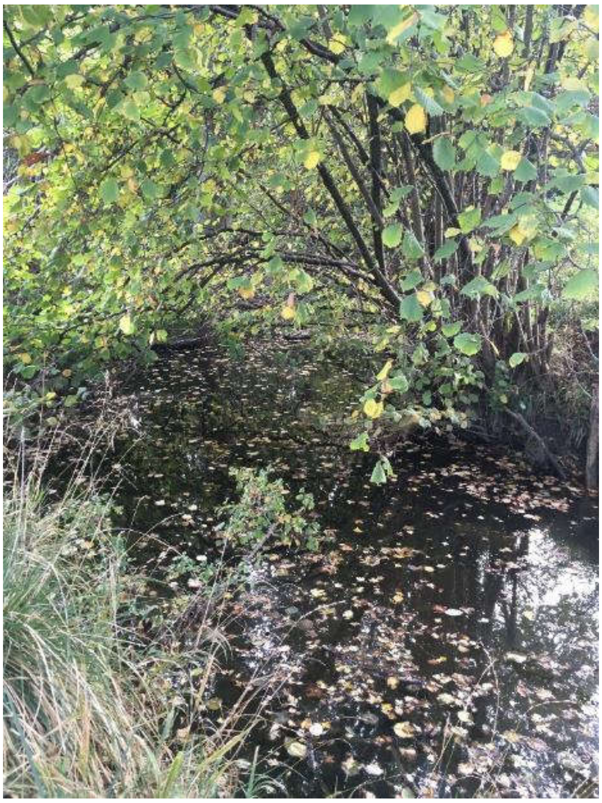

	

Photo 8	
	

Technical note

Summary

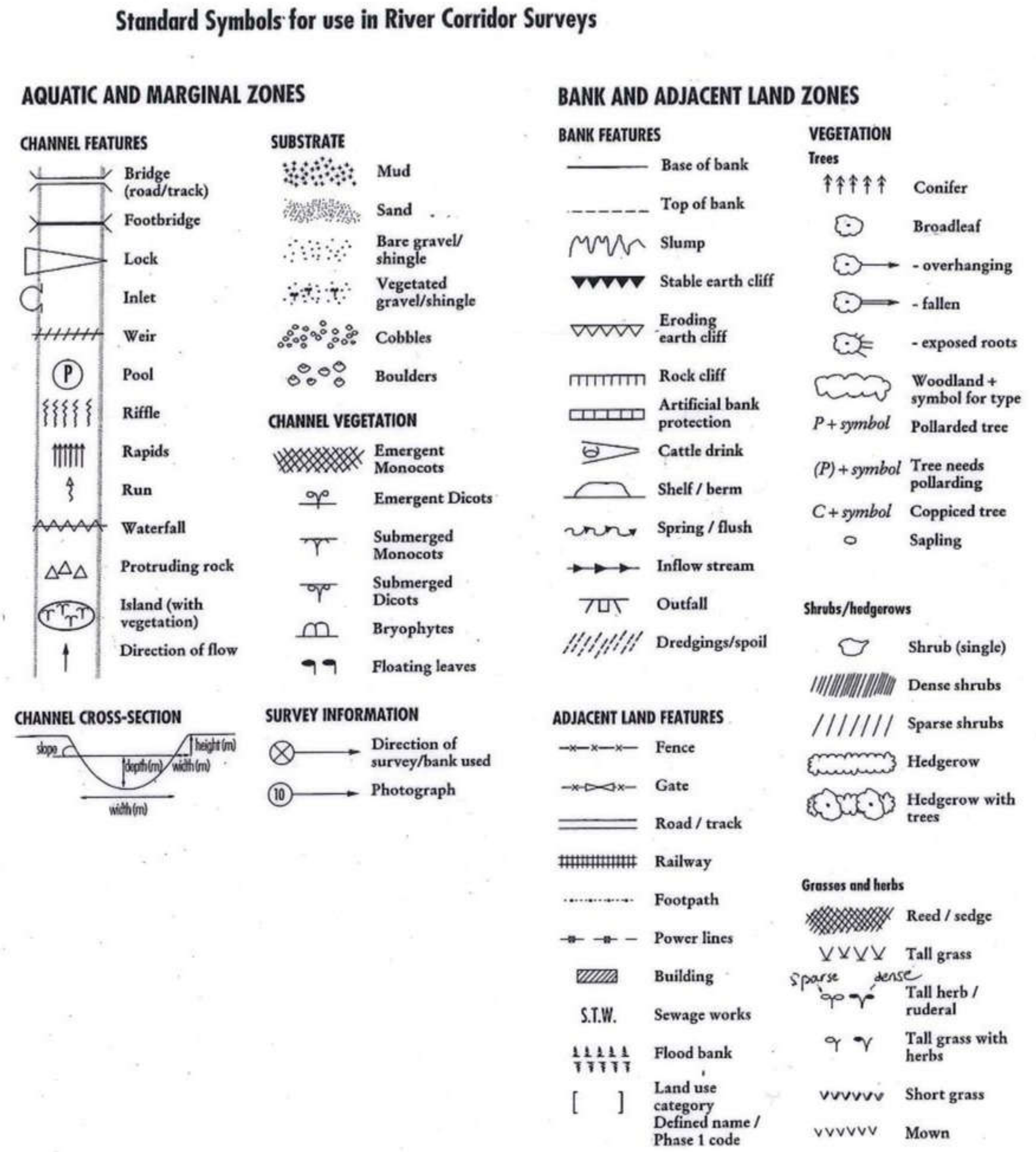
The four reaches surveyed as part of the Scheme were all heavily shaded by a mixture of mature trees and hedgerows. The Weald Brook is heavily sedimented and slower flowing than the Ingrebourne River. It contains large amounts of woody debris within the channel causing natural obstruction to flow. While this may provide refuge for some fish and aquatic macro-invertebrate species, the large amount of sediment is likely to be acting to limit the range of species that can be supported, this is despite the presence of a meandering planform and in-stream habitat complexity.

The Ingrebourne River, while historically straightened for the adjacent A12/M25 slip road, shows a greater variety of in-stream habitats and flow types for both fish and aquatic macro-invertebrates such as pools, riffles, underwater tree roots, and marginal vegetation.

Road crossing are proposed across both the Weald Brook and Ingrebourne River with realignments being required in all instances. It is suggested that any realignments include reintroduction of meanders/sinuosity to increase habitat diversity coupled with a reduction in trees and shrubs to reduce shading and enhance ecological condition through improved distribution and abundance of in-stream vegetation.

Technical note

Appendix 1 – Symbols used in RCS maps



Appendix 2 – List of plant species and abbreviations used in RCS maps

Abbreviation	Scientific name	Common name
Acam	*Acer campestre*	Field maple
Aglu	*Alnus glutinosa*	Alder
Anod	*Apium nodiflorum*	Fool's water-cress
Apse	*Acer pseudoplatanus*	Sycamore
Cal. Sp	*Callitriche species*	Water star-wort
Cave	*Corylus avellana*	Hazel
Cbet	*Carpinus betulus*	Hornbeam
Cmon	*Crataegus monogyna*	Hawthorn
Cpen	*Carex pendula*	Pendulous sedge
Ehir	*Epilobium hirsutum*	Great willowherb
Fexc	*Fraxinus excelsior*	Ash
Fsyl	*Fagus sylvatica*	Beech
Lmin	*Lemna minor*	Common duckweed
Pspi	*Prunus spinosa*	Blackthorn
Qrob	*Quercus robur*	Pedunculate oak
Rfru	*Rubus fruticosus*	Bramble
Salb	*Salix alba*	White willow
Sfra	*Salix fragilis*	Crack-willow
Snig	*Sambucus nigra*	Elder
Sol. Sp	*Solidago* species	Goldenrod
Udio	*Urtica dioica*	Common nettle
Vbec	*Veronica beccabunga*	Brooklime
Aglu	*Alnus glutinosa*	Alder

Appendix D. Geomorphological and ecological walkover surveys

D.1 Introduction

D.1.1 This section describes the results of geomorphological and ecological walkover surveys of reaches of the Ingrebourne River and Weald Brook potentially affected by the Scheme.

D.1.2 Survey of all reaches except reach 3 of the Ingrebourne River were carried out on 15th February 2019. Reach 3 of the Ingrebourne River was surveyed on 23rd May 2019.

D.1.3 The extent of the survey reaches are shown in Figure 4.1.

D.2 Geomorphological survey

Ingrebourne River

Reach 1

D.2.1 An 250m artificially straightened and hence steeper than natural reach. Two structures affect longitudinal connectivity: a) most substantially a 190m twin box culvert immediately upstream of the reach carrying the Ingrebourne River beneath M25 junction 28 and b) to a much lesser extent a high single-track 5m wide bridge providing access across the river Grove Farm.

D.2.2 The channel is of a consistent width along this reach, wetted width varying between approximately 2 m and 2.5 m. Flow depths at time of survey varied between 0.02m and 0.3m. Banks were formed of earth (silty clay), made ground and tree roots. The channel is disconnected from its floodplain. The left bank is steep and formed by the edge of the A12 slip road, rising to 5m at the upstream end of the reach and to around 1.75 m downstream. The right bank is steep and around 1.5 to 1.75 m high for the majority of its length. The higher parts of the right bank appear to be raised by deposition from dredging works.

D.2.3 The channel cross and long sectional profile are strongly influenced by its artificial origins. The long section consists of a series of shallower runs, interspersed by slightly deeper pool sections. The thalweg has a sinuous form. Very occasionally sufficient bank erosion has occurred to create a very slight sinuosity in the channel. The bed is dominated by gravels (approximately 2-4 cm along its long axis) and occasional cobbles. Pool substrate also consisted of gravels. When disturbed the bed released large volumes of silt.

D.2.4 The riparian zone is fenced, c. 4m wide on the right bank, and c. 6m on the left bank. It is predominantly steep bank that is heavily shaded by trees. As a result of the shade the understorey is poorly developed. The floodplain of the Ingrebourne River shows little evidence of regular inundation and was dominated by grasses that was dry underfoot at the time of the site visit.

D.2.5 In summary, this reach is geomorphologically homogeneous. It is straight, over-steepened, with an ill-defined planform and long section (runs and shallow pools). It is heavily shaded by trees. Although evidence of incision is present in the form of exposed tree roots and angled trees, the dominant sediment process is transfer.

An indicative photograph of Ingrebourne River Reach 1

Reach 2

D.2.6 The planform, channel dimensions, bank form / composition and riparian zone of this short 20 m are identical to those of Reach 1.

D.2.7 The key differences between the two reaches are caused by the backwater effect of the 50m culvert at the downstream end of Reach 2 that carries the Ingrebourne River beneath the A12. This culvert forms a substantial longitudinal disconnect in the river. It also forces a deeper upstream flow depth in Reach 2 (greater than 0.3m at the time of survey). There is a pronounced change in substrate, depositional features and hydraulic gradient. The substrate in Reach 2 is predominantly silt and possibly sand, with a substantial silty bar formed on the left bank (inside bend) of the channel on the approach to the A12 culvert. Connection with the floodplain along this reach is probably more frequent than in Reach 1 at high flows.

D.2.8 In summary, the form of this reach is very similar to Reach 1. However, the backwater effect of the downstream A12 culvert generates a less steep hydraulic gradient, forcing a deeper flow depth and a marked transition to a predominantly silt and sand bed substrate and silty depositional features. The dominant sediment process in the reach is a sink.

An indicative photograph of Ingrebourne River Reach 2

Reach 3

D.2.9 The current channel on this reach runs immediately adjacent to the A12. It is artificially straightened and deepened. Consequent excess gradient and disconnect from the floodplain has created an active sediment system, expressed predominantly through incision and formation of regularly spaced (c 10m interval) gravel side bars together with shallow runs in sections without tree roots. Where tree roots have been exposed these strongly influence channel form. The channel is recovering slight sinuosity. The left bank looking downstream of the channel runs very close to, and sometimes in continuity with, a piled retaining wall supporting northbound carriageway of A12. The right bank is steep and natural. No excessive areas of bank erosion, though vegetated failing bank protection observed in upper reaches. There is evidence of recent incision (tree roots exposed by up to 0.5m, tree roots creating bed features). The channel takes the form of a trapezoid with 1-1 ½ m base width, c 2 ½ m depth and c 6 m top width.

D.2.10 Running next to the existing channel is an historic course of the Ingrebourne River. This relict channel is still pronounced in the landscape. No active sediment processes are evident, though natural relict channel form still visible – variation in cross sectional shape (steep and shallow banks) and widths. An estimated 60 cm of soft sediment are present in bottom of the dry channel. The common cross section shape is 1m base width, c 1 ½ m depth and c 4 m top width. The floodplain is woodland and was dry at time of visit, but understorey vegetation suggests it is damp for extended periods of time.

An indicative photograph of Ingrebourne River Reach 3 (existing channel)

An indicative photograph of Ingrebourne River Reach 3 (historic channel)

Weald Brook

Reach 1

D.2.11 A 1200 m long reach with a 45 m long culvert under the M25 at the upstream end that restricts longitudinal connectivity.

D.2.12 The channel is of varied width, with a wetted width at time of survey typically between 3 m and 4 m. Flow depths at time of survey varied substantially (between approximately 0.1m and 1m), depending on the frequent presence and backwater effect of large wood features in the channel. Banks were formed of earth (silty clay). Exposed tree roots are very common in the banks. On both sides of the river, banks are often close to vertical and vary in depth between approximately 1.7 m and 2.5 m. Bank heights were often less in the upstream 300m of the reach.

D.2.13 Although much of reach has been straightened in the past, there are sections exhibiting a very sinuous more natural planform. Channel cross and long sectional profiles are variable throughout the reach and strongly influenced by the presence of large wood in the channel. These wood features cause steps in water level along the long profile. Long backwaters form behind these woody controls. Active bank erosion is common, typically 5-10m in length, most often at tighter bends where the wood features are present. Short sections of shallower runs over bed gravels often form just downstream of the wood features. It is likely that bed substrate behind wood features has a high silt and organic content.

D.2.14 The riparian zone is c. 2-4m wide on either bank, partially fenced and comprises rank vegetation understorey heavily shaded by trees. Channel incision means the floodplain is disconnected from the river, although this disconnection becomes less pronounced in the upstream 300 m of the reach. Note there are sections of the floodplain that have vegetation associated with wetter soils. These have formed as a result of surface water not draining to the channel rather than water regularly spilling from the Weald Brook.

D.2.15 In summary, this section exhibits moderate lateral activity. In sections where planform has been straightened, the channel is recovering a more natural planform. In sections of more sinuous planform, natural lateral process continues. The channel has natural cross and long sectional profiles as the result of bed and bank erosion substantially accelerated by the hydraulic effects of large wood. There is pronounced evidence of incision in the form of exposed tree roots and angled trees – this may be less pronounced in the upper 300m of the reach. The dominant sediment process is that of sediment transfer, although the bed and bank also form substantial local sources of sediment.

An indicative photograph of Weald Brook Reach 1

Reach 2

D.2.16 An 250m historically straightened, incised reach. There are no bridges or culverts restricting longitudinal connectivity. The key distinguishing feature between this reach and reach 1, is that the entire length of this reach has been artificially straightened in the past.

D.2.17 The channel is of varied width along this reach, with a wetted width at time of survey typically between 3 m and 4 m. Flow depths at time of survey varied substantially (between approximately 0.1m and 1m), depending on the frequent presence and backwater effect of large wood features in the channel. Banks were formed of earth (silty clay). Exposed tree roots are very common in the banks. On both sides of the river, banks are often close to vertical and vary in depth between approximately 1.7 m and 2.5 m.

D.2.18 The channel cross and long sectional profile are variable and strongly influenced by the presence of large wood in the channel. These wood features cause steps in water level along the long profile. Long backwaters form behind these woody controls. Active bank erosion is common, typically 5-10m in length, most often at tighter bends where the wood features are present. Short sections of shallower runs over bed gravels often form just downstream of the wood features. It is likely that bed substrate behind wood features has a high silt and organic content.

D.2.19 The riparian zone is c. 2-4m wide on either bank, partially fenced and comprises rank vegetation understorey heavily shaded by trees. Channel incision means the floodplain is disconnected from the river. However, there are sections of the floodplain that have vegetation associated with wetter soils. These have formed as a result of surface water not draining to the channel rather than water regularly spilling from the Weald Brook.

D.2.20 In summary, this reach has been straightened in the past. It has recovered a more natural cross and long sectional profile as the result of bed and bank erosion substantially accelerated by the hydraulic effects of large wood. A more natural planform is also starting to re-develop. There is pronounced evidence of incision in the form of exposed tree roots and angled trees. The dominant sediment process is that of sediment transfer, although the bed and bank also form substantial local sources of sediment.

An indicative photograph of Weald Brook Reach 2

Reach 3

D.2.21 The planform, channel dimensions, bank form / composition and riparian zone of this short 80 m are very similar to those of Reach 1.

D.2.22 The key differences between the two reaches are caused by the backwater effect of the 50m culvert at the downstream end of Reach 2 that carries the Ingrebourne River downstream of its confluence with the Weald Brook beneath the A12. This culvert forces a deeper upstream flow depth in Reach 3 of the Weald Brook (greater than 0.3m at the time of survey). There is a pronounced change in substrate, depositional features and hydraulic gradient. The substrate in Reach 2 is predominantly silt and possibly sand. Connection with the floodplain along this reach is probably more frequent than in Reaches 1 and 2 at high flows.

D.2.23 In summary, the form of this reach is very similar to Reach 2. However, the backwater effect of the downstream A12 culvert generates a less steep hydraulic gradient, forcing a deeper flow depth and a marked transition to a predominantly silt and sand bed substrate. The dominant sediment process in the reach is a sink.

An indicative photograph of Weald Brook Reach 3

D.3 Ecological survey

Introduction

D.3.1 The following comments are made to supplement the River Corridor Survey presented in Appendix C.

Ingrebourne River (reach 1 and 2)

D.3.2 During the survey in February 2019, little in the way of aquatic vegetation was present, which was not surprising for the time of year). Fool's water-cress (*Apium nodiflorum*) was present in places. During the visit for the RCS, (November 2017) brooklime (*Veronica beccabunga*) was also present, however, it was not present at this visit. Vegetation present was identified growing where berms/sedimentation is occurring at the margins. Sediment observed to be a mix of gravels/pebbles, although downstream (towards the confluence with the Weald Brook) much more sedimentation was present. Animal burrows into the banks were observed (both above and below the water level) along the reaches, likely to be from bank voles (one seen on survey) and signal crayfish (seen during 2018 fish/invert surveys). No in-channel vegetation, although some filamentous algae present. The channel was shaded by bankside trees/hedgerows along most of the reach.

D.3.3 No ecological information has been collected for reach 3 to date.

Weald Brook (reaches 1, 2 and 3)

D.3.4 The Weald Brook is a slow flowing, heavily sedimented river which likely limits fish and aquatic macroinvertebrates present. This assumption is backed up by 2018 fish and aquatic macroinvertebrate surveys (more details provided in the Biodiversity chapter (Chapter 7) of the ES (application document TR010029/APP/6.1)). Downstream the channel is wider and deeper with a layer of deep sediment (this was presumed from observations from the bank, the channel not entered) as the water backs up due to the confluence/culvert. Natural dams formed by tree roots limit the flow in places, creating a mix of pools with no visible flow and high flow/mini waterfalls. Aquatic vegetation is heavily limited by dense bankside shading, occurring in only two places; *callitriche sp.* present in area where no trees were casting shade, and fool's watercress at most upstream end next to culvert (again, this area was not shaded).

Drainage ditches

D.3.5 No side channels/drainage ditches were observed along the Ingrebourne River. A number of smaller drainage ditches were observed along the Weald Brook, most of them well above the water level of the main channel and completely dry. It is anticipated they act as drainage channels following very high rainfall only. One side channel present towards the most upstream end, with water present at time of survey (very slow flow).

Appendix E. Riverine habitat assessment and preliminary design specification

Technical Note

Project:	M25 Junction 28 Interchange Improvements
Subject:	Riverine Habitat Assessment and Preliminary Design Specification
Author:	[redacted]

Date:	27/04/20	Project No.:	5158157
Distribution:	External	Representing:	Atkins

Document history

[redacted]

1. Purpose of technical note

The purpose of this technical note is to:

- provide further detail on the assessment undertaken to determine the net effect of the Scheme on riverine habitat;
- set out assessments carried out on the benefits of enhancements to non-riverine elements of the water environment including drainage ditches, areas of floodplain lowering and maintenance of riparian trees;
- set out the net riverine habitat benefit associated with a channel realignment investigated on the Ingrebourne near Frenches Farm; and
- capture outline specifications for key mitigation and enhancement measures.

2. Assessing the net effect of the Scheme on riverine habitat and other elements of the water environment

2.1. Riverine habitat assessment

Purpose

The purpose of this riverine habitat assessment was to estimate the net effect of a) the Scheme components and b) measures put in place to mitigate the effect of those Scheme components on riverine habitat. It is solely concerned with the net effect of Scheme components and mitigation measures within the DCO boundary.

Scheme components included in assessment

The assessment considers all Scheme components physically affecting the Ingrebourne River and Weald Brook (ING1-ING3 and WB1-WB5 as listed in Table 4.3 of the main document). The remaining Scheme Components, ING4 and WB6 together with ING5 and WB7 are not considered in this assessment because they solely affect water quality, and their effect is assessed using alternative tools.

Mitigation measures included in assessment

The assessment just considers mitigation measures within the DCO boundary. It considers the embedded measures put in place to mitigate the effect of Scheme components ticked as mitigation in Table 5.1 in the main body of the report, but excludes W12 (which addresses the water quality effects of road runoff on the natural drainage system). It also considers additional measures W14 and W15 listed in Section 5.3. These measures comprise channel realignments to more natural courses, natural river beds through culverts, minimising the footprint of the A12 slip road, wide span bridge structures, limiting hard bank protection at river crossings, avoiding scour at the exit of culverts and provision of mammal passage.

Measures ticked as enhancements in Table 5.1 (floodplain lowering, maintenance of riparian trees and provision of unlined drainage ditches) are NOT included in this assessment because, although they complement riverine habitat, the EA discourage considering them as direct mitigation for Scheme effects on the riverine environment. Measure W13 in Section 5.3 is not considered in this assessment because it is mitigation outside of the DCO boundary. Measure W16 is not considered because it addresses potential effects on ground, not surface, water.

Assessment method

The basis of the assessment is a comparison of the product of habitat extent and habitat quality in a) the baseline condition and b) the Scheme scenario. Habitat extent is measured as length of river channel. Habitat quality is measured using a conservation index.

The length of river channel in both the baseline condition and Scheme scenario were measured using a Geographical Information System. Reaches used to assess the baseline condition were identified in the geomorphological survey reported in Appendix D of the WFD compliance assessment and are shown in Figure 1 below.

The reaches used in the Scheme scenario are shown in Figure 2. These reaches were defined by apparent geomorphological and riverine habitat changes. Four reaches were identified on the Ingrebourne River and 13 on the Weald Brook to adequately account for the adverse effects and proposed mitigation of the scheme.

A conservation status score based on the criteria set out in Table-1 was used to represent habitat quality in both the baseline and Scheme scenario. This was determined using professional judgement and information collated during site visits (Appendix D). Higher status scores indicate that the reach conforms more closely to an unaltered state. Conservation status is a commonly used metric in catchment scale geomorphological assessment (Sear et al., 2010).

The outcome of the assessment is presented in Table-2. This shows that the net effect of the Scheme components combined with proposed mitigation on riverine habitat within the DCO boundary is -0.23, measured using the metric applied in this assessment. The most substantial part of this deficit is generated on the Ingrebourne River due to the extension to Grove culvert (Scheme component ING1 in reach ING A1).

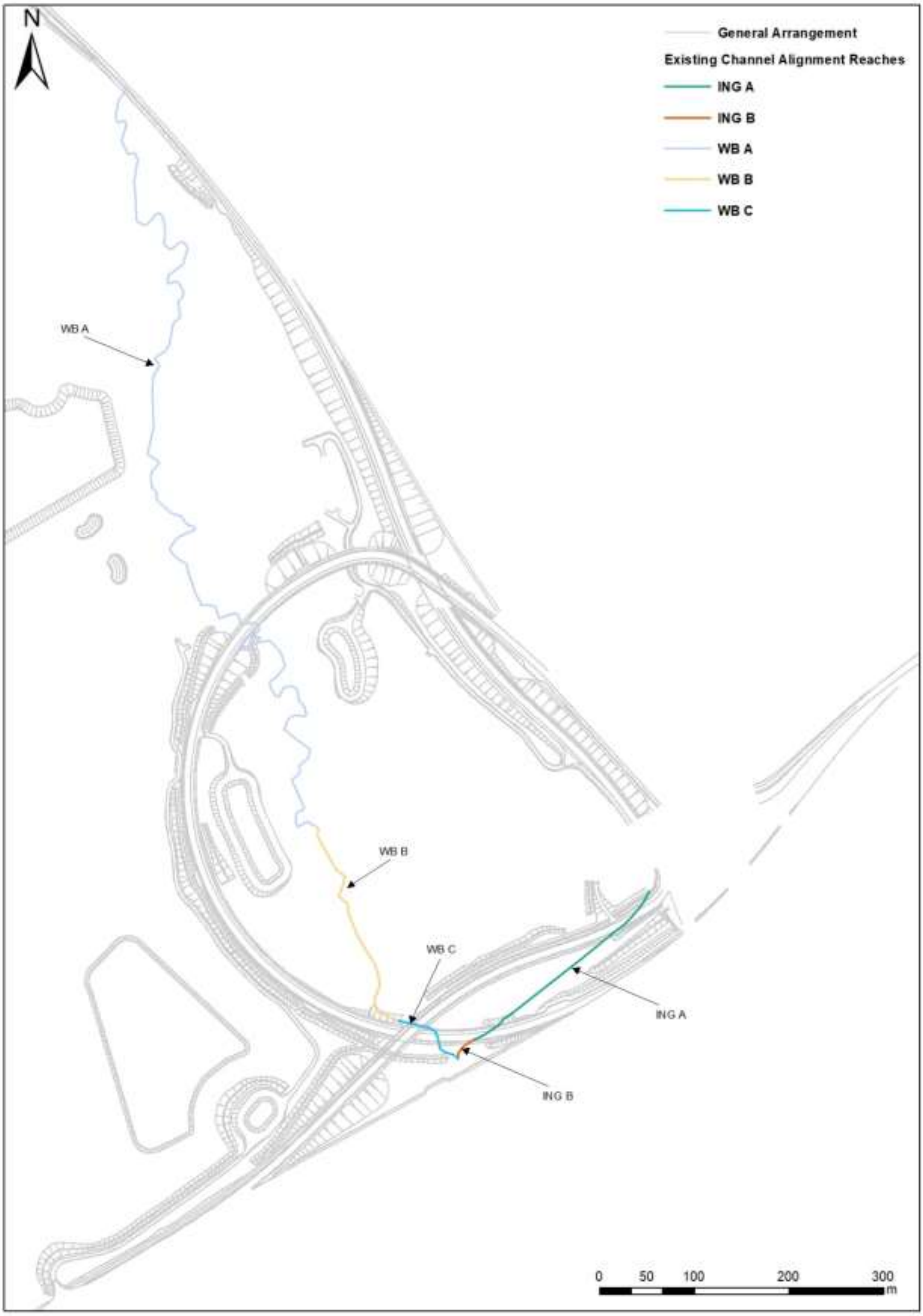


Figure-1 - Reaches used to assess the baseline condition

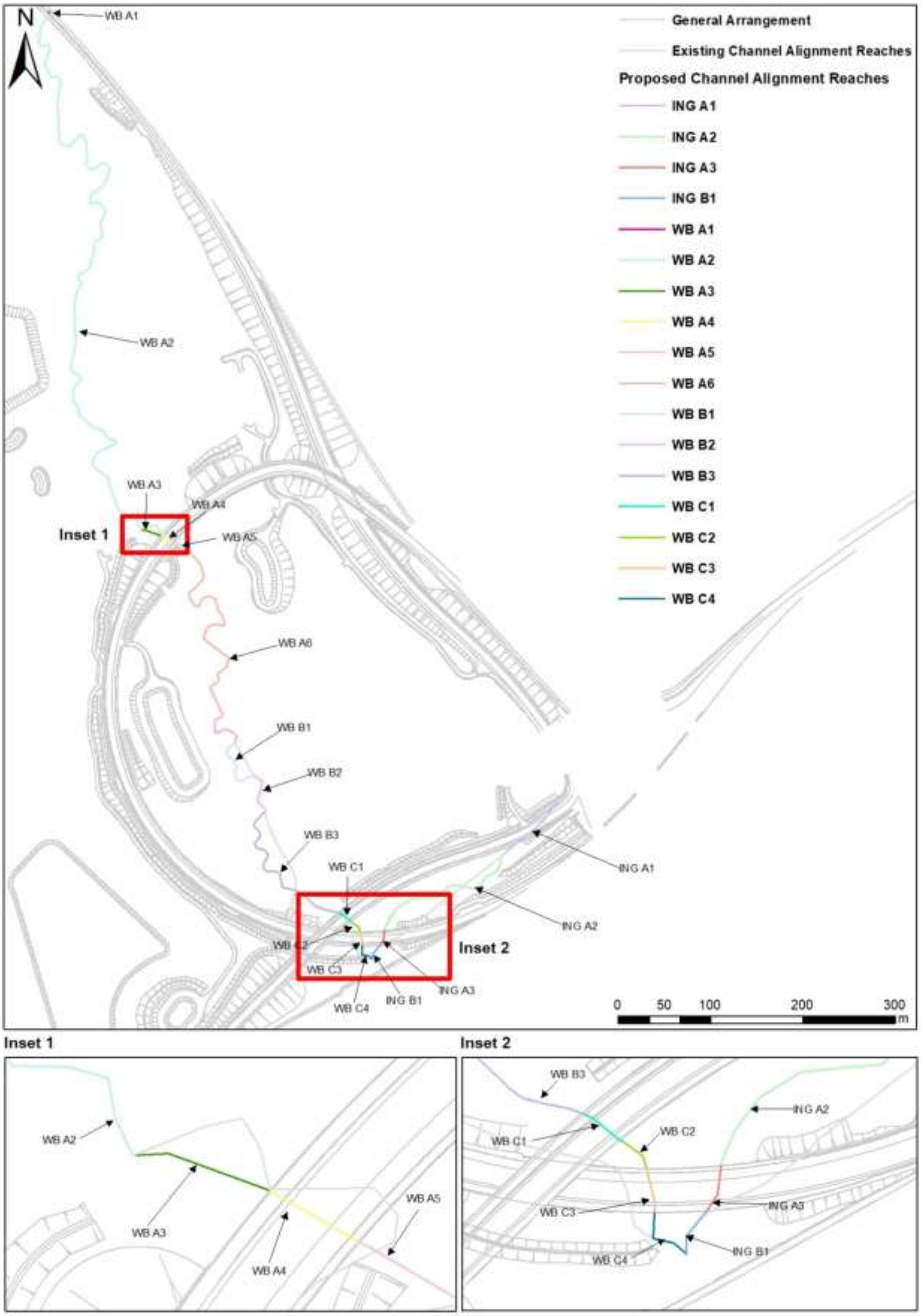


Figure-2 - Reaches used to assess the Scheme scenario

Table-1 – Reach conservation status

Susceptibility to disturbance	Score	Description
High	8-10	Conforms most closely to natural, unaltered state and will often exhibit signs of free meandering and possess well-developed bedforms (point bars and pool-riffle sequences) and abundant side vegetation
Moderate	5-7	Shows signs of previous alteration but still retains many natural features, or may be recovering towards conditions indicative of higher category
Low	2-4	Substantially modified by previous engineering works and likely to possess an artificial cross-section (e.g. trapezoidal) and will probably be deficient in bedforms and bankside vegetation
Channelised	1	Awarded to reaches whose bed and banks have hard protection (e.g. concrete walls or sheet piling)
Culverted	0	Totally enclosed by hard protection
Navigable	-	Classified separately due to their high degree of flow regulation and bank protection, and their probable strategic need for maintenance dredging

Table-2 – Riverine habitat assessment (baseline condition and Scheme scenario)

Receptor	Baseline Condition					Scheme Scenario					Riverine habitat metric Loss/Gain
	Reach	Reach Length (km)	Susceptibility to disturbance class	Score	Riverine habitat metric	Reach	Reach Length (km)	Susceptibility to disturbance class	Score	Riverine habitat metric	
Ingrebourne River	ING A	0.246	Low-moderate	5	1.23	ING A1	0.085	Culverted	0	0.00	-0.19
						ING A2	0.174	Moderate	6	1.04	
	ING B	0.027	Low	3	1.08	ING A3	0.018	Channelised	1	0.02	-0.01
						ING B1	0.018	Low	3	0.05	
Weald Brook	WB A	1.204	High-moderate	7	8.43	WB A1	0.003	Channelised	1	0.00	-0.63
						WB A2	0.766	High-moderate	7	5.36	
						WB A3	0.022	Low	3	0.07	
						WB A4	0.017	Channelised	1	0.02	
						WB A5	0.019	Low	3	0.06	
						WB A6	0.328	High-moderate	7	2.30	
	WB B	0.242	Low-moderate	5	1.21	WB B1	0.073	High-moderate	7	0.51	+0.75
						WB B2	0.048	High-moderate	7	0.34	
						WB B3	0.185	Moderate	6	1.11	
	WB C	0.084	Low	4	0.34	WB C1	0.018	Channelised	1	0.02	-0.16
						WB C2	0.013	High-low	4	0.05	
						WB C3	0.016	Channelised	1	0.02	
						WB C4	0.023	High-low	4	0.09	
Ingrebourne River riverine habitat metric					**1.31**					**1.12**	**-0.20**
Weald Brook riverine habitat metric					**9.97**					**9.94**	**-0.04**
Overall riverine habitat metric					**11.29**					**11.05**	**-0.23**

Note: Small inconsistencies in summing figures arise in the table above due to rounding error.

2.2. Non riverine elements of the water environment

Other water features

To contribute to an overall net gain of habitat quality within the Scheme boundary, additional water environment enhancements have been embedded into the proposed Scheme. The additional enhancements aim to improve existing ground conditions and utilise remaining landscape features for the benefit of enhancing the water environment. These enhancements are summarised in Table 5.1 of the main report:

- Ingrebourne floodplain lowering (W03) – In association with the Ingrebourne River realignment (W01) the associated floodplains are being lowered to improve the connection to the river to further enhance the floodplain from a botanical perspective. Lowering the floodplain will result in the rooting depth of established plants to be closer to the sub-surface water table during the dryer months and will promote over topping of the banks and floodplain inundation during the wet seasons. These changes have the potential to sustain seasonally saturated wet grassland habitat. As part of this, within two remnant sections of the existing Ingrebourne River channel, backwaters will be created to further diversify the aquatic habitats (c. 47m combined total length). Backwaters offer a zone of calm often stationary flows that offer great spawning and feeding opportunities to water dependant species and refugia during high flows.
- Along the Weald Brook, two Floodplain Compensation Areas (FCAs) will be created to compensate for floodplain lost because of the Scheme (W04 and W05). The FCAs will be linked to the Weald Brook channel and be lowered to a level that will sustain wet grassland habitats without compromising their primary function to store flood waters. W04 includes a backwater to further diversify the aquatic habitats. Note three additional backwaters are proposed for the Weald Brook outside of the floodplain lowering areas, generating a total backwater length of c.150m as a result of these enhancement measures on the Weald Brook.
- Tree works to improve sunlight penetration to the channel and understorey vegetation along the Ingrebourne and Weald Brook will take place (W06).
- The tree management works and back water desilting are included in the Scheme Landscape and Ecology Management and Monitoring Plan (LEMP, application document TR010029/APP/7.16) to ensure that they continue long term.

Drainage ditches

The proposed scheme will impact on the existing ephemeral drainage network. A desktop review of the drainage ditches indicated that there is c. 1 915m of drainage ditch habitat within the site boundary. Although sections of the existing drainage network will be infilled, c. 3 049m of drainage ditch will exist within the post scheme scenario. This simple count of drainage ditch habitat lost and gained indicates that there is an overall gain of c. 1 134m of drainage habitat (W07).

2.3. Riverine habitat assessment (Upstream realignment at Frenches Farm)

Appendix F of the WFD compliance assessment presents an investigation of the feasibility of delivering additional mitigation for the effects of the Scheme within the DCO boundary. The study focused on the Ingrebourne River immediately upstream of junction 28 of the M25, adjacent to Frenches Farm. Three options were investigated, none of which were viable. However, the most attractive of the options from the perspective of river and floodplain habitat restoration was called "upstream realignment".

Discussions between Highways England and the EA established that the "upstream realignment" option in Appendix F delivered sufficient improvement to riverine habitat to offset the Scheme deficit reported in section 2.1. The "upstream realignment" therefore provides a useful benchmark (or target) on the scale of the offsite mitigation works required to address the Scheme deficit.

Table-3 and Figure-3 set out the habitat assessment for the "upstream realignment" option presented in Appendix F. The assessment uses the method described in section 2.1. It shows the gain in riverine habitat using this metric to be +0.55.

Table-3 – Riverine habitat assessment - upstream realignment near French's Farm

Receptor	Baseline Condition					Upstream realignment option					Riverine habitat metric Loss/Gain
	Reach	Reach Length (km)	Susceptibility to disturbance class	Score	Riverine habitat metric	Reach	Reach Length (km)	Susceptibility to disturbance class	Score	Riverine habitat metric	
River riverine habitat metric	ING C	0.258	Low-Moderate	5	1.29	ING C1	0.058	Moderate	6	0.35	+0.55
						ING C2	0.176	High-moderate	7	1.23	
						ING C3	0.043	Moderate	6	0.26	
River riverine habitat metric					**1.29**					**1.84**	**+0.55**

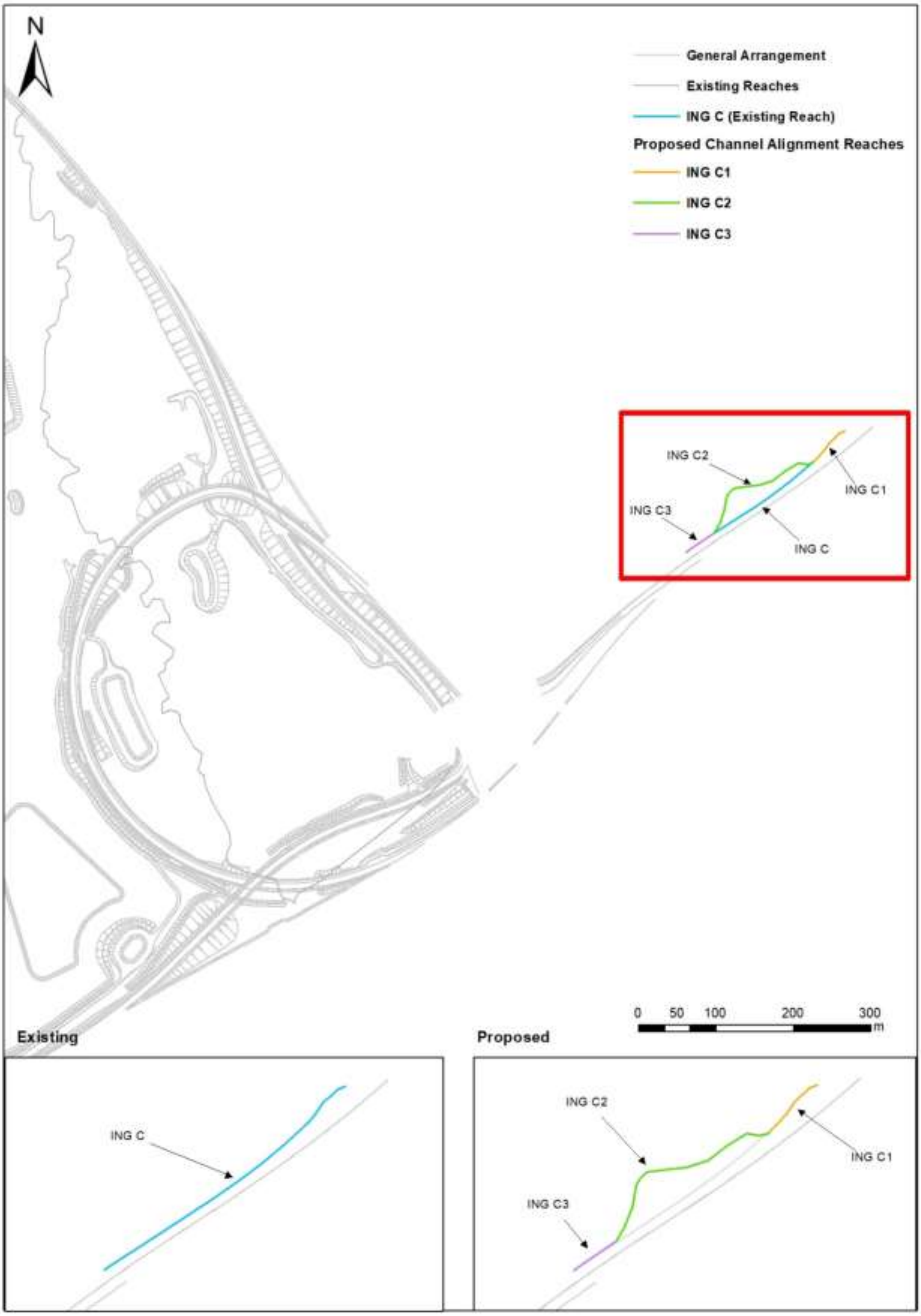


Figure-3 - Riverine habitat assessment - upstream realignment near Frenchs Farm

3. Outline specifications for key mitigation and enhancement measures

The sections below outline the preliminary design specifications of the proposed mitigation and enhancements planned for the Ingrebourne River and Weald Brook systems. The proposed mitigations and enhancements should be viewed as an amalgamated work package that has an overall benefit for the water environment even though the enhancements have not been considered within the riverine habitat assessment presented in section 2.1. It should be noted that all levels, slopes and areas are provisional and must be confirmed at detailed design.

3.1. Ingrebourne River

Descriptions of works

To address the adverse effects of the scheme on the water environment, the Ingrebourne River would be realigned between the new outfall of Grove Culvert and the confluence of the Weald Brook as an embedded mitigation measure (W01). The Ingrebourne River would be realigned into a sinuous channel utilising the engineered base levels of the proposed upstream and existing downstream (A12) culverts. The realigned channel would have a length of c. 200m with an average channel depth of 0.5m and varied top width of 6-12m.

A number of additional enhancements have also been included as part of the environment design. The enhancements aim to improve the overall water environment between the proposed A12 slip road and the loop road. Floodplains are often considered as a single element within the landscape, however, floodplains and the rivers that flow through them are directly linked and should be viewed as channelled valley bottom system[1]. Alterations made to a river will influence the functioning of the adjacent floodplain and vice-versa. The proposed enhancements will mean that the realigned channel would have an improved connection to the floodplain that it flows through and will offer areas of slow-flowing water. The proposed enhancements for the Ingrebourne River include:

- The northern and southern floodplains (c. 3 500m^2) of the Ingrebourne River will be lowered (W03) to approximately 30.90m AOD. The lowering of the floodplain level increase connectivity with the realigned channel and therefore would increase the frequency and duration of flooding and will bring sub-surface water level closer to the surface. A gentle gradient along the length of the floodplains from east to west is envisaged. The improved connection with the river would create wetter conditions within the floodplain. Based on this a wet grassland habitat is envisaged to dominate the lowered floodplain areas.
- As part of W03, sections of the existing Ingrebourne River channel will be retained and connected to the proposed realigned channel. These retained sections would act as backwaters that offer a unique range of habitats. The eastern-most backwater would receive flows from a sub-surface drainage outfall pipe.

The implementation of both the proposed mitigation and enhancements would result in a substantial improvement to the water environment between the proposed A12 slip road and the loop road. The enhancements would complement the mitigation (realigned channel) and over time should allow for more natural hydrological and geomorphological process such as periodic flooding of the connected floodplains during the wet seasons and natural sediment erosion and deposition to take place. The enhancements would also lead to changes in the botanical communities within this area of the site with wet-grassland dominating the floodplain and aquatic habitats provided by slow flowing water within the proposed backwaters (Figure 4).

[1] A valley-bottom area with a well-defined stream channel. Majority of water inputs to the floodplain are from main channel (when channel overtops the banks) and from adjacent slopes as overland runoff surface flow confined to drainage lines.

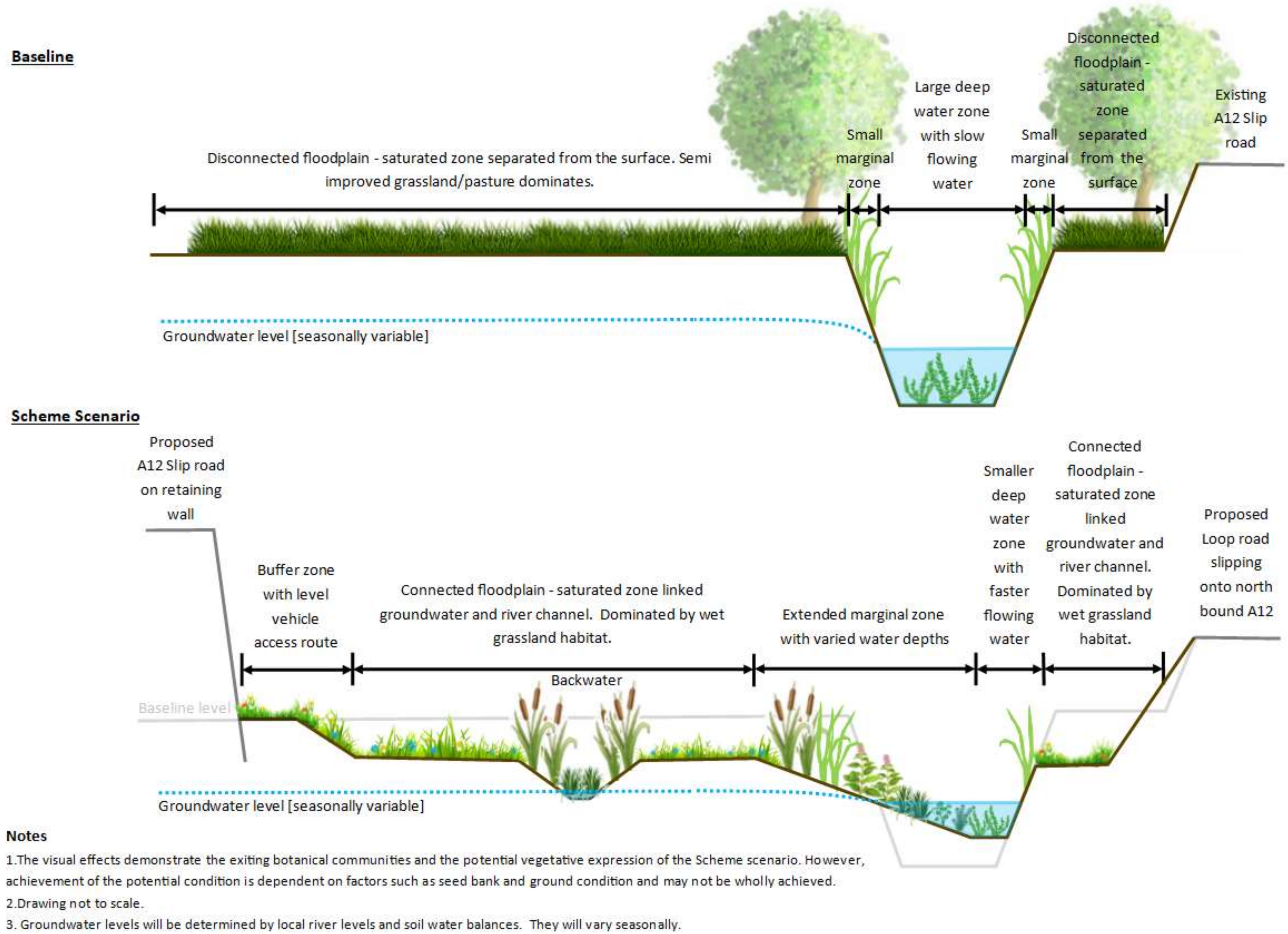


Figure 4- Representation of the potential increase in habitat complexity provided by reconnecting the Ingrebourne River to its floodplain.

Key constraints on Ingrebourne River works

There are a number of scheme constraints that have led to the proposed design of the water environment features between the loop road and A12 slip road. The following (Figure 5) are the currently known constraints:

- A 6m buffer is required adjacent to the A12 slip road retaining wall for drainage and geotechnical purposes;
- A 1:5 slope is required from the A12 slip road buffer down to the preferred northern floodplain environmental level. If existing ground level will be maintained as the environmental level, then a 1:5 slope will not be required;
- A 1:3.5 slope is required from the loop road down to the preferred southern floodplain environmental level; and
- The top of the bank rising from the environmental level of the western edge of the northern floodplain can be no closer than 5m to the sub-surface pipeline (BPA).

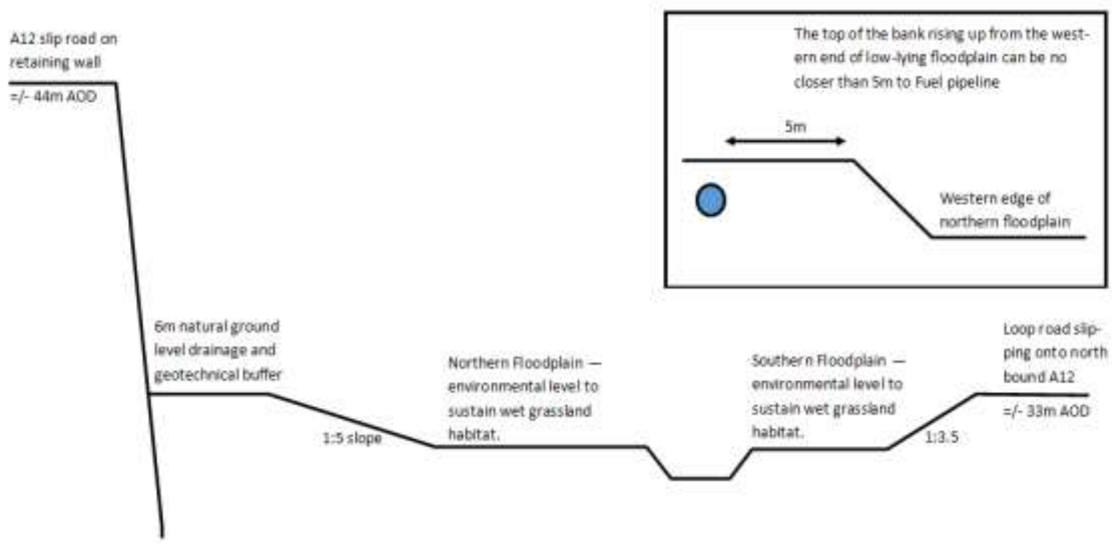


Figure 5 – Scheme constraints affecting the design aspect of the Ingrebourne River and floodplains

3.2. Weald Brook

To address the adverse effects of the scheme on the water environment, two section of the Weald Brook would be realigned increase the length of channel habitat within the DCO boundary. It should be noted that these sections are currently straightened. The two straightened sections of the Weald Brook would be realigned into a more sinuous course (W02).

A number of additional enhancements have also been included as part of the environment design. The enhancements aim to improve the overall water environment along the length of the Weald Brook, including the adjacent floodplains. Like the Ingrebourne system, the Weald Brook and the adjacent floodplains should be viewed as channelled valley bottom area. Two FCAs would be included in the environmental design to compensate for where the scheme encroaches into existing floodplain adjacent to the Weald Brook. The design of the FCAs has taken a two-fold approach by ensure they increase ecological benefit alongside flood risk.

The FCA located to the north of the loop road, near Duck Wood Bridge (W04), which covers an approximate area of 2 100m^2, will be lowered to a level of 32.7m AOD. W04 will be lowered to improve the connectivity of the Weald Brook to the floodplain. The FCA within loop road crossing (W05), which covers an approximate area of 9 100m^2, will be lowered to a level of 31.2m AOD for the purposes of floodplain storage and to improve the connectivity of the Weald Brook to the floodplain. Both FCAs will be lowered sufficiently to adequately sustain wet grassland and wet woodland habitat.

As part of W04, a c. 70m backwater will be created and connected to the channel. Three further backwaters will be created along the length of the Weald Brook system. These backwaters will be created within remnant sections of the existing channel once the channel realignments have been completed.

Riparian zone tree works will take place along the length of the Weald Brook to improve sunlight penetration to the channel (W07). This would be done to promote instream and understorey vegetation establishment and growth and to improve instream ecology. The tree management works and back water desilting are included in LEMP (application document TR010029/APP/7.16) to ensure that they continue long term.

3.3. Relevant references

Useful references to inform further design of the above measures are bulleted below:

- Manual of River Restoration Techniques, Managing Overland Floodwaters, Profiling of land between meanders, Section 6.2. Online Source: https://www.therrc.co.uk/MOT/Final_Versions_%28Secure%29/6.2_Cole_Skerne.pdf, accessed on the 26th June 2019.
- Manual of River Restoration Techniques, Modifying River Bed Levels, Water Levels and Flows, Raising bed levels, Section 5.5. Online Source: https://www.therrc.co.uk/MOT/Final_Versions_%28Secure%29/5.5_Kennet.pdf, accessed on the 26th June 2019.
- Manual of River Restoration Techniques, Restoring Meanders to Straightened Rivers, New channel meandering either side of existing channel, Section 1.2. Online Source: https://www.therrc.co.uk/MOT/Final_Versions_%28Secure%29/1.2_Cole.pdf, accessed on the 26th June 2019.
- Manual of River Restoration Techniques, Restoring Meanders to Straightened Rivers, Returning a woodland stream to its former sinuous course, Section 1.11. Online Source: https://www.therrc.co.uk/MOT/Final_Versions_%28Secure%29/1.11_Highland_Water.pdf, accessed on the 26th June 2019.

Appendix F. Feasibility study into delivery of RBMP Measure 22480 as part of the Scheme

Technical Note

Project:	M25 Junction 28 improvement scheme		
Subject:	River Ingrebourne near Frenches Farm - WFD mitigation feasibility study		
Author:	[redacted]		
Date:	27/04/2020	Project No.:	5158157
Distribution:	[redacted]	Representing:	Highways England Environment Agency

Document history

[redacted]

1. Background

1.1. Water Framework Directive (WFD) non compliance

The M25 junction 28 improvement scheme (the Scheme) will affect reaches of the River Ingrebourne and Weald Brook. Key impacts are an 80 m extension to the Grove Culvert, channel realignments to accommodate embankments / structures and shading of channel / riparian zone by bridges. In all, around 150 m of open channel habitat are compromised, to varying degrees. The Scheme will need to incorporate measures to mitigate these effects and to satisfy the requirements of the Water Framework Directive (WFD). These mitigation measures need to be discussed and agreed with the Environment Agency (EA), the Competent Authority for the WFD in England.

The EA response to the Scheme design presented as part of the statutory consultation (between Dec 2018 and Jan 2019) confirmed that the package of measures currently proposed was insufficient to fully mitigate the adverse effects on the water environment. On 21 May 2019 Atkins and EA representatives undertook a site visit to discuss the current mitigation proposals and understand the EA's expectations. The EA view is that the 'extent – quality' mix of the habitat proposed to mitigate for the effect of the Scheme is inadequate. In particular, the EA does not consider backwaters and lowered floodplain appropriate direct mitigation for compromised open channel habitat.

Without provision of additional mitigation, the Scheme is therefore likely to be considered as non-compliant with the WFD and following discussions with EA it was proposed to look at opportunities to provide additional mitigation on the River Ingrebourne on the upstream side of the junction. This is one of the 'action measures' identified by the EA within the Thames River Basin Management Plan (Figure 1-1).

This report sets out the outcome of the feasibility study undertaken to understand if further mitigation measures are possible within the DCO boundary on the 'action measure' reach shown in Figure 1-1.

1.2. WFD 'action measure' as additional mitigation

As part of WFD river basin management planning, the EA has identified 'action measures' throughout the River Thames Basin that, if implemented, would improve the WFD status of water bodies. One of these 'action measure' reaches is located on the River Ingrebourne immediately upstream of M25 junction 28, between Westbrook and Grove culverts, near Frenches Farm (EA, 2019; Figure 1-1).

This 'action measure' was identified by the EA through a desk study as a river restoration intervention with potential to contribute to improvement of WFD status within the Ingrebourne catchment. It comprises improvement to hydromorphology of the Ingrebourne, either by a) use of in-stream measures (deflectors specifically mentioned) or b) by re-meandering (where possible).

The EA has proposed that delivery of all or part of this 'action measure' as part of the Scheme should generate sufficient additional mitigation to ensure that the package of measures proposed for the Scheme is sufficient to fully mitigate adverse effects on the water environment. This is a way of making the Scheme compliant with WFD requirements.

The baseline condition of the upstream section of the Ingrebourne 'action measure' reach is summarised in Appendix A. This describes the reach as observed during a site visit on 21/5/19.

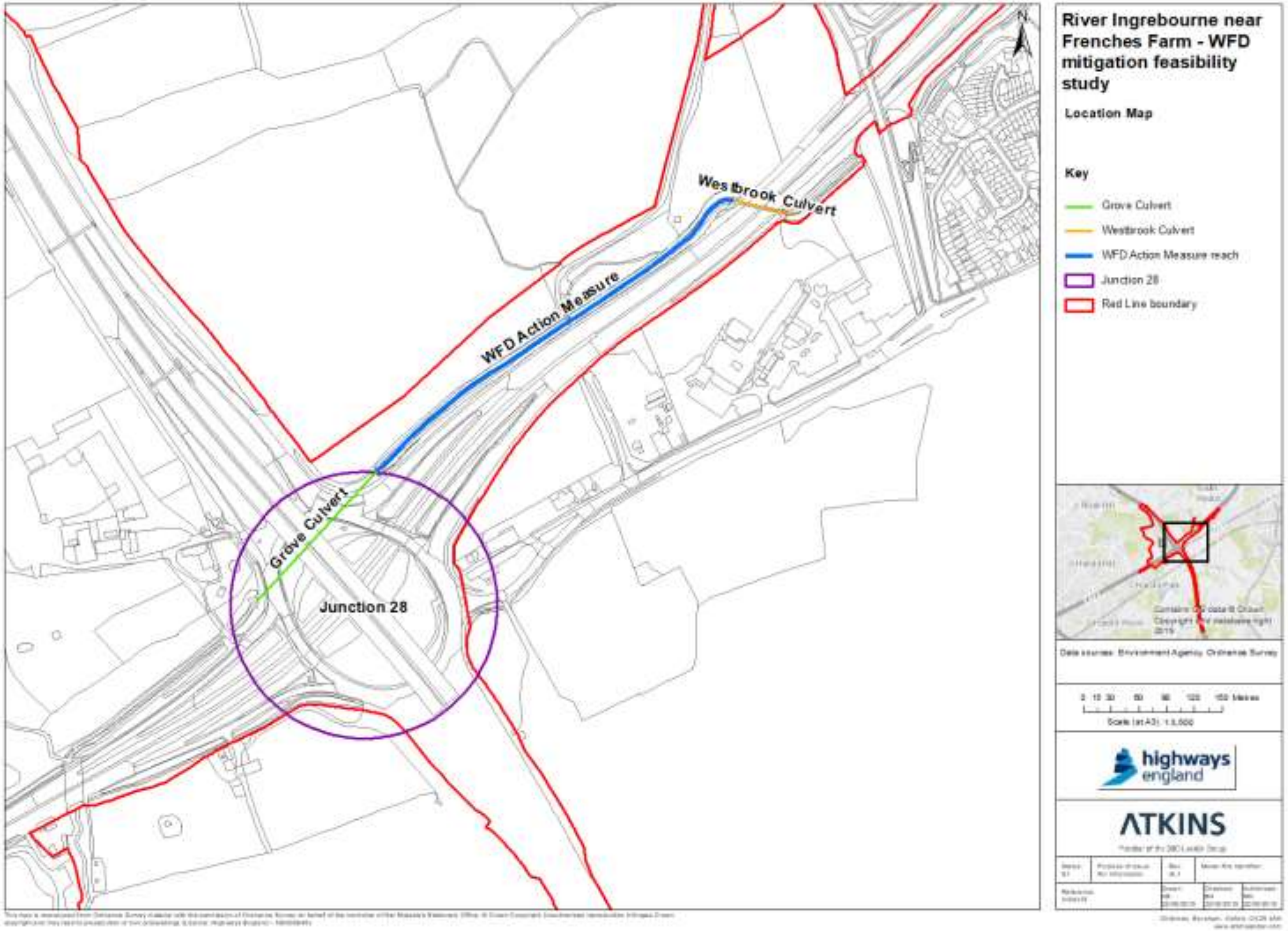


Figure 1-1 **- Location of the WFD 'action measure' reach, Grove Culvert and Westbrook Culvert**

2. Purpose of note

The purpose of this note is to assess the feasibility of implementing three packages of mitigation works to restore or create river and floodplain habitat on the 'action measure' reach of the River Ingrebourne between Westbrook and Grove Culvert near Frenches Farm. The packages comprise two channel realignments (re-meandering) and a set of in-channel measures. Feasibility is assessed on the following:

- Contribution to river and floodplain habitat improvement
- Effect of works on the drainage of the A12 trunk road
- Effect of works on flood risk to third party property and land
- Indicative cost and value for money
- Additional minor issues specific to each package of works

3. Description of mitigation works

3.1. In-channel measures

The Environment Agency desk study of 'action measures' identified in-channel measures as a potential restoration technique to improve in-stream habitat on the Ingrebourne between Westbrook and Grove culverts.

In-channel measures include placement of large wood, berms or bed raising to increase hydromorphological diversity. They are a particularly effective restoration tool for reaches in which geomorphological function is unnaturally subdued or dominated by low energy depositional processes. An example of use of wood deflectors back-filled with mineral material in a low energy river is shown in Figure 3-1.

Figure 3-1 - Example of in-channel deflectors (River Wensum, Norfolk)

3.2. Upstream realignment

This realignment would partially return the Ingrebourne to an historic channel with diverse natural morphology and in natural connection with a wooded floodplain (see Figure 3.2) If feasible it has the potential to:

- reconnect / create approx.175 m natural river habitat of varied plan, cross and long-sectional form as a realignment;
- Improve approx. 100 m of habitat along the existing Ingrebourne channel by bed raising to introduce sinuosity and variation in water depth through pools and riffles;
- Generate more frequent floodplain inundation and consequential development of wet floodplain habitat within a wooded environment;
- Create refuges for fish and other fauna as backwaters, along a reach where slow-moving water during times of flood is rare.

The principal aim of this package of mitigation works is to return the river Ingrebourne to a historic channel that has connectivity with the floodplain. This requires the river to be lifted out of its existing channel and then be returned to the same channel at a slightly lower elevation a short distance downstream. The difference in bed elevation of circa 1m between the existing and historic courses of the Ingrebourne creates technical challenges. These include raising water levels at outfalls to the A12 trunk road drainage system and an unavoidable steep bed gradient on the downstream section of the realignment as it returns to the existing course of the river (see Figure 3-2 and section 4).

An example of a realignment of the River Wensum to a historic course through woodland is shown in Figure 3-3.

3.3. Downstream realignment

Another opportunity exists to realign the Ingrebourne to a more varied plan, cross and long sectional form by creating a new course through a field currently given over to improved pasture at the location marked as ‘downstream realignment’ in Figure 3-2.

The potential of this downstream realignment is similar to that of the upstream realignment discussed above. However, this is a habitat creation scheme rather than habitat restoration (restoration of a historic natural habitat is likely to yield greater biodiversity benefit).

This realignment is faced with the same key challenge as the upstream realignment (substantial circa 1m difference in bed elevations of existing and realigned channels). Channel alignment and extent of floodplain lowering are significantly constrained by the close proximity of the Scheme red line boundary to the channel (30m). However, the creation of a new alignment allows flexibility in locating the connection points with the existing channel.

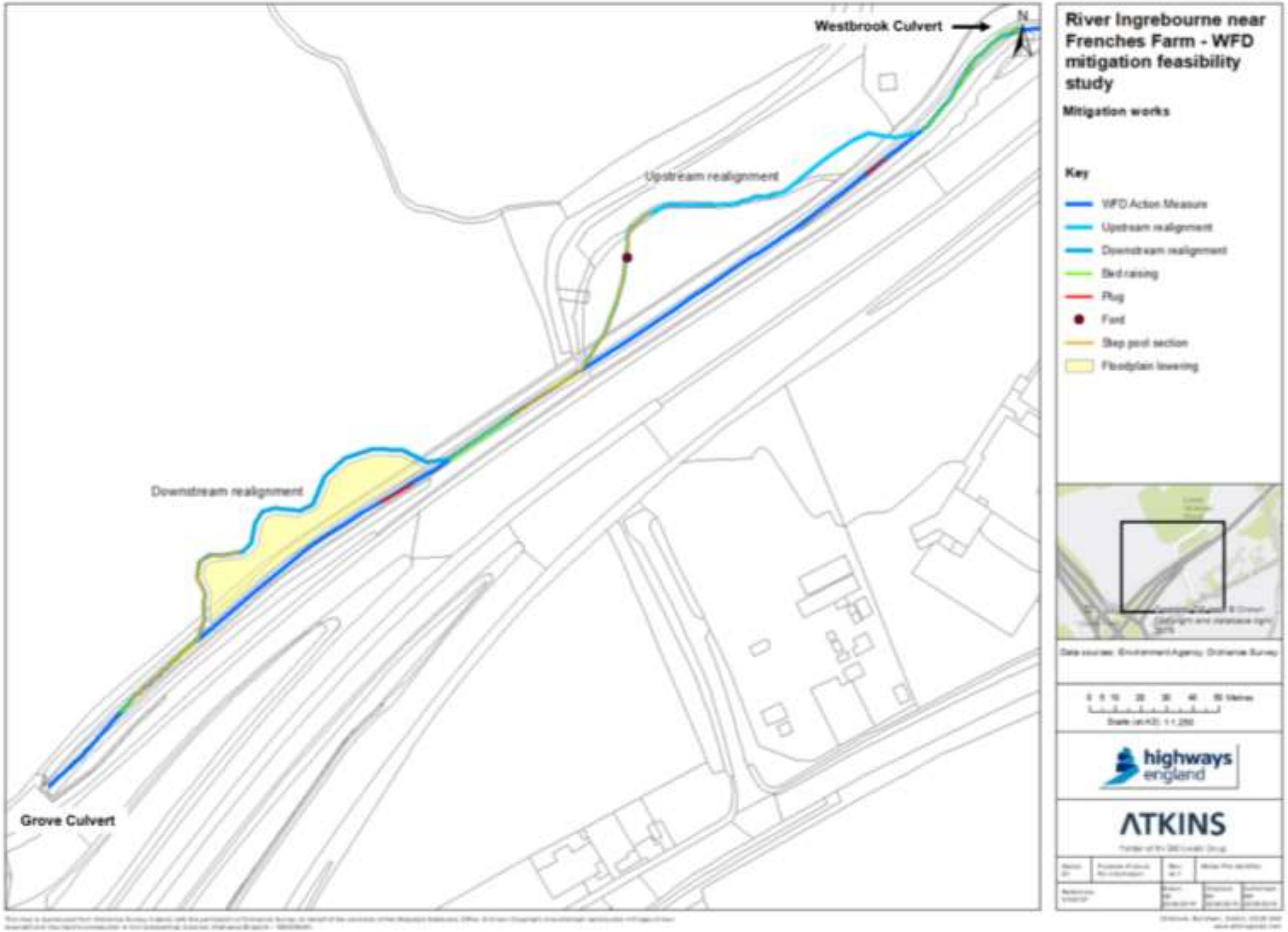


Figure 3-2 – Location of downstream and upstream realignment, showing the different elements of mitigation works

Section of River Wensum (before construction)

Section of River Wensum after construction

Figure 3-3 - Example of channel realigned along historic course (River Wensum, Norfolk)

4. Constraints on mitigation works

Table 4-1 and Figure 4-1 summarise key constraints on the mitigation works described in the previous section.

Table 4-1 - Key constraints on the mitigation works

Constraints	Upstream realignment	Downstream realignment
Ecological	**Designated sites** Lower Vicarage Wood (to the NW of the upstream realignment) is designated as Ancient Woodland and a Local Wildlife Site. This area should not be disturbed during construction. Note these areas are on the periphery of the area defined by the Scheme red line boundary. **Protected species** Otter spraints have been seen on the Ingrebourne immediately downstream; it is therefore possible that otters are active on this reach. A survey has identified trees with potential as bat roosts along the reach. Design and construction of mitigation will need to be managed in accordance with legislation protecting these species.	There is a **veteran tree** c 30 m to the north west of the downstream realignment. This tree must not be affected by the mitigation works. Note it is on the periphery of the works area defined by the Scheme red line boundary. **Designated sites.** See notes for upstream reach, noting these sites are more distant from downstream reach. **Protected species.** See notes for upstream realignment (opposite)
High pressure gas pipeline	A gas main passes underneath the River Ingrebourne immediately downstream of the upstream realignment. Works should not increase risk of exposure of this utility. This is a key constraint.	See notes for upstream realignment (opposite), noting the gas pipeline is more distant from the downstream reach.
Mobile phone mast	A mobile phone mast is located on raised ground to the north of the upstream realignment. The stability of slopes supporting should not be compromised by landscaping or excavation associated with works. We have assumed the slope supporting the mast should be no steeper than 1 in 3.	N/A
Field drainage of third party land	Drainage of fields to the north west is partially dependent on discharge through the historic channel proposed as part of the upstream realignment. The effectiveness of this drainage pathway should not be compromised by works.	N/A
Flood risk to third party land and properties	The EA will not consent implementation of a scheme that increased flood risk to third party land or property, unless agreement to the change in flood risk is accepted by the third party. The common design standards for flood risk to property is 100 years (up to 30 years for land).	See notes for upstream realignment (opposite).
A12 road drainage	Measures that increase water levels in the River Ingrebourne immediately adjacent to outfalls from the A12 trunk road drainage network potentially compromises the ability of the drainage system to evacuate runoff from road surface during flood events.	See notes for upstream realignment (opposite)
Maintenance access	It is good practice provide access to both river banks to facilitate access for maintenance by landowners and public bodies. Access should be provided to the left bank of both alignments.	See notes for upstream realignment (opposite)

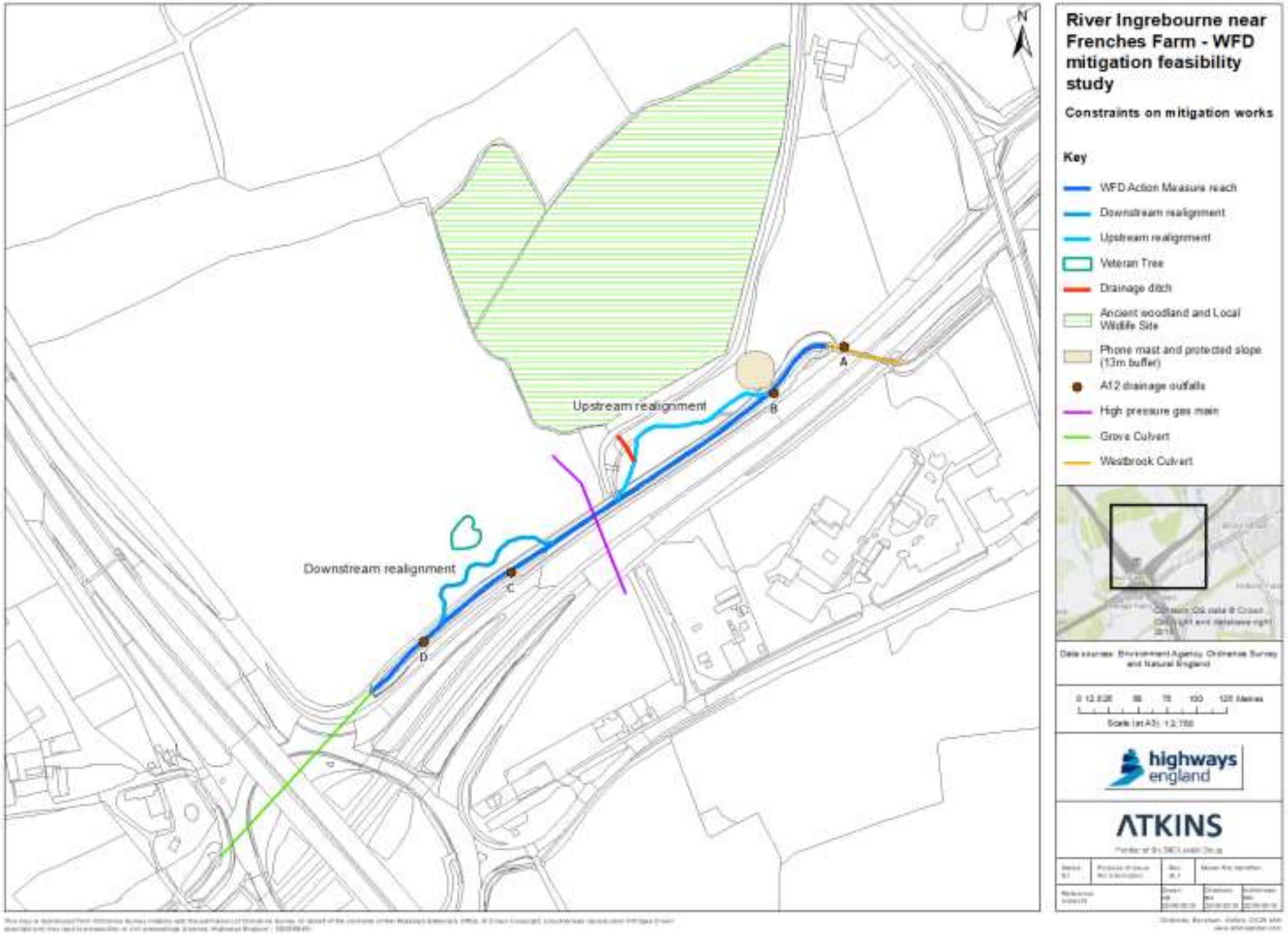


Figure 4-1 - Key constraints on mitigation works

5. Assessment

5.1. In-channel measures

There is very limited benefit to river habitat in implementing in-channel measures such as large wood to deflect flow. The principle purpose of such measures is to encourage or accentuate natural geomorphological process within the river channel. Observations on a field visit on 21 May 2019 confirmed that these processes are already active within this reach. These active processes are already creating diverse and dynamic in-stream habitat associated with high energy river environment (see Appendix A).

The key hydromorphological issue within the reach is that it lacks connection between channel and floodplain (and retention of extreme flows up to and beyond the 100-year event wholly within the channel). In-channel measures will not address this issue.

It is not proposed to implement in-channel measures because a) these generate little additional benefit to in channel habitat and b) they do not address the fundamental hydromorphological issue within the reach (floodplain disconnection).

5.2. Upstream realignment

5.2.1. River and floodplain habitat improvement

The upstream connection of the realignment to the existing channel, as shown in Figure 3-1, is determined by the extent of stable slope needed to support a phone mast to the north. Alternatively, the connection could be made at the difluence of historic and existing courses. The downstream return of the realignment is fixed by the need to avoid a new crossing of the high-pressure gas main. A new alignment on the lower section of the realignment is proposed to avoid a return to the main channel at an abrupt angle and associated erosion risk to the A12 trunk road embankment on the left bank.

A number of hydraulic model runs were carried out to settle on an optimum solution that best balanced the requirements of river and floodplain habitat improvement with the constraints set out in Section 4. The following are key controls on the hydraulic functioning of the realignment:

- A plug filling the existing Ingrebourne to a bank full top height of 37.6 m OD.
- A bed level at the upstream end of the realignment of 35.7 m OD. This assumes c. 300 mm of soft material in the base of the channel that could be removed without destroying natural form. It compares to bed level in the main channel of around 35.0 m OD.
- The grade of the realignment is kept very gradual in the upstream half, with the intention of encouraging spill to the floodplain. This creates a realigned channel approximately 1.5 m deep. Beyond the half way point, the grade steepened to around 1 in 60 to enforce reconnection with the existing River Ingrebourne.
- A realigned channel of 1.5 m width at the bed widening to 10 m at the bank.

This configuration diverts all flow up to the 30-year event into the realignment (Figure 5-1). However, flow does not spill from the realignment to the floodplain in any event up to and including the 100-year event (although freeboard is such that it may be possible to induce more regular spill by placement of large wood in the realignment).

The 1 in 60 slope required along the downstream half of the realignment to facilitate reconnection with the existing course is uncharacteristically steep for rivers in Essex and likely to be geomorphologically unstable. This steep section of channel would also overlie a high-pressure gas main (Figure 4-1). To enforce geomorphological stability and protect the gas main bed and bank protection would be needed. The most natural way of achieving a steep slope would be an “engineered” step pool sequence (example in Figure 5-2 below). This feature set mimics the natural response of a channel to this type of gradient.

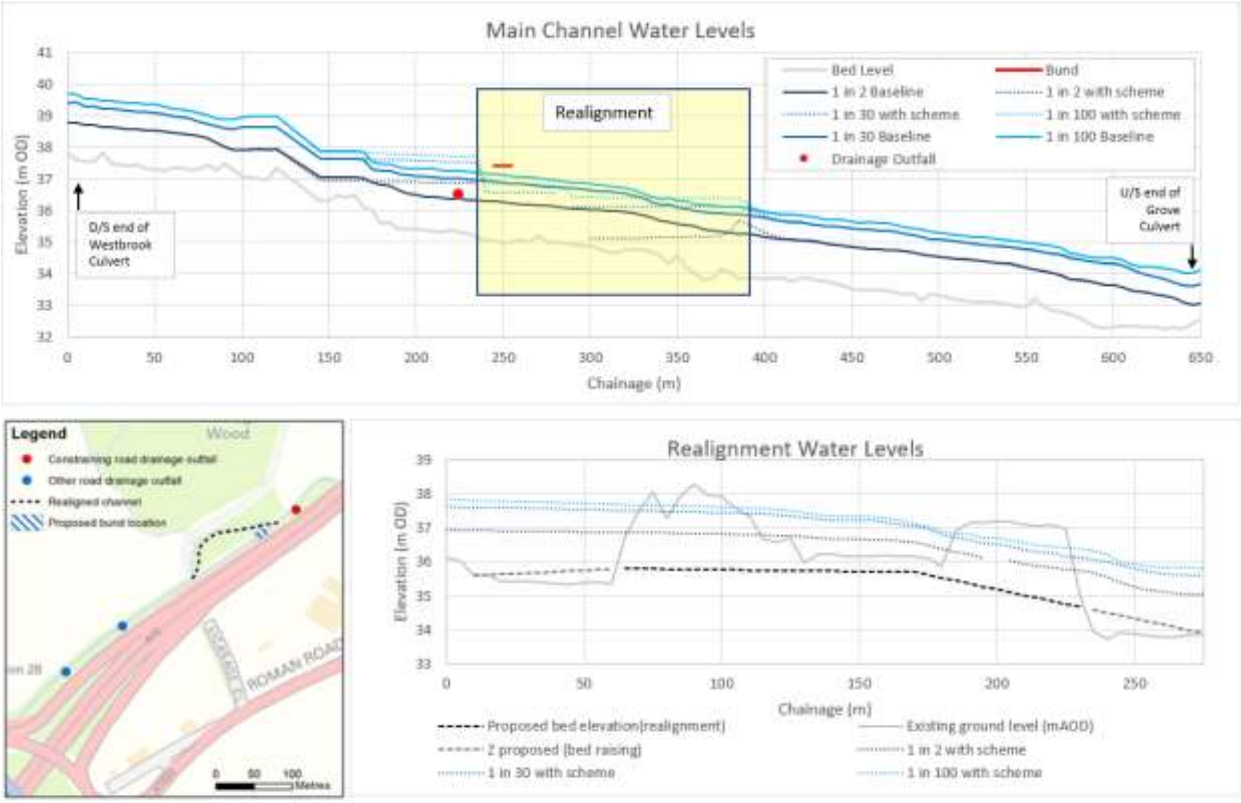


Figure 5-1 - Long section through River Ingrebourne (main channel) and upstream realignment

Figure 5-2 - Engineered step pool sequences on channel associated with Aberdeen Western Peripheral Road

5.2.2. A12 drainage

Hydraulic modelling summarised in Figure 5-1 indicates that the upstream realignment could be implemented in such way as to avoid increasing the design standard 30-year flood level adjacent to outfall A in Figure 4-1. This serves a large road surface catchment immediately downstream of Westbrook culvert. However, the works would raise the 30-year flood levels at the outfall immediately upstream of the realignment (outfall B in Figure 4-1)) by around 500 mm, thus compromising the function of the outfall.

There are ways of mitigating submergence of an outfall to a drainage system, for instance fitting a non-return value at the outfall or increasing storage capacity within the drainage network by replacing sections of pipe with larger diameter pipes. At present it is not possible to determine the scale, complexity or extent of works that would be required to mitigate submergence of outfall B, because there is no as built record of this system on the Highways England archive (HADDMS).

In summary, the proposed realignment will reduce the rate at which water can discharge from outfall B, compromising the function of the A12 drainage system served by the outfall. There is also a risk that more detailed assessment of outfall A establishes risk to this structure as well. Although it may be technically feasible to modify the drainage system served by these outfalls, there is significant uncertainty about both the technical feasibility and potential cost of such works.

5.2.3. Flood risk to third party property and land

Hydraulic modelling indicates that the upstream realignment could be implemented in such way as to limit the increase in 100-year water levels associated with the works to the reach adjacent to and upstream of the realignment. Levels would not increase upstream of Westbrook culvert (Figure 5-1).

5.2.4. Indicative cost estimate

An indicative cost of this works package is between £350k and £450k. This includes an allowance for design and assumes construction works are carried out by a standard ‘framework’ contractor. It allows a 40% contingency, given uncertainties associated with the feasibility stage of design. The estimate is most sensitive to earth moving quantities, assumptions about volumes of material disposed and material brought to site.

5.3. Downstream realignment

5.3.1. River and floodplain habitat improvement

The downstream connection of the realignment with the existing Ingrebourne channel was determined by leaving a 20 m gap to the downstream A12 drainage outfall (Figure 4-1). The upstream end of the realignment was located upstream of an A12 drainage outfall (to avoid compromising the associated road drainage system) and a slight low point in bank topography. The planform of the realignment was strongly influenced by the need for stable slopes on land close to the Scheme red line boundaries.

A single set of hydraulic model runs were carried out for this realignment. The following are key controls on the hydraulic functioning of the realignment:

- A plug filling the existing Ingrebourne to a bank full top height of 36.0 m OD.
- A bed level at the upstream end of the realignment of 34.5 m OD (compared to a bed level in the main channel of 33.5 m OD).
- The grade of the upstream part of the realignment was around 1 in 100, steepening to 1 in 60 in the downstream section.
- A realigned channel of 13 m width and 1.7 m bankfull depth (assuming no floodplain lowering).

Hydraulic modelling results (Figure 5-3) indicate that flows up to and including the 100-year event remain within the realigned channel unless the ground is lowered to create a floodplain with which the channel can connect (as shown in Figure 5-3). Proximity of the works to the Scheme red line boundary suggests that the maximum extent of this lowered floodplain would be around 1300 m^2.

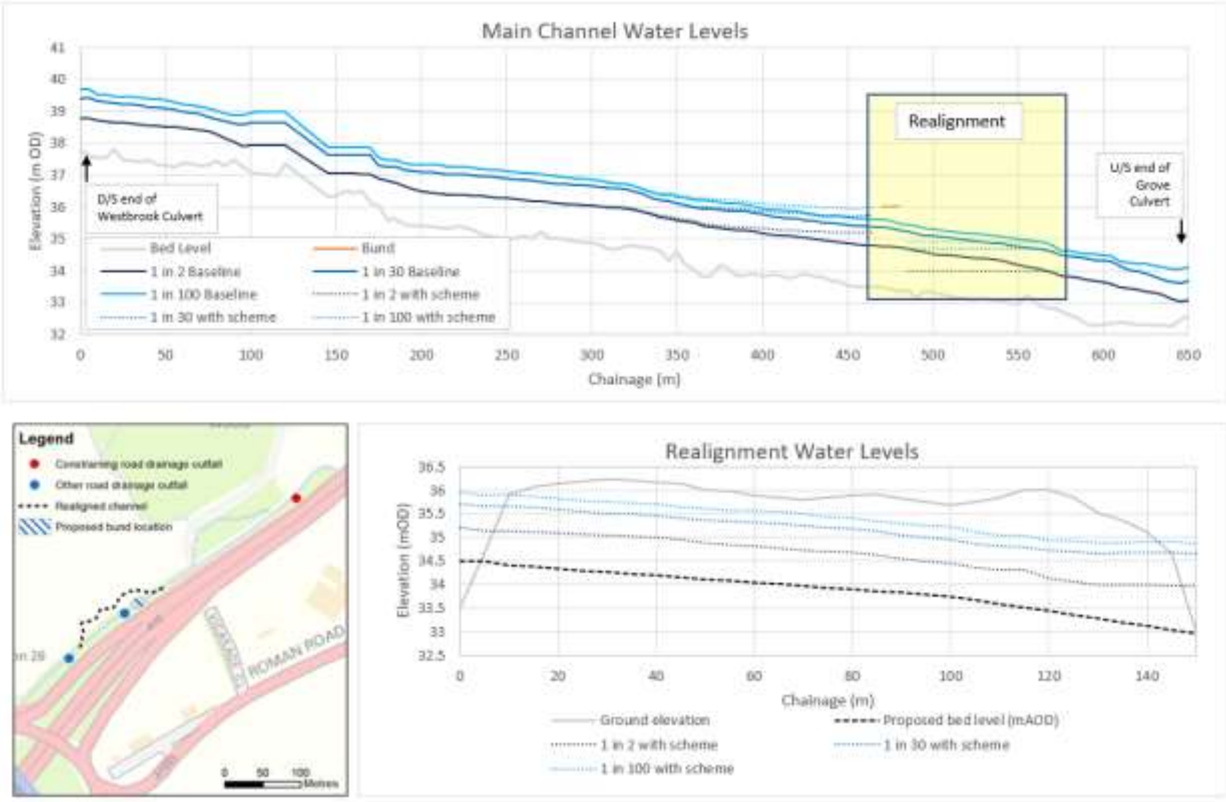


Figure 5-3 - Long section through River Ingrebourne (main channel) and downstream realignment

Note that an "engineered" step-pool sequence or alike would also be required on the steep downstream section of this realignment, to ensure geomorphological stability of the channel bed.

5.3.2. A12 drainage

The upstream and downstream connections between the existing Ingrebourne channel and the proposed realignment have been located so as to mitigate the effect of the realignment on outfalls from the A12 drainage system in the design 30-year event (Figure 5-3). Note that connection of the downstream drainage outfall back to the Ingrebourne would need further consideration, but room exists for a SuDS[1] feature to improve water quality prior to return to the river.

5.3.3. Flood risk to third party property and land

Hydraulic modelling indicates that this package of mitigation works could be implemented in such way as to limit the increase in 100-year water levels associated with the works to the reach adjacent to and c. 200m upstream of the realignment (Figure 5-3).

5.3.4. Indicative cost estimate

An indicative cost of this works package is between £450k and £550k. Assumptions and sensitivities of this cost are as for the upstream alignment above. This higher indicative cost for the downstream realignment is because additional material needs to be excavated and removed from site to lower ground and create floodplain.

[1] Sustainable drainage system

6. Discussion

In channel measures

It is not proposed to implement in-channel measures because a) these generate little additional benefit to in-channel habitat and b) they do not address the fundamental hydromorphological issue within the 'action measure' reach (floodplain disconnection).

Upstream realignment

The key challenges to realigning the River Ingrebourne to an historic course at the upstream end of the reach are a) the substantial difference in elevation between the bed levels of the existing channel and historic course (c. 1m) and b) the potential cost of mitigating the effects of the realignment on a road drainage outfall and high-pressure gas main crossing. The principle objective of this realignment would be to return the river to an historic channel with diverse natural morphology and natural connection with a wooded floodplain. To achieve this, reconnection would require substantial elevation of the river bed. This elevation would submerge an upstream road drainage outfall in events more frequent than 1 in 30 year. It would also require a very steep gradient on the bed of the channel returning the river to its existing course in the vicinity of a gas main crossing. This steep section of channel would need to be engineered as a 'step-pool' section to discourage erosion generally and specifically at the gas main crossing. The estimated cost of this realignment is already substantial (£350k to 450k), and a further large contingency would be needed to address likely complications associated with the issues above and lack of drainage survey data. For these reasons the option is considered both to be technically challenging and to carry substantial risk. It is also considered to deliver poor value for money. Comparable habitat improvement could be achieved by implementing a similar scheme of lower cost at a technically less challenging location elsewhere in the Ingrebourne catchment.

Downstream realignment

Realignment of the Ingrebourne to a new course towards the downstream end of the reach is less attractive than the upstream realignment because it requires engineering of a new channel and floodplain as opposed to reconnection to a more natural historic channel and floodplain. However, engineering a new course is very likely to allow the intake and offtake of this new channel to be placed so as to avoid compromising the hydraulic function of outfalls serving drainage from the A12 trunk road. A single set of hydraulic model runs indicate that it would be very difficult to achieve floodplain reconnection without lowering an area of ground to artificially create a floodplain to the realigned section of the river.

Although the extent of ground lowering has been constrained by the close proximity of the Scheme red line boundary to the river (c. 30m) in this study, the red line boundary could be revised during a supplementary consultation process being undertaken in the near future.

In summary, although the downstream realignment is more technically feasible than the upstream realignment it is habitat creation as opposed to restoration, it would only generate a limited area of floodplain reconnection (the principal mitigation required on this reach) and the total cost (£450k to 550k) is elevated by substantial earth movement and drainage system modifications. It is rejected because it is likely to deliver less habitat improvement than the upstream realignment at a greater cost. It therefore delivers poor value for money. Greater habitat improvement and value for money could be achieved by implementing a similar scale scheme at a technically less challenging location elsewhere in the Ingrebourne catchment.

7. Conclusions and recommendation

This note assesses the feasibility of implementing three packages of mitigation works to restore or create river and floodplain habitat on the 'action measure' reach of the River Ingrebourne between Westbrook and Grove Culvert near Frenches Farm. None of the packages are considered viable, on the following grounds:

- **In-channel measures** - it is not proposed to implement these measures because a) they generate little additional benefit to in-channel habitat and b) they do not address the fundamental hydromorphological issue within the 'action measure' reach (floodplain disconnection).
- **Upstream realignment** - Although the most attractive works package from the perspective of river and floodplain habitat restoration, constraints imposed by road drainage and a high pressure gas pipeline crossing make this mitigation package technically very challenging and potentially not viable. There is

also substantial uncertainty over the out-turn cost of the works. The works package is therefore likely to be technically infeasible and is not considered to offer value for money.

- **Downstream realignment -** This works package is likely to be technically feasible but only achieves connectivity between channel and floodplain if combined with land lowering. Earth moving at this scale is costly. In this study the lowered area has been limited to c 1300 m^2 (by the extent of the current Scheme red line boundary) but could be extended. This works package is considered not to deliver value for money.

None of the three packages of mitigation works investigated in this study have proved attractive propositions for delivering the habitat improvements required for the M25 junction 28 scheme to achieve WFD compliance. We recommend exploring other mechanisms for delivering the necessary mitigation and potential betterment at technically less challenging locations in the Ingrebourne catchment. Works at alternative sites are likely to deliver substantially better value for money.

8. References

Environment Agency, 2019. Email from [redacted] (EA) to [redacted] (Atkins) and [redacted] (HE) (dated 29 January, 2019)

Appendices

Appendix A. Baseline conditions

A.1. Introduction

This appendix describes the key hydromorphological features of a) the existing course of the Ingrebourne adjacent to the upstream realignment and b) the historic course of the river (the proposed realignment). This description is based on observations made during a site visit carried out on 21/5/19 by Atkins (David Scarcelli, Marcus Huband) and the Environment Agency (Keira Murphy, Neale Hider and Sacha Barnes).

Photos of the two reaches are in Figure A-1.

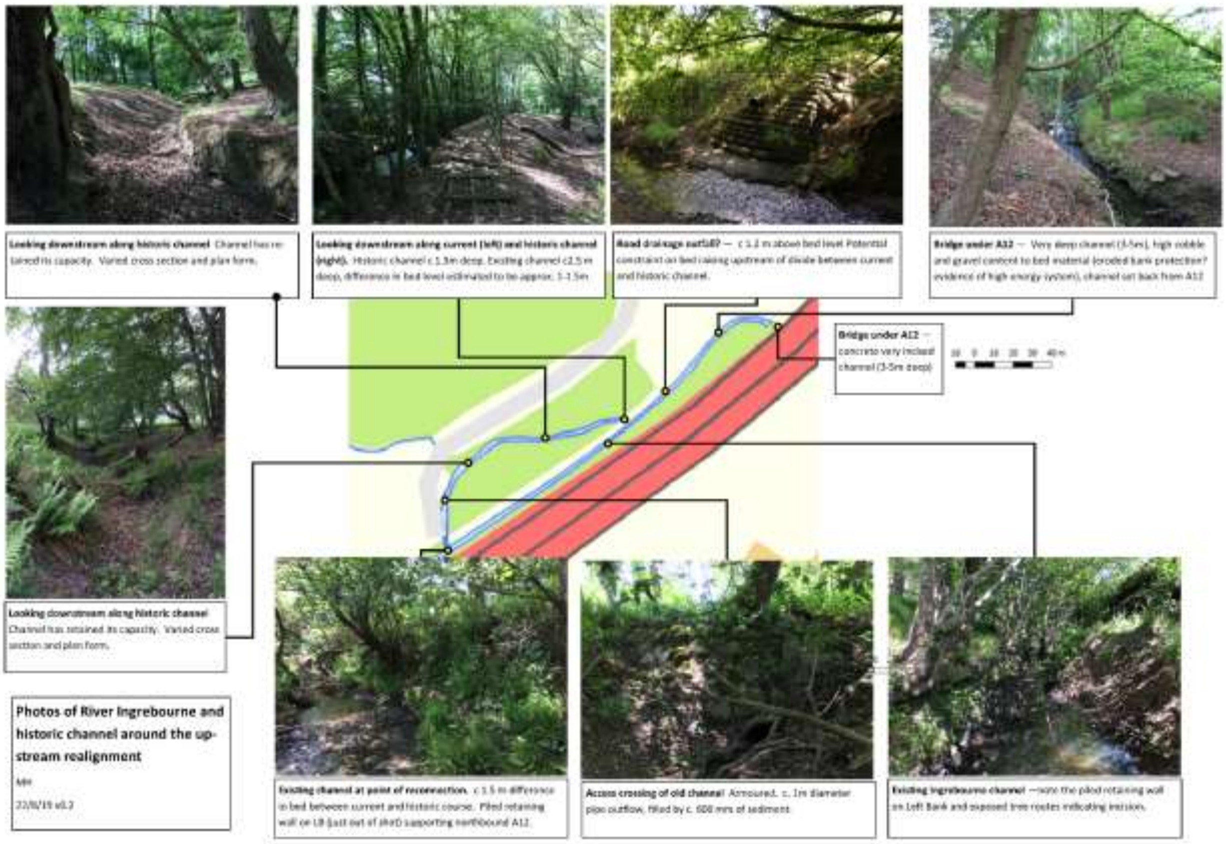


Figure A-1 - Baseline condition of the existing and historical channel of the River Ingrebourne

A.2. Existing course of the River Ingrebourne

Summary – artificially straightened and deepened channel. Consequent excess gradient and disconnect from flood plain creating active sediment system, expressed predominantly through incision and formation of regularly spaced gravel side bars together with shallow runs in sections without trees. Where tree roots have been exposed these strongly influence channel form. Key additional points:

- Straightened channel running adjacent to A12. Left bank looking downstream (LB) of river runs very close to, and sometimes in continuity with, piled retaining wall supporting northbound carriageway of A12. Right bank looking downstream (RB) is steep and natural (c 1 in 1 slope)
- Channel is recovering slight sinuosity through formation of predominantly gravel side bars at c 10 m spacing. No excessive areas of bank erosion, though vegetated failing bank protection observed in upper reaches.
- Evidence of recent incision (tree roots exposed by up to 0.5m, tree roots creating bed features) – possible source of sediment for bars.

- Common cross section shape – trapezoidal: 1-1 ½ m base width, c 2 ½ m depth and c 6 m top width
- Long section- flow depth varies between 2 and 40 cm, pools commonly formed behind root barriers

A.3. Historic course

Summary – semi natural relict slightly sinuous channel with varied cross, long and plan form. Channel still pronounced in landscape. Key additional points:

- No active sediment processes evident, natural relict channel form still visible – variation in cross sectional shape (steep and shallow banks) and widths
- Estimated 60 cm of soft sediment present in bottom of channel
- Common cross section – varied: 1m base width, c 1 ½ m depth and c 4 m top width
- Long section- bed obscured by soft sediments
- Floodplain – woodland (predominantly poplar?, 30 + years old?) dry at time of visit, but understorey vegetation suggests it is damp for extended periods of time

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