A66 Northern Trans-Pennine Project
TR010062

3.4 Environmental Statement Appendix 14.4 Hydromorphology Assessment

APFP Regulations 5(2)(a)

Planning Act 2008

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

Volume 3

June 2022

Infrastructure Planning

Planning Act 2008

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

A66 Northern Trans-Pennine Project Development Consent Order 202x

3.4 ENVIRONMENTAL STATEMENT
APPENDIX 14.4 HYDROMORPHOLOGY ASSESSMENT

Regulation Number:	Regulation 5(2)(a)
Planning Inspectorate Scheme Reference	TR010062
Application Document Reference	3.4
Author:	A66 Northern Trans-Pennine Project Team, National Highways

Version	Date	Status of Version
Rev 1	13/06/22	DCO Application

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14.4 Hydromorphology Assessment

14.4.1 Introduction

Legislation overview

14.4.1.1 The Water Framework Directive (WFD) came into force in 2000. The WFD imposes legal requirements to protect and improve the water environment. All activities in the water environment need to take the WFD into account. The EU WFD was transposed into law in England and Wales by the Water Environment (WFD) (England and Wales) Regulations 2003. The 2003 regulations were consolidated and replaced with the Water Environment (WFD) (England and Wales) Regulations 2017. The Floods and Water (Amendment etc.) (EU Exit) Regulations 2019 ensure that floods and water legislation continues to be operable in the United Kingdom following withdrawal from the EU in January 2021. The instrument addresses deficiencies in retained EU law arising from the UK's withdrawal from the EU. The purpose of the instrument is to preserve and protect the existing policy regime rather than to introduce new policy. The Water Environment (WFD) (England and Wales) Regulations 2017, as amended by the Floods and Water (Amendment etc.) (EU exit) Regulations 2019, are hereafter referred to as the WFD Regulations in this report.

Purpose of the assessment

14.4.1.2 This hydromorphology assessment aims to determine the effects of the Project on hydromorphological quality and identify any potential impacts that are likely to cause deterioration in the current status of the water bodies or could hinder the water bodies from meeting their WFD objectives in the future.

Methodology

14.4.1.3 There are nine schemes which, between them, are expected to cross watercourses at 36 different sites. The schemes were divided between two teams of fluvial geomorphologists / hydromorphologists, with each team comprising two surveyors. The assessments for each of the 36 sites have been split into three elements:

- Desktop review
- Site walkover surveys (surveys undertaken across the watercourse crossing points displayed in ES Figure 14.1: Surface Water Features (Application Document 3.3))
- Hydromorphology impact and partial WFD assessment (hydromorphology-related sections only)

14.4.1.4 Guidance on the hydromorphology survey method can be found in the hydromorphology survey method statement included in Annex B (Section 0). This survey method statement was approved by Environment Agency in an email response dated 19th October 2021. The survey method used aligns with that outlined in the *Design Manual for Roads and Bridges (DMRB) LA 113 Road drainage and the water* *environment (DMRB LA 113)* (Highways England, 2020)[1] document included in Annex C: DMRB LA 113.

14.4.1.5 The methodology for each element of the assessment is detailed below.

Desk assessment

14.4.1.6 Existing documentation and proposed design details have been reviewed in order to understand the nature of the proposals. During this initial stage each design was screened to assess potential hydromorphological WFD impacts. There are 36 river crossing to consider across the various schemes. This assessment has been fed back to the design team.

14.4.1.7 In addition, the desktop review includes analysis of historic mapping, LiDAR DTM data and aerial imagery to identify any evidence of historical modification to the channels. This will help set the context and provide insight into existing morphological processes and pressures and is used to inform the baseline hydromorphological assessment.

Surveys

14.4.1.8 Hydromorphological surveys were carried out at each proposed crossing site between 25 October and 5 November 2021 as per the hydromorphology survey method statement in Annex B: Hydromorphology Method Statement. The purpose of the surveys was to understand site conditions in the area of interest as well as sensitivity to change, which is essential to understanding sediment and flow dynamics and determine any potential impacts.

Table 1: Hydromorphology survey dates

Date of survey	Scheme surveyed
1st November 2021	M6 Junction 40 t0 Kemplay Bank
1st to 2nd November 2021	Penrith to Temple Sowerby
2nd to 3rd November 2021	Temple Sowerby to Appleby
3rd to 5th November 2021	Appleby to Brough

14.4.1.9 The onsite surveys carried out the following:

- Assessed and characterised the baseline hydromorphological conditions of the watercourses (200m either side of the impact site). Additional coverage was carried out if deemed necessary when on site (i.e., to capture evidence of hydromorphic features that extend beyond the 200m or to gain a more comprehensive view on hydromorphic processes operating within higher energy / more mobile river systems, where the potential for impact is greater).
- Identified hydromorphological 'reaches' based upon the dominant characteristics and controls present.
- Collected data and documented observations such as typical channel dimensions and form; channel bank composition; dominant flow

[1] Highways England (2020) Design Manual for Roads and Bridges LA 113 Road drainage and the water environment

types; dominant erosion and depositional processes/substrates; and land use along each reach.
- Identified the location and approximate spatial extent of flow types (e.g. riffles, runs, pools) and other hydromorphological features (e.g. bars, berms, bank erosion) and physical pressures/modifications (e.g. realignments, embankments, impoundments) along the survey extent.
- Collected georeferenced videos at crossing points and photographs of crossing points, as well as throughout the survey reach where needed to capture key geomorphological features and processes.

Impact assessment

14.4.1.10 The hydromorphology assessment acts as supporting evidence to the Environment Statement (ES) Chapter 14: Road drainage and the Water Environment (Application Document 3.2) and ES Appendix 14.1: WFD Compliance Assessment (Application Document 3.4).

14.4.1.11 More detailed assessment of hydromorphological conditions for key watercourses for the Temple Sowerby to Appleby and Appleby to Brough schemes can be found in ES Appendix 14.9: Detailed Geomorphological Modelling (Application Document 3.4). Hydraulic modelling of watercourses is presented in (ES Appendix 14.2: Flood Risk Assessment and Outline Drainage Strategy (Application Document 3.4)). Analysis of hydromorphological conditions using hydraulic model data was included due to the complexity of both schemes and the potential for detrimental impact to watercourses in the vicinity.

14.4.1.12 Using the knowledge gained from desk and site-based work, the potential impact of the proposed scheme for each of the proposed crossing locations has been assessed using published methods. The following elements were focused on, in order to assess the impact and the hydromorphological quality elements of each water body:

- flow processes
- sediment movement
- boundary conditions (channel bed and banks)
- riparian zones
- floodplains
- downstream and catchment-channel connectivity
- the general form and function of the channel and near-channel zones
- the setting of the watercourse within the wider catchment.

14.4.1.13 The location of the schemes and watercourse crossing points are shown on Figure 14.1: Surface Water Features (Application Document 3.3). WFD catchments are shown on Figure 14.3: WFD Surface Water Bodies (Application Document 3.3).

Identification of mitigation measures

14.4.1.14 The assessment reported in this assessment is based on a precautionary worst case scenario. As such, the mitigation identified in this assessment as being required to mitigate the likely significant effects reported are based on this worst case scenario. It may be the case that as detailed design of the Project evolves, it becomes apparent that a lesser form of mitigation is required to achieve the same outcome. As such, the EMP secures the 'maximum' extent of mitigation required (as identified in this assessment) but also, where appropriate, includes mechanisms (e.g. by way of further surveys or modelling) to establish, pre-construction and during detailed design, whether the identified mitigation can be refined such that a lesser extent is required to achieve the outcome reported in this assessment. The fundamental point is that the mitigation identified in this assessment is secured by the EMP, where required to achieve the outcome reported in this assessment.

14.4.1.15 Any potentially significant hydromorphological impacts identified during this process are clearly documented within each scheme assessment with suggested mitigation measures. The mitigation measures stipulated within the impact assessment are secured by the Project Design Principles (Application Document 5.11) and the Environmental Management Plan (Application Document 2.7), which are certified documents under DCO.

14.4.2 M6 Junction 40 to Kemplay Bank

Scheme overview and proposed works

Scheme location and existing conditions

14.4.2.1 The scheme location for M6 Junction 40 to Kemplay Bank, and the proposed Watercourse Crossing Points, are shown in Plate 1: Scheme location for M6 Junction 40 to Kemplay Bank and the proposed watercourse crossing point. The Thacka Beck is currently culverted beneath the A686, existing A66 and the Cumbria Police HQ for approximately 300m. Downstream of the Cumbria Police HQ, Thacka Beck returns to an open channel watercourse for approximately 100m before discharging into the River Eamont.

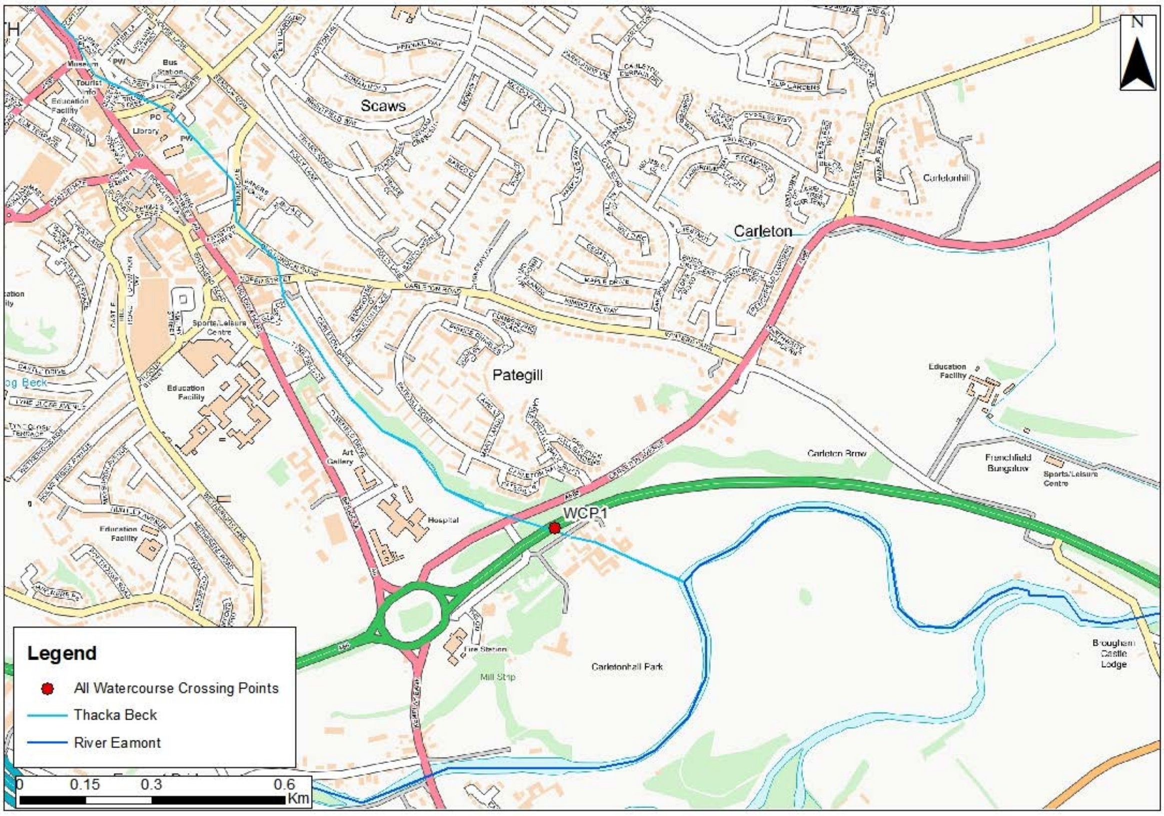

Plate 1: Scheme location for M6 Junction 40 to Kemplay Bank and the proposed watercourse crossing point

Proposed works

14.4.2.2 The existing Watercourse Crossing Point on Thacka Beck is to be retained as part of the proposed works. The proposed works do not involve upgrading the existing culvert on Thacka Beck. As such, there are no proposed works on Thacka Beck as part of the scheme.

Baseline hydromorphology desktop study

Survey scope

14.4.2.3 The scheme watercourse crossing point is located within the Eamont (Upper) WFD water body catchment (ES Figure 14.3: WFD Surface Water Bodies (Application Document 3.3). The following sections provide a summary of the geomorphological characteristics of this catchment.

Catchment and character

14.4.2.4 The River Eamont rises at Ullswater in Glenridding within the Lake District National Park. The Eamont (Upper) water body catchment drains an area of 87.82km². Approximately 11.6km north of Ullswater, the Eamont (Upper) waterbody flows through the village of Pooley Bridge. The River Eamont continues to flow in a north easterly direction for approximately 11.2km towards the village of Eamont Bridge, south of Penrith.

14.4.2.5 Thacka Beck, on which WCP1 is located, drains into the River Eamont at Penrith. Thacka Beck flows through Penrith for approximately 5.7km in a south easterly direction.

14.4.2.6 The Eamont (Upper) water body catchment is primarily rural with areas of grassland, woodland, and farmland. The southern area of the catchment is characterised by steep topography. In addition to rural land, the catchment consists of urban settlements. The urban centre of Penrith is situated in the north of the catchment. The waterbody crosses beneath the M6 at Eamont Bridge and beneath the A66 in Brougham.

14.4.2.7 The geology within the Eamont (Upper) waterbody catchment is mixed. The catchment consists of Ordovician rocks (undifferentiated) including Mudstone, Siltstone and Sandstone and Upper Devonian rocks (undifferentiated) including Sandstone and Conglomerate. The north of the catchment is mainly Yoredale Group geology, characterised by Limestone with Subordinate Sandstone and Argillaceous rocks.

Historic trend analysis

14.4.2.8 Historic Ordnance Survey (OS) mapping has been used to examine the extent of historic channel change within the water body catchment. The watercourse routes illustrated in the 1888 OS mapping (the earliest OS mapping available online) have been compared to current watercourses to identify areas of channel migration and realignment.

14.4.2.9 There has been little change to the planform of the Upper River Eamont in the c.130 years since the earliest mapping available online. In the south of the water body catchment, the lack of planform change can be attributed to steep topography and riparian woodland vegetation preventing significant channel migration. There has been slight migration of the River Eamont planform in Pooley Bridge.

14.4.2.10 In the north of the water body catchment, insignificant change to the River Eamont planform can be attributed to urbanisation. Historic mapping, published in 1900, identifies mill and weir structures, used to manage river flow in Eaton Bridge for manufacturing. Weir removal has since taken place, although some structures remain. At present, the River Eamont continues to be managed to protect the urban settlement of Eamont Bridge and the surrounding road network from flooding.

14.4.2.11 There has been insignificant change to the planform of Thacka Beck in the c. 130 years since the earliest mapping available online (Plate 2: Assessment of historic planform change on Thacka Beck). The planform of Thacka Beck has been managed to facilitate the development of Penrith and prevent lateral migration of the channel from threatening existing buildings in the town. Thacka Beck is culverted beneath a large area of the town, between Brunswick Square to the north and Roper Street to the south. The section of open channel between Penrith and Carleton Hall has retained the same planform since the earliest mapping available online. Bank modifications, such as rock armour and wooden toe boards, fix the planform of Thacka Beck into position. Thacka Beck has been culverted beneath Carleton Hall for at least the last c. 130

years. Historically, a weir located at the confluence of Thacka Beck and the River Eamont regulated discharge. However, this culvert has since been removed from the River Eamont.

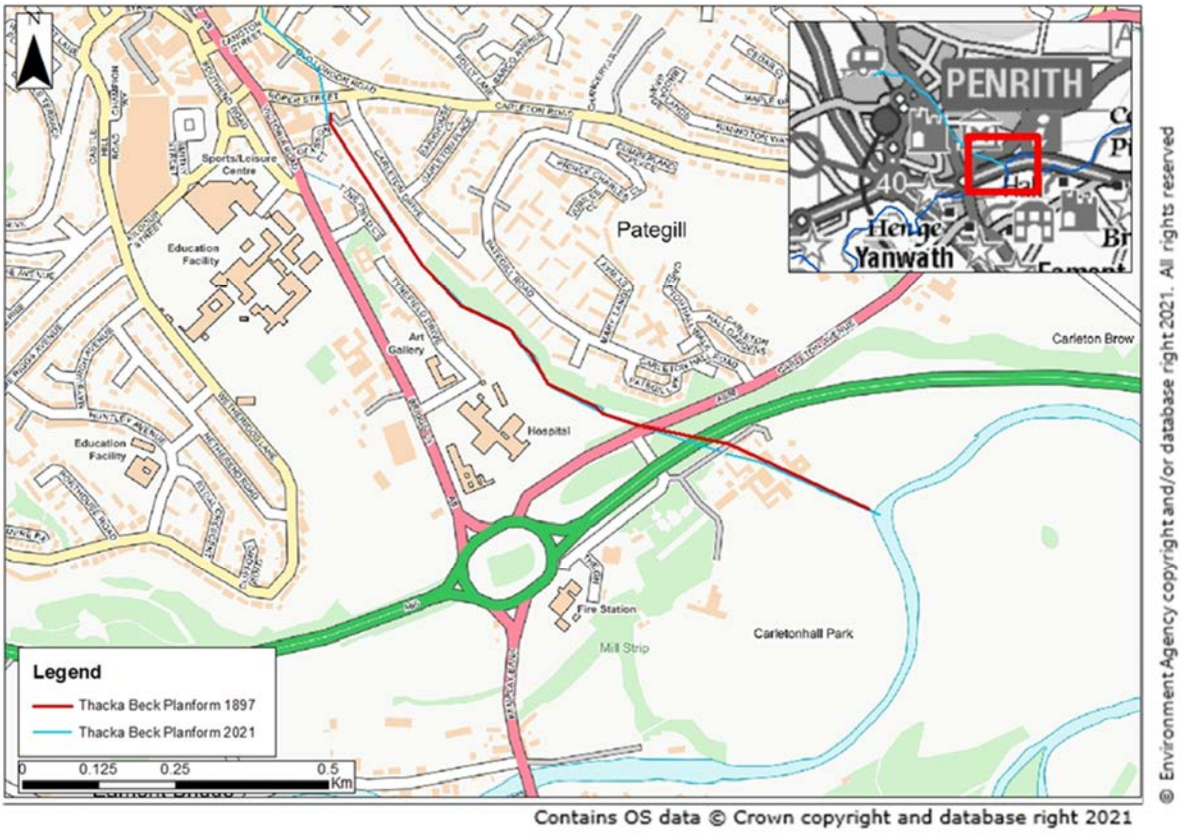

Plate 2: Assessment of historic planform change on Thacka Beck

Assessment of LiDAR data

14.4.2.12 Several palaeo channels can be identified in the vicinity of Brougham in Penrith. In Area 1 (Plate 3: Assessment of LiDAR data in the vicinity of M6 Junction 40 to Kemplay Bank) palaeo channels identified on the left and right bank floodplain indicate that the River Eamont has migrated across the floodplain historically. In Area 1 the planform of the River Eamont has not been modified, which has allowed the river to adopt a more sinuous planform and meander across the floodplain. The palaeo channels in Area 1 suggest that the River Eamont has been more active in the past, prior to the earliest OS mapping available.

14.4.2.13 Palaeo channels have been identified in the vicinity of the Eamont Bridge in Area 2 (Plate 3: Assessment of LiDAR data in the vicinity of M6 Junction 40 to Kemplay Bank). To the east of Area 2, there is less evidence of historic channels. This can be attributed to the anthropogenic modification and management of the River Eamont over a long period of time. Since the 1800s, flow has been managed and controlled by weir structures, preventing channel migration.

14.4.2.14 Palaeo channels have not been identified along Thacka Beck watercourse. This is likely a result of a narrow and constricted floodplain and historical channel planform management, which have both prevented Thacka Beck from adopting a more sinuous planform.

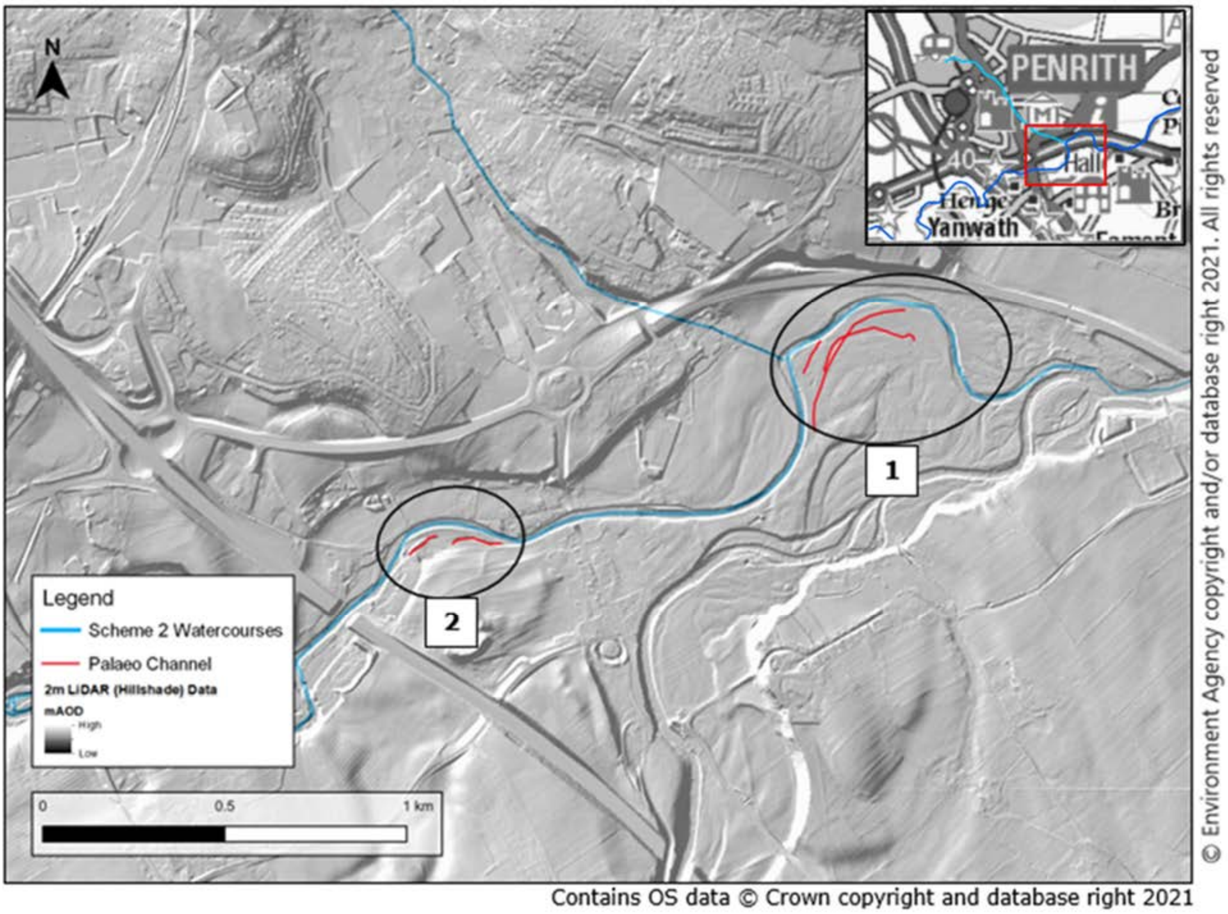

Plate 3: Assessment of LiDAR data in the vicinity of M6 Junction 40 to Kemplay Bank

Baseline hydromorphology site observations

Table 2: Baseline hydromorphology for each watercourse with a crossing point

Crossing Point/ Watercourse	Site Observations
WCP1, Thacka Beck	**Wider Catchment Characteristics:** Thacka Beck rises to the north of Penrith and flows in a generally southern direction before discharging into the River Eamont to the south of the Cumbria Constabulary. Photographs of the location are shown in Annex A: Site Photograph Locations. **Observed In-Channel Modifications:** Culvert beneath the A686, M6 Motorway and Cumbria Police HQ **Typical Flow Biotopes:** Upstream of the culvert beneath the A686, Thacka Beck the flow is energetic, a product of the steep channel gradient and artificially straightened channel planform. As such, the typical flow biotopes range from rapid features where the flow is supercritical to riffle features. It is clear that the high energy system upstream of the A686 culvert has

Crossing Point/ Watercourse	Site Observations
	sufficient energy to erode the riverbanks, as brick bank protection was identified in sporadic locations across Thacka Beck to mitigate against erosion and potential channel planform change. Downstream of the A686 and Cumbria Constabulary, the flow becomes less energetic as the channel gradient becomes shallower and the River Eamont has an impounding influence on the flow dynamics in Thacka Beck. As such, flow velocities reduce significantly on the approach to the confluence, with rapid riffle features transitioning to run biotopes. It is likely that the heavy rainfall before the site work influenced the flow dynamics within Thacka Beck, and the water levels and impounding influence from the River Eamont. **Typical Bed Substrate:** The bed material in Thacka Beck ranges from cobbles to gravels. The energetic flow within the channel results in finer material being transported to downstream reaches, leaving coarse material to occupy the river bed. As such, both the upstream and downstream reaches of Thacka Beck act as sediment transfer reaches. On the approach to the confluence with the River Eamont, the typical size of bed substrate decreases, as flow velocities reduce due to the impounding influence the River Eamont has on Thacka Beck. As a result, the typical bed substrate ranges from gravels to sands. Finer substrate such as silts continue to be transported to downstream reaches on the River Eamont. **Typical Riparian Composition:** The condition of the riparian zone of Thacka Beck varies considerably. Upstream of the A686 road culvert, a thin buffer strip of riparian trees cover the left bank of Thacka Beck, whereas the right bank of the watercourse lacks riparian tree cover. The right bank floodplain is occupied by grassland, with fencing on the right bank preventing access to the watercourse by livestock. It is likely that the lack of riparian tree cover on the right bank has led to the structural integrity of the riverbank degrading, leaving the right bank more susceptible to bank erosion. Conversely, the well vegetated left bank of the channel has enhanced structural integrity and is therefore more resistant to bank erosion. Downstream of the Cumbria Constabulary, the condition of the riparian corridor becomes degraded compared to upstream reaches. There is a distinct lack of riparian tree cover on both riverbanks, and instead the riverbanks are occupied by long grasses. Fencing has been installed on both riverbanks to prevent access to the watercourse for livestock, which has reduced the risk of livestock poaching further degrading the condition of the riparian zone. **Typical Floodplain Connectivity:** The floodplain connectivity of Thacka Beck upstream of the A686 is degraded. It is clear that the channel has been historically realigned and

Crossing Point/ Watercourse	Site Observations
	repositioned to the far left of the floodplain, and as such the channel planform has been straightened. This has increased the channel gradient and provided the watercourse with sufficient energy to erode the river bed, which has resulted in river bed incision over time. The result is a disconnected floodplain from the channel. The floodplain is also noticeably perched above the natural valley bottom. Downstream of the Cumbria Constabulary, the floodplain connectivity remans poor. This downstream reach of Thacka Beck has undergone bed incision, which has left the floodplain disconnected from the channel. In addition, the channel geometry is trapezoidal, which further reduces the ability of flow within Thacka Beck to enter the floodplain. It is likely that the floodplain becomes frequently inundated by flood events on the River Eamont, rather than Thacka Beck.

Stage 1: Hydromorphology screening

14.4.2.15 The screening assessment aims to screen in any works that require WFD assessment and to identify which WFD water bodies are within and near to the proposed screened in works.

14.4.2.16 Drainage channel outfalls have been screened out of the assessment as their design is secured by the Environmental Management Plan (Application Document 2.7), which is a certified document under DCO. Where hard outfalls currently exist, new drainage channel outfalls will be tied into the existing structure. Drainage channels in areas with natural banks will be designed as a natural outfall (i.e. without hard bank protection).

14.4.2.17 Table 3: Screening of each water body, indicates which water bodies have been screened in or out of the assessment and the reasons for this decision.

14.4.2.18 The baseline status of the hydromorphology quality elements within the water bodies screened into the assessment are outlined in this section. If there is potential for the proposed works to cause deterioration in the status of a water body or prevent it from achieving its status objectives as defined in the Solway Tweed River Basin Management Plan 2021, the relevant water body and its quality elements have been taken forward and considered further in the scoping assessment at Stage 2.

Table 3: Screening of each water body

Water body/ies	Reason	Screening outcome
Eamont (Lower)	There are no proposed works taking place on Thacka Beck. As such, there is no potential for an impact on the Eamont (Lower) water body.	Screened Out
Eamont (Upper)	There are no proposed works taking place on Thacka Beck. As such, there is no potential	Screened Out

Water body/ies	Reason	Screening outcome
	for an impact on the Eamont (Upper) water body.	

14.4.2.19 Both the Eamont (Lower) and the Eamont (Upper) water bodies have been screened out of the assessment. As such, the scheme will not be considered further at the scoping (Stage 2) or impact assessment (Stage 3) stage.

M6 Junction 40 to Kemplay Bank key considerations

14.4.2.20 Although all water bodies were screened out of the assessment, the mitigation outlined in Section 14.4.9 must still be incorporated into the design for the M6 Junction 40 to Kemplay Bank scheme. This is secured through the Project Design Principles (Application Document 5.11) and the Environmental Management Plan (Application Document 2.7) which are certified documents under the DCO.

Summary

14.4.2.21 The WFD screening (Stage 1) stage identified that none of the proposed works at any of the watercourse crossing points assessed will have a detrimental impact to the Eamont (Upper) or Eamont (Lower) WFD water bodies and all water bodies were screened out of the assessment.

14.4.2.22 The mitigation measures outlined in section 14.4.9 will be incorporated into the design for the M6 Junction 40 to Kemplay Bank scheme.

14.4.2.23 The assessment reported in this assessment is based on a precautionary worst case scenario. As such, the mitigation identified in this assessment as being required to mitigate the likely significant effects reported are based on this worst case scenario. It may be the case that as detailed design of the Project evolves, it becomes apparent that a lesser form of mitigation is required to achieve the same outcome. As such, the EMP secures the ‘maximum’ extent of mitigation required (as identified in this assessment) but also, where appropriate, includes mechanisms (e.g. by way of further surveys or modelling) to establish, pre-construction and during detailed design, whether the identified mitigation can be refined such that a lesser extent is required to achieve the outcome reported in this assessment. The fundamental point is that the mitigation identified in this assessment is secured by the EMP, where required to achieve the outcome reported in this assessment.

14.4.3 Penrith to Temple Sowerby

Scheme overview and proposed works

Scheme location

14.4.3.1 The scheme location for Penrith to Temple Sowerby, and the proposed watercourse crossing points, are shown in Plate 4: Scheme location for Penrith to Temple Sowerby and the proposed watercourse crossing points.

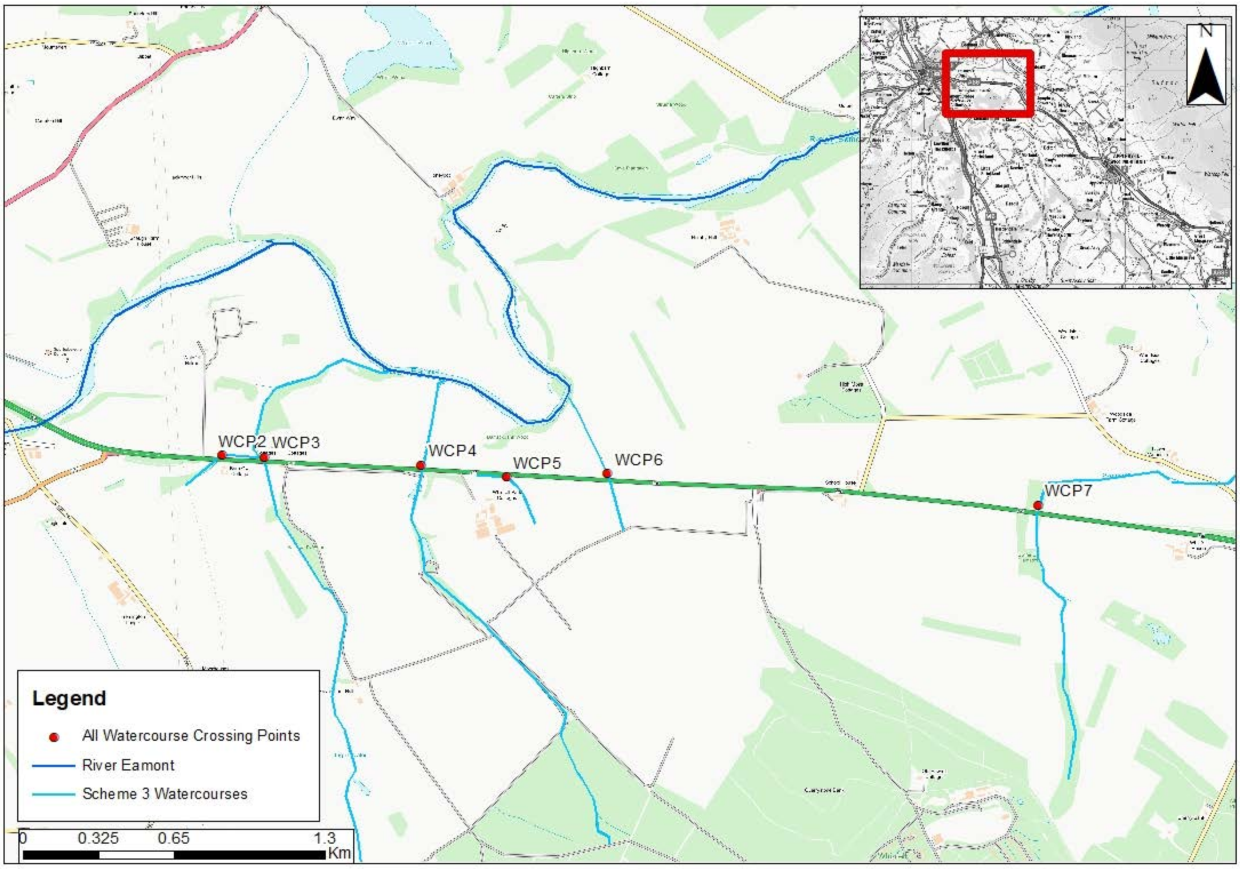

Plate 4: Scheme location for Penrith to Temple Sowerby and the proposed watercourse crossing points

Proposed works

14.4.3.2 The proposed works at each identified watercourse crossing point in Plate 4: Scheme location for Penrith to Temple Sowerby and the proposed watercourse crossing points are summarised in the following sections.

Watercourse Crossing Point 2 (Culvert 303)

- The existing pipe culvert on the Unnamed Tributary of the Lightwater 3.1 adjacent to Barn Owl Cottage has a diameter of 0.675m and has a length of 200m.
- The proposed works at the culvert involve the replacement of the existing structure with a new culvert. The proposed culvert is to have a diameter of 0.675m, and a length of 232m.
- At the inlet of the new proposed culvert, a precast headwall with an inlet grille is to be installed.
- At the outfall of the new proposed culvert, a precast headwall with a baffle outlet is to be installed.
- The culvert inlet is to be placed 32m upstream of the existing culvert inlet, to accommodate the wider A66 extent. As such the replacement culvert is to have an extended footprint compared to the original structure.

- The diameter of the replacement culvert is to be the same diameter as the existing structure.
- A chamber is to be installed 12m downstream of the inlet, to accommodate a right-hand bend in the structure as the culvert approaches the outfall on the left bank of the Lightwater.

Watercourse Crossing Point 3 (Lightwater)

- The existing culvert on the Lightwater is to be extended to the north and south to accommodate the expansion of the A66 carriageway.
- A proposed in-situ pre-cast reinforced concrete culvert extension is to be added to the south of the existing culvert, extending the structure by 6.22m. A reinforced pre-cast concrete headwall unit is to be installed to the south of this proposed culvert extension. The internal clear span and height of the culvert extension is to match the dimensions of the existing structure.
- The existing southern concrete headwall of the Lightwater culvert is to be removed.
- A proposed in-situ pre-cast reinforced concrete culvert extension is to be added to the north of the existing culvert, extending for 7.51m. A reinforced pre-cast concrete headwall unit is to be installed to the north of the proposed culvert. The internal clear span and height of the culvert extension is to match the dimensions of the existing structure.
- Beneath the proposed culvert extensions to the north and south of the existing structure, a minimum 0.15m thick granular pipe bedding will be installed.
- An additional maintenance culvert will be installed approximately 110m downstream of the existing Lightwater culvert outfall, called Lightwater Maintenance Lane Culvert, to convey the Lightwater beneath a proposed maintenance access track. The length of the proposed culvert is 10m.
- The barrel dimensions of the Lightwater Maintenance Lane Culvert are to match the dimensions of the existing Lightwater Culvert.

Watercourse Crossing Point 4 (Culvert 301)

- The existing culvert on the Unnamed Tributary of the Eamont 3.1 is a rectangular culvert, with a 1.0m high by 0.6m wide opening and covers a length of 30m.
- The proposed works at the culvert involve the installation of a chamber on the outfall of the existing culvert, to allow the installation of a 0.9m diameter pipe culvert across a length of 40m. A precast headwall outlet is to be installed at the outfall of the proposed culvert extension.
- The gradient of the proposed culvert extension is steeper (0.037) than the existing culvert gradient (0.016) to take into account the change in topography on the floodplain downstream of the existing culvert outfall.

Watercourse Crossing Point 5 (Culvert Unnamed - Whinfell)

- The existing pipe culvert inlet is situated on the Unnamed Tributary of the Eamont 3.4. The culvert extends for approximately 120m west towards Culvert 301 beneath the existing A66, where it joins Culvert 301. The outfall of Culvert Unnamed is shared with Culvert 301. The diameter of the existing culvert is 0.45m.
- The proposed works involve the extension of the culvert for approximately 320m upstream of the existing culvert inlet. In addition, the culvert is to be diverted around the proposed road embankment associated with an access/service road for the A66 dual carriageway, and away from the existing 130m of open channel. A precast headwall and inlet grille is to be installed in the Unnamed Tributary of the Eamont 3.4 at the start of the watercourse diversion.
- The diameter of the proposed culvert extension is to match that of the existing culvert diameter (0.45m) and will match the geometry of the existing culvert.

Watercourse Crossing Point 6 (Culvert 302)

- The existing pipe culvert has a diameter of 0.6m and extends across a length of 30m beneath the A66.
- The proposed works involve the extension of the culvert downstream for a distance of 50m. A precast concrete headwall will be installed at the outfall of the proposed culvert extension. The watercourse downstream of the proposed culvert extension is to be realigned approximately 10m to the west, and as such the culvert extension will need to dog leg to the west to ensure the culvert outfall is situated at the realigned channel. Two chambers will be installed in the extended culvert to facilitate the change in culvert direction.

Watercourse Crossing Point 7 (Swine Gill)

- The existing culvert on the Swine Gill is to be extended to the north to accommodate the expansion of the A66 carriageway and the A66 embankment.
- A proposed in-situ pre-cast reinforced concrete culvert extension is to be added to the north of the existing culvert, extending for 39.10m. A reinforced pre-cast concrete headwall unit is to be installed to the north of the proposed culvert extension. The internal clear span and height of the culvert extension is to match the dimension of the existing structure. The gradient of the existing culvert will be extended and maintained through the proposed culvert extension.
- Beneath the proposed culvert extension, a minimum of 0.075m blinding and 0.15m thick granular pipe bedding will be installed.

Baseline hydromorphology desktop study

Survey scope

14.4.3.3 The watercourse crossing points are located within the Eamont (Lower) and Eden Lyvennet to Eamont WFD water body catchments (ES Figure 14.3: WFD Surface Water Bodies (Application Document 3.3). The following sections provide a summary of the geomorphological characteristics of these catchments.

Catchment and character

Eamont (Lower)

14.4.3.4 The Eamont (Lower) water body catchment drains an area of 23.17km^2. The source of the River Eamont is Ullswater Lake in Glenridding within the Lake District National Park. The Eamont (Lower) water body flows downstream from the village of Brougham for approximately 8.6km in a north easterly direction.

14.4.3.5 At Brougham, the Light Water (WCP3, WCP78) watercourse drains into the River Eamont. The Lightwater rises in Clifton at an elevation of approximately 142mAOD and flows in an easterly direction for 1.5km. The watercourse continues to flow in a northernly direction for approximately 2.6km before discharging into the River Eamont.

14.4.3.6 Four Unnamed Drains have been identified within the Eamont (Lower) water body which contain watercourse crossing points relating to the proposed works at Penrith to Temple Sowerby.

14.4.3.7 The Eamont (Lower) water body is primarily rural with areas of grassland, woodland and farmland and the underlaying bedrock is the Penrith Sandstone Formation.

Eden Lyvennet to Eamont

14.4.3.8 The Eden Lyvennet to Eamont waterbody drains an area of 12.95 km^2. The River Eden within this waterbody flows in a north easterly direction past the villages of Temple Sowerby and Culgaith. The length of the River Eden within this waterbody is 7.6km.

14.4.3.9 The Eden Lyvennet to Eamont waterbody catchment is mostly rural with areas of grassland, woodland and farmland.

14.4.3.10 The geology within the Eden Lyvennet to Eamont waterbody catchment is mixed. The geology to the north of the catchment is Eden Shales Formation, characterised by Mudstone. In the south of the catchment, the geology is Penrith Sandstone Formation.

Historic trend analysis

14.4.3.11 Historic OS mapping has been used to examine the extent of historic channel change within the water body catchment. The watercourse routes illustrated in the 1888 OS mapping (the earliest OS mapping available online) have been compared to current watercourses to identify areas of channel migration and realignment.

Eamont (Lower)

14.4.3.12 There has been little change to the Eamont (Lower) waterbody in the c. 130 years since the earliest mapping available online.

14.4.3.13 The watercourses that drain into the River Eamont, including the Light Water and a number of unnamed drains, have largely remained in the same location since 1888. The lack of historic planform change to the Light Water channels can be attributed to agricultural management. The Light Water appears to have been straightened and realigned to improve drainage for farming.

Eden Lyvennet to Eamont

14.4.3.14 There has been planform change to the River Eden within the Eden Lyvennet to Eamont waterbody in the c. 130 years since the earliest mapping available online. To the west of Culgaith, the River Eden planform appears artificially straightened compared to the historic channel planform. Given the sinuous nature of the River Eden both upstream and downstream of this location, it is likely that this reach of the River Eden has been modified to generate this straightened channel planform. (Area 1 of Plate 5: Assessment of historic planform change on the River Eden).

14.4.3.15 The Swine Gill watercourse, which drains into the River Eden, has been managed for agriculture and has remained largely in the same location. As such, historic planform change was not identified in the earliest historic maps available online.

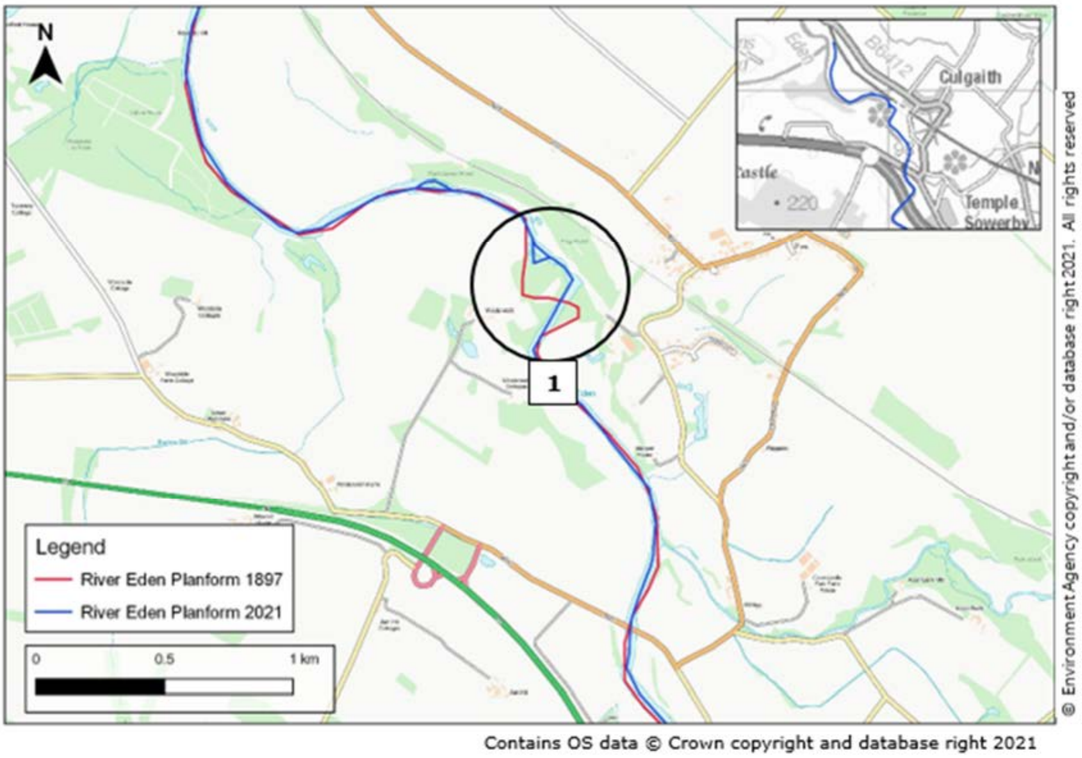

Plate 5: Assessment of historic planform change on the River Eden

Assessment of LiDAR data

14.4.3.16 Several palaeo channels can be identified on the floodplain of the River Eamont in Area 1 and Area 2 (Plate 6: Assessment of palaeo channels in the vicinity of Penrith to Temple Sowerby). The identification of palaeo channels on the floodplain suggests that the Eamont was previously a multi-threaded river system. However, human intervention over time has led to the river system becoming a more simple, single threaded river system observed today. Palaeo channels can be seen on the inside section of meander bends. Historic flow paths indicate that the River Eamont planform has decreased in sinuosity over time.

14.4.3.17 In Area 3 (Plate 6: Assessment of palaeo channels in the vicinity of Penrith to Temple Sowerby) palaeo channels have been identified between the Swine Gill and the Unnamed Tributary of the Lightwater 3.1. The channels do not appear in historic mapping. This suggests that the watercourses were previously more sinuous, complex and multi-threaded, but have most likely been straightened and realigned for land use and drainage reasons. The straightened channel planform has increased the channel gradient and increased the rate of bed incision. This has disconnected the channel from the floodplain, and exacerbated rates of bed erosion. The identification of palaeo channels on the floodplain provide further evidence of historical planform modification and bed incision. The palaeo channels identified on the floodplain are raised at a much higher elevation compared to the river bed. It is probable that the watercourses have been pinned in place to increase the extent of agricultural land for farming. A lack of planform change in recent years can be explained by agricultural management and narrow floodplains that have restricted migration.

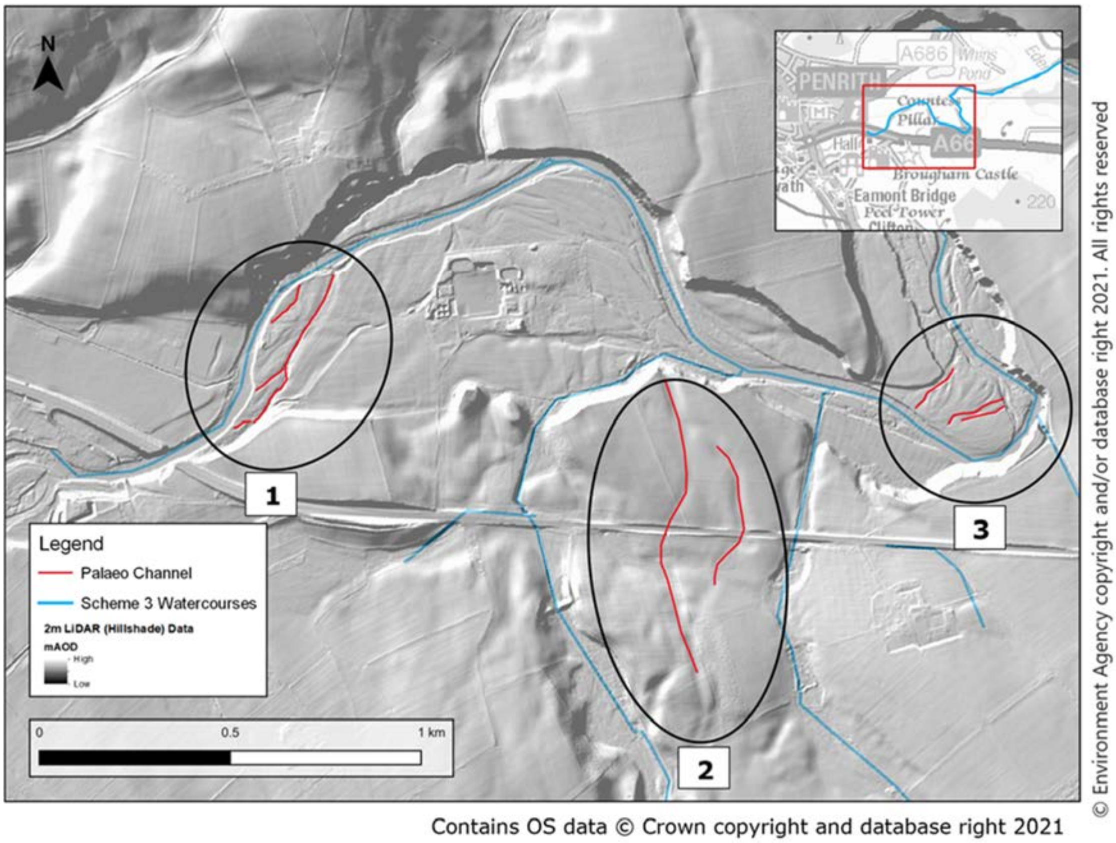

Plate 6: Assessment of palaeo channels in the vicinity of Penrith to Temple Sowerby

Baseline hydromorphology site observations

Table 4: Baseline hydromorphology for each watercourse with a crossing point

Crossing Point/ Watercourse	Site Observations
WCP2, Unnamed Tributary of the Lightwater 3.1 (Culvert 303)	**Wider Catchment Characteristics:** The Unnamed Tributary of the Lightwater 3.1 rises within woodland to the south-west of Barn Owl Cottage (south of the existing A66). Flow inputs from a number of agricultural drainage networks to the south of Barn Owl Cottage converge within the woodland and are discharged via a culvert into the Unnamed Tributary of the Lightwater 3.1. The watercourse flows in a south easterly direction for approximately 100m before the watercourse is culverted beneath the A66. The watercourse remains culverted on the northern side of the existing A66, before discharging into the Lightwater from a culvert outfall located on the left bank of the channel. Photographs of the location are shown in Annex A: Site Photograph Locations. **Observed In-Channel Modifications:** • Culvert at upstream extent of the Unnamed Tributary of the Lightwater 3.1 • Culvert beneath the A66 and remains culverted to the Lightwater confluence **Typical Flow Biotopes:** Downstream of the culvert at the upstream limit of the Unnamed Tributary of the Lightwater 3.1, in-channel flow velocities are moderate as flow concentrated within the culvert barrel is discharged into the channel. The result is a diverse range of flow biotopes downstream of the culvert ranging from riffles to runs. The channel is relatively sinuous in the open channel section of the Unnamed Tributary of the Lightwater 3.1, a contributing factor in the development of the flow biotope diversity observed. On the approach to the culvert beneath the A66, the flow energy reduces compared to the upstream reach. It is likely that the shallower channel gradient, combined with the overgrown nature of the river bed leads to a reduction in flow energy on the approach to the culvert. As such, gliding flows are the typical flow biotope within the channel in this reach. Flow dynamics downstream of the A66 culvert were not observable, as the channel is culverted from the A66 to the culvert outfall on the left bank of the Lightwater located further downstream. **Typical Bed Substrate**: At the upstream limit of the Unnamed Tributary of the Lightwater 3.1, the typical bed substrate ranges from cobbles to gravels and sands. Flow velocities within the channel are moderate, as flow concentrated within the culvert barrel is discharged into the channel. As a result, finer material such as sands and silts are conveyed to downstream reaches of the watercourse, leaving behind a matrix of coarser material. On the approach to the culvert beneath the A66, the bed substrate composition changes. As flow velocities reduce, fine material suspended in the water column is deposited on the river bed, resulting in the build-up of

Crossing Point/ Watercourse	Site Observations
	finer bed substrate such as sands and silts. In addition, the invert of the culvert traps fine material upstream of the culvert, increasing the accumulation of fine bed substrate. **Typical Riparian Composition:** At the upstream limit of the Tributary of the Lightwater 3.1, the riparian zone is well vegetated. The culvert at the upstream extent of the watercourse is situated within woodland, and as such trees cover the left and right riverbanks and the floodplain. On the approach to the culvert beneath the A66, the riparian cover in the vicinity of the watercourse changes. The woodland gives way to overgrown riverbanks and a river bed comprised of dense vegetation. The lower channel energy in this reach leads to the deposition of finer bed material, which facilitates the colonisation of vegetation on the bed. **Typical Floodplain Connectivity:** The floodplain connectivity within the Unnamed Tributary of the Lightwater 3.1 is generally poor. The channel has incised downwards into the river bed over time, which has left the floodplain disconnected from the channel. River bed scour has occurred as a result of the high rates of flow discharge from the culvert. A distinguishable drop in river bed level from the culvert invert and the river bed was observable. This has led to the river bed level dropping gradually over time and the riverbanks and floodplain becoming disconnected from the channel.
WCP3 Lightwater (Lightwater Culvert)	**Wider Catchment Characteristics:** The Lightwater rises to the east of Clifton and flows in a generally northern direction towards Lightwater Cottages and the existing A66. The watercourse is subsequently culverted beneath the A66 and continues to flow in a northern direction before discharging into the River Eamont. Photographs of the location are shown in Annex A: Site Photograph Locations. **Observed In-Channel Modifications:** • Culvert beneath the existing A66 **Typical Flow Biotopes:** The upstream limit of the survey on the Lightwater is located in Hallstead's Wood approximately 500m to the south of the existing A66. The channel planform exhibits good sinuosity within the woodland which provides the flow with localised diversity and results in biotopes ranging from runs to riffles. The channel gradient within the woodland is steep, providing the watercourse with sufficient energy to generate moderate flow-energy biotopes. Where Hallstead's Wood ends and the Lightwater flows through agricultural fields, the typical flow biotopes change. The channel sinuosity reduces significantly, and it is clear that the channel has been realigned historically. As such, flow diversity reduces compared to upstream

Crossing Point/ Watercourse	Site Observations
	reaches. The channel gradient remains steep and a densely vegetated river bed results in a prevalence of riffle flow biotopes. This flow environment continues down to the culvert beneath the A66. Downstream of the A66 Culvert, the flow velocities remain high in the channel, likely a result of the steep channel gradient and the high rate of discharge out of the culvert beneath the A66. As such the typical flow biotopes range from riffles to runs throughout this reach of the Lightwater. Flow diversity is varied as a result of a sinuous channel planform and woody debris within the channel generating localised flow heterogeneity. **Typical Bed Substrate:** The bed material in the Lightwater ranges from cobbles to gravels, in reaches of the watercourse both upstream and downstream of the A66 culvert. The moderate flow energy within the channel results in finer material being transported to downstream reaches, leaving behind a matrix of coarser material. As such, the upstream and downstream reaches of the Lightwater can be categorised as a sediment transfer **Typical Riparian Composition:** The riparian zone of the Lightwater upstream of the existing A66 varies considerably. Upstream of the confluence with the Unnamed Tributary of the Lightwater 3.1, the riparian cover is poor with almost no vegetation lining the riverbanks. As a result, there has been significant poaching of the riverbanks by the sheep occupying the field. In the vicinity of the confluence and further downstream, riparian cover improves significantly, with an isolated woodland area surrounding the confluence. Downstream of this woodland, riparian cover remains significant. Downstream of the existing A66, a riparian strip of trees exists on both the left and right bank of the channel. These trees provide a source of large woody debris to the channel, which generates localised variation in sediment and flow dynamics. Further downstream, the riparian zone of the watercourse is populated with a dense strip of rushes, as the inset floodplain becomes frequently wetted. **Typical Floodplain Connectivity:** The floodplain connectivity of the Lightwater upstream of the A66 varies significantly. The channel within Hallsteads Wood has good connectivity to the floodplain, with evidence of the woodland on the right bank being inundated with water. Further downstream where Hallsteads Wood ends, the floodplain connectivity reduces. The channel has clearly been managed on the approach to the A66 culvert, with evidence of the watercourse being straightened and artificially deepened to increase the capacity of the channel. As a result, water is less able to spill into the floodplain, leading to a degradation in floodplain connectivity.

Crossing Point/ Watercourse	Site Observations
	Downstream of the existing A66, the floodplain connectivity remans poor. It is clear that the river bed has incised downwards historically, as the riverbanks are 4-5m above the river bed level. Despite this, there is no evidence of 'J' shaped trees, a typical indicator of bed incision. It is likely therefore that the riparian strip of trees has recently been planted following gradual bed incision. Further downstream an inset floodplain has developed between the steep sided floodplain. It is likely that this becomes frequently wetted, as the presence of rushes indicate.
WCP4 (Unnamed Tributary of the Eamont 3.3 (Culvert 301)	**Wider Catchment Characteristics:** The Unnamed Tributary of the Eamont 3.3 to the west of Park Cottages rises on the hills to the west of Whinfell Forest, before flowing in a generally north westerly direction towards Whinfell Park Cottages. The Unnamed Tributary of the Eamont 3.3 is subsequently culverted beneath the A66, before continuing to flow in a northern direction towards the River Eamont. Photographs of the location are shown in Annex A: Site Photograph Locations. **Typical Flow Biotopes:** Upstream of the existing A66, there were no distinguishable flow biotopes in the channel. The shallow channel gradient combined with the overgrown nature of the channel has resulted in low in-channel flow energy. It is also likely that a partial blockage within the culvert barrel beneath the existing A66 backs water up and further reduces flow velocities within the channel. Downstream of the existing A66, the flow velocities within the channel increase significantly compared to upstream. A high rate of discharge out of the culvert outfall has created a scour pool in the immediate vicinity of the outfall. The steep channel gradient, combined with the straight channel planform has provided the watercourse with increased flow velocities. As such, a continuous riffle has developed. Despite the straight channel planform, the flow exhibits sinuous characteristics, meandering across the bed of the channel. There is the potential for this sinuous flow to influence the straight channel planform gradually over time, and for the channel to adopt a more sinuous planform in the future. On the approach to the confluence with the River Eamont, flow velocities reduce as the channel gradient reduces and the flow is controlled by a culvert directly upstream of the confluence. The flow is relatively homogeneous between the existing A66 and the River Eamont due to a lack of channel sinuosity and woody debris in the channel. **Typical Bed Substrate:** Upstream of the existing A66, the bed substrate is difficult to discern due to the overgrown nature of the channel. However, in areas where the bed is exposed, the bed substrate is predominantly fine material, ranging from sands to silts. This fine material has likely be input into the channel from the surrounding agricultural land during heavy rainfall events. Downstream of the existing A66, the typical bed substrate is coarse, ranging from cobbles to gravels. This is likely a result of the increased

Crossing Point/ Watercourse	Site Observations
	channel velocities, which transport finer material downstream to the confluence with the River Eamont leaving behind a matrix of coarser material. The surrounding floodplain and river channel have a large volume of very coarse cobbles and boulders, which are likely derived from glacial material deposited on the surrounding floodplain during the last glacial retreat. **Typical Riparian Composition:** Upstream of the existing A66, the riparian strip is overgrown, and comprised of long grasses. There is a distinct lack of riparian tree cover on both banks. Downstream of the existing A66, the riparian cover on both banks deteriorates significantly. As such, the structural integrity of the riverbanks has deteriorated, and riverbank erosion, undercutting and slumping is widespread between the existing A66 and the confluence with the Eamont. **Typical Floodplain Connectivity:** Upstream of the existing A66, the connectivity of the floodplain to the channel is reasonable. The presence of rushes on the floodplain suggests that the floodplain becomes regularly wetted during heavy rainfall events. Downstream of the existing A66, the connectivity of the floodplain to the channel becomes significantly degraded compared to the upstream reach. The channel has undergone straightening, which has resulted in bed incision and the channel bed level to drop. This is further compounded by the trapezoidal channel shape, which reduced the ability of water to spill into the floodplain. Floodplain connectivity improves on the approach to the confluence with the Eamont, as the channel gradient reduces and in channel velocities decrease. Bed incision is less widespread in this reach, and as such water is able to spill into the floodplain.
WCP5 (Unnamed Tributary of the Eamont 3.4 (Culvert Unnamed, Whinfell)	**Wider Catchment Characteristics:** The Unnamed Tributary of the Eamont 3.4 rises from a series of agricultural field drains to the north-west of Whinfell Forest and flows in a generally northerly direction towards Whinfell Park Cottages. The Unnamed Tributary of the Eamont 3.4 is subsequently culverted beneath the A66, and discharges into the Unnamed Tributary of the Eamont 3.4 located to the north-west of Whinfell Park Cottages. Photographs of the location are shown in Annex A: Site Photograph Locations. **Typical Flow Biotopes:** The typical flow energy within the channel is moderate. The shallow channel gradient results in low flow velocities. This has provided suitable conditions for the establishment of in channel vegetation. The development of in channel vegetation has further reduced the in-channel velocities. As such, the dominant flow biotope in the channel are runs.

Crossing Point/ Watercourse	Site Observations
	Typical Bed Substrate: The typical bed substrate in the channel is very fine, ranging from silts to sands. A large volume of fine material is input to the watercourse from a number of sources. The moderate flow energy is sufficient to erode the riverbanks of the channel, which are comprised of soil. As such bank erosion, slumping and collapse in this reach are widespread. This process acts as a source of fine material for the watercourse. In addition, cattle poaching was identified on both riverbanks, which acts as an additional source of fine material into the watercourse. **Typical Riparian Composition:** Riparian cover on the Unnamed Tributary of the Eamont 3.4 is mixed. The 150m length of watercourse from the upstream limit is devoid of any riparian vegetation, and as such it is evident that cattle poaching has been an issue historically. It was noted that fencing had been installed recently to mitigate the extensive cattle poaching in this reach. Despite this, the condition of the riverbanks remained degraded. On the approach to the culvert beneath the A66, riparian cover improves significantly. A thin strip of riparian tree cover and vegetation lines the right bank of the watercourse, with a fence present on the left bank of the channel. As such cattle poaching had been prevented in this reach of the watercourse. **Typical Floodplain Connectivity:** Floodplain connectivity on the Unnamed Tributary of the Eamont 3.4 is generally poor. The river bed has undergone natural incision over time, as a result of the moderate flow energy within the channel. This is sufficient energy to erode the fine material comprising the river bed, leading to a reduction in river bed levels gradually over time. As such, water is less able to access the floodplain.
WCP6 (Unnamed Tributary of the Eamont 3.5) (Culvert 302)	**Wider Catchment Characteristics:** The Unnamed Tributary of the Eamont 3.5 of the River Eamont rises from a number of agricultural field drains to the east of Whinfell Park Cottages that converge to the south of the existing A66, before being culverted and discharging into the channel to the north of the A66. The watercourse flows in a generally northern direction before discharging into the River Eamont. Photographs of the location are shown in Annex A: Site Photograph Locations. **Typical Flow Biotopes:** The flow within the channel from the existing A66 culvert to downstream is very low, with gliding flows being the typical flow biotope. The low channel gradient, combined with the densely vegetated riverbanks and river bed results in low flow velocities. On the approach to the confluence with the River Eamont, the channel becomes very steep within a confined gully as the Unnamed Tributary of the Eamont 3.5 approaches the River Eamont from the left bank river terrace. The elevation difference between the river bed of the Eamont and

Crossing Point/ Watercourse	Site Observations
	the bed of the Unnamed Tributary of the Eamont 3.5 is approximately 15-20m. **Typical Bed Substrate:** The typical bed substrate in the Unnamed Tributary of the Eamont 3.5 is varied, ranging from coarse material such as gravels and cobbles to very fine material such as silts. It is likely that some of the coarse material found on the river bed is derived from glacial material deposited on the surrounding floodplain during the last glacial retreat, rather than being transported by the watercourse. The observed flow energy in the channel was low upstream of the gully, which suggests that the watercourse is unable to move coarse cobbles and boulders except during extreme events. **Typical Riparian Composition:** Riparian cover on the Unnamed Tributary of the Eamont 3.5 is mixed. There is a distinct lack of riparian tree cover on both riverbanks, although the riverbanks and river bed are overgrown with dense vegetation. As such, access for livestock to the riverbanks is prevented, and poaching of the riverbanks has been mitigated against. On the approach to the confluence with the River Eamont, a thicket of woodland exists, which improves the condition of the riparian corridor. **Typical Floodplain Connectivity:** Floodplain connectivity of the watercourse is mixed. Upstream of the confluence with the River Eamont the Unnamed Tributary of the Eamont 3.5 is well connected to the floodplain. It is likely that the low flow energy within the channel is not sufficient to mobilise and erode the coarse bed substrate, preventing the riverbank elevation from decreasing gradually over time. On the approach to the confluence with the River Eamont, floodplain connectivity decreases significantly. The 15-20m drop in river bed elevation between the Unnamed Tributary of the Eamont 3.5 and the River Eamont results in the watercourse having no access to the floodplain, as flow cascades down the significant drop to the River Eamont.
WCP7 (Swine Gill) (Swine Gill Culvert)	**Wider Catchment Characteristics:** The Swine Gill rises on the hills to the north of Whinfell Forest and flows in a generally northern direction towards the A66 at Swine Gill Plantation. A wet woodland area exists within the Swine Gill Plantation, extending approximately 250m upstream of the A66. The Swine Gill is subsequently culverted beneath the road before continuing in a north easterly direction past Woodside Cottages towards the River Eamont. Photographs of the location are shown in Section 0. **Typical Flow Biotopes:** At the upstream extent of the Swine Gill (approximately 500-250m upstream of the existing A66) the typical flow energy is low, and the predominant flow biotope can be characterised as a glide. It is likely that

Crossing Point/ Watercourse	Site Observations
	the low channel gradient, combined with the impoundment on the flow caused by the inundated wet woodland at the culvert is reducing the flow velocities on the Swine Gill in this reach. The low flow energy within the channel has facilitated the establishment of vegetation on the riverbanks and in the channel, which further reduces flow velocities in the channel. A wet woodland occupies the channel and surrounding riparian zone approximately 250m upstream of the A66 culvert. The invert of the double-barrelled culvert is at a slightly higher elevation that the river bed upstream, which results in the build-up of water upstream of the culvert, and the subsequent inundation of the woodland. Due to this control on flow upstream of the culvert, flow velocities are very low, with the movement of flow almost imperceptible on the day of the site visit. Downstream of the A66 culvert, flow velocities increase as the channel gradient increases and the impoundment on the flow no longer effects flow dynamics. As such the typical flow biotopes range from riffles to glides. The increased channel sinuosity in this downstream reach increases flow diversity, facilitating the development of alternating flow biotopes. In addition, woody debris within the channel generates localised variation in flow dynamics, further enhancing the development of flow heterogeneity. **Typical Bed Substrate:** Upstream of the culvert beneath the A66, the typical bed substrate is fine, ranging from silts to sands. The low flow velocities within the channel, combined with a source of fine material conveyed from the surrounding agricultural farmland leads to the accumulation of silts and sands on the river bed. Within the wet woodland area, the overgrown nature of the riparian corridor and channel made observations of the river bed substrate difficult. However, it is likely that the river bed is composed of very fine material as a result of the very low flow energy directly upstream of the culvert. Downstream of the A66 culvert, the typical bed substrate changes, and coarse material is found on the river bed ranging from gravels to cobbles. The increase in flow velocities result in finer bed substrate being conveyed to downstream reaches, leaving the coarse material to occupy the river bed. **Typical Riparian Composition:** The riparian cover on the Swine Gill is generally good. At the upstream limit of the watercourse, the riparian buffer strip lacks tree cover, although the riverbanks are densely vegetated. As a result, the structural integrity of the riverbanks is poor, and there was observable riverbank erosion, undercutting and slumping. Riparian tree cover improves significantly on the approach to the A66 culvert, as the watercourse passes through a wet woodland. Tree cover on the riverbanks and floodplain in this reach is thick. Downstream of the existing A66, riparian tree cover continues, with another woodland areas existing on the northern side of the road. As such, the structural integrity of the riverbanks is improved, and incidents of riverbank erosion and slumping are reduced.

Crossing Point/ Watercourse	Site Observations
	Typical Floodplain Connectivity: Floodplain connectivity on the Swine Gill is generally good. The wet woodland directly upstream of the A66 culvert demonstrates that the floodplain in this reach is frequently inundated with water and that connectivity between the channel and floodplain is good. Downstream of the existing A66 the floodplain remains well connected to the channel. There is evidence of the woodland in the vicinity of the channel being wet, which suggests that the flow inundates the floodplain on a frequent basis.

Stage 1: Hydromorphology screening

14.4.3.18 The screening assessment aims to screen in any works that require WFD assessment and to identify which WFD water bodies are within and near to the proposed works.

14.4.3.19 Drainage channel outfalls have been screened out of the assessment as their design is secured by the Environmental Management Plan (Application Document 2.7), which is a certified document under DCO. Where hard outfalls currently exist, new drainage channel outfalls will be tied into the existing structure. Drainage channels in areas with natural banks will be designed as a natural outfall (i.e. without hard bank protection).

14.4.3.20 Table 5: Screening of each water body, indicates which water bodies have been screened in or out of the assessment and the reasons for this decision.

14.4.3.21 The baseline status of the hydromorphology quality elements within the water bodies screened into the assessment are discussed in this section. If there is potential for the proposed works to cause deterioration in the status of a water body or prevent it from achieving its status objectives as defined in the Solway Tweed River Basin Management Plan 2021, the relevant water body and its WFD quality elements associated with hydromorphological function have been taken forward and considered further in the scoping assessment at Stage 2.

Table 5: Screening of each water body

Water body/ies	Reason	Screening outcome
Eamont (Lower)	The proposed works for Penrith to Temple Sowerby are located within the waterbody catchment and therefore, direct impact on this waterbody is possible.	Screened In
Eden Lyvennet to Eamont	The proposed works for Penrith to Temple Sowerby are located within the waterbody catchment and therefore, direct impact on this waterbody is possible.	Screened In
Eden - Eamont to tidal	The waterbody is located approximately 4.3km downstream of the easternmost	Screened Out

Water body/ies	Reason	Screening outcome
	point of WCP7. As such the waterbody catchment is located far enough downstream from the works to not be impacted.	

Baseline status of screened-in water bodies

14.4.3.22 Table 6: Current WFD status of connected water body catchments in Cycle 2 (2019) summarises the water body ID, hydromorphological designation, current ecological status / potential and ecological objective for each water body screened into the assessment. This information is provided by the Solway Tweed River Basin Management Plan 2021.

Table 6: Current WFD status of connected water body catchments in Cycle 2 (2019)

Water body ID	Name of water body	Hydromorphological designation	Current Ecological Status/ Potential	Ecological Objective
GB102076070990	Eamont (Lower)	Not designated artificial or heavily modified	Good	Good by 2027
GB102076070980	Eden Lyvennet to Eamont	Not designated artificial or heavily modified	Moderate	Good by 2015

14.4.3.23 The tables below describe the current status of the hydromorphological quality elements and reasons for not achieving good status (RNAGS) for each water body screened into the assessment, according to the most recent WFD cycle.

WFD water body: Eamont (Lower)

Table 7: Hydromorphological quality element of Eamont (Lower) Cycle 2 (2019)

Hydromorphological Quality Element	Current Status	Objective
Hydrological Regime	Supports good	Supports good by 2015
Morphology	Supports good	Not available

Table 8: RNAGS for Eamont (Lower) Cycle 2 (2019)

SWMI*	Activities	Classification Element
Not Available	Not Available	Not Available

WFD water body: Eden Lyvennet to Eamont

Table 9: Hydromorphological quality element of Eden Lyvennet to Eamont Cycle 2 (2019)

Hydromorphological Quality Element	Current Status	Objective
Hydrological Regime	High	High by 2015
Morphology	Supports good	Not available

Table 10: RNAGS for Eden Lyvennet to Eamont Cycle 2 (2019)

SWMI*	Activities	Classification Element
Suspect data	Not applicable	Macrophytes and Phytobenthos Combined

* Significant water management issue

Stage 2: Hydromorphology scoping

14.4.3.24 The scoping assessment identifies whether the water body catchment's quality elements, identified during the screening assessment, are at risk from the proposed works. The proposed development works are being appraised in terms of their impact on WFD status and objectives. If any quality elements are found to be at risk of detrimental impact, further assessment and/ or mitigation may be required.

Hydromorphological quality elements of the Eamont (Lower) water body

14.4.3.25 The following Watercourse Crossing Points were identified as falling within the Eamont (Lower) water body catchment:

- Watercourse Crossing Point 2 (Culvert 303)
- Watercourse Crossing Point 3 (Lightwater Culvert)
- Watercourse Crossing Point 4 (Culvert 301)
- Watercourse Crossing Point 5 (Whinfell Park Culvert)
- Watercourse Crossing Point 6 (Culvert 302).

14.4.3.26 As such, the potential impacts of the proposed works at each identified crossing point will have on the Eamont (Lower) water body have been assessed. Where there is the potential for the proposed works to impact the geomorphological condition of watercourses within the Eamont (Lower) water body, the requirement for a further assessment within paragraph 14.4.2.8 - 14.4.2.11 to has been stipulated.

Watercourse Crossing Point 2 (Culvert 303)

14.4.3.27 The proposed works at this location include the replacement of an existing 200m length of culvert, as well as extension of the existing culvert 32m upstream. As such, the replacement culvert is to have an extended footprint compared to the original structure, with a total length of 232m. The diameter of the replacement structure is to be the same diameter as the existing structure. A full description of the works is available in paragraph 14.4.3.2.

14.4.3.28 Table 11: Assessment of works at Watercourse Crossing Point 2 (Culvert 303) on the Unnamed Tributary of the Lightwater 3.1 against the hydromorphological quality elements for the Eamont (Lower) WFD water body catchment, assesses the potential impacts arising from proposed works at Watercourse Crossing Point 2 (Culvert 303) on the Unnamed Tributary of the Lightwater 3.1, which is within the Eamont (Lower) WFD water body catchment.

Table 11: Assessment of works at Watercourse Crossing Point 2 (Culvert 303) on the Unnamed Tributary of the Lightwater 3.1 against the hydromorphological quality elements for the Eamont (Lower) WFD water body catchment

WFD Quality Element	Current Status	Potential Impact	Further assessment and/or mitigation required?
Hydrology: Quantity and Dynamics of flow	Not Assessed	The 32m culvert extension will alter the dynamics of flow (e.g., flow velocity, water depth, wetted area etc.) on a local scale at the Unnamed Tributary of the Lightwater 3.1. However, the existing flow dynamics on the watercourse are homogeneous and lack geomorphological diversity and can be described as already degraded as a result of anthropogenic and agricultural pressures. The 200m length of channel that is already culverted will remain culverted in the culvert replacement works. Flow dynamics within the culvert and at the culvert outfall will therefore remain largely similar to existing conditions. As such, the proposed works are unlikely to lead to a degradation of the quantity and dynamics of flow. Therefore, this quality element will not be considered as part of the impact assessment for the Eamont (Lower) water body.	No
Hydrology: Connection to ground water bodies	Not Assessed	The existing 200m length of culvert already prevents interaction between the fluvial and ground water systems over its length. Replacement of the culvert as part of the proposals will maintain existing conditions. The proposed 32m extension of impermeable surface along the watercourse accounts 0.37% of the total length of the WFD water body and is unlikely to significantly impact the interaction between fluvial and ground water systems. The proposed works on Culvert 303 are unlikely to have an impact on the existing connectivity to ground water bodies at the water body scale in the Eamont (Lower) water body. Therefore, this quality element will not be considered as part of the impact assessment for the Eamont (Lower) water body.	No
River Continuity	Not Assessed	The existing Culvert 303 on the Unnamed Tributary of the Lightwater 3.1 already limits the conveyance of flow and sediment from upstream of the culvert to downstream reaches and the Lightwater. Extending the length of this control on flow and sediment conveyance will not further restrict flow and sediment conveyance; the internal clear span and height of the proposed culvert replacement to the north and south will match that of the existing culvert. As such, the proposed works are unlikely to lead to a degradation of the existing river continuity of the watercourse. In addition, existing geomorphological features and	No

WFD Quality Element	Current Status	Potential Impact	Further assessment and/or mitigation required?
		processes occurring downstream of the proposals are unlikely to be affected, as the existing 200m long culvert will prevent impacts from propagating downstream. The proposed works on Culvert 303 are unlikely to have an impact on the existing river continuity at the water body scale in the Eamont (Lower) water body. Therefore, this quality element will not be considered as part of the impact assessment for the Eamont (Lower) water body.	
Morphology: River width and depth	Not Assessed	The replacement of a 32m long section of open channel with a culvert will result in a change to the existing width and depth of the Unnamed Tributary of the Lightwater 3.1. However, the existing channel is homogeneous and lacks geomorphological diversity and can be described as degraded as a result of anthropogenic and agricultural pressures. The small size of the watercourse (approximate channel width of 3m) further limits the diversity in channel geometry. Moreover, the presence of the existing 200m long culvert conveying the watercourse beneath the A66 carriageway to the Lightwater severely restricts the existing condition of the watercourse. As such, the proposed works are unlikely to have an impact on river width and depth Therefore, this quality element will not be considered as part of the impact assessment for the Eamont (Lower) water body.	No
Morphology: Structure and substrate of the river bed	Not Assessed	The proposed works will involve the loss of a 32m length of open channel upstream of the proposed culvert extension, which will result in a loss of river bed substrate. However, the existing condition of the river bed in this reach is already degraded and lacks geomorphological diversity and character. Moreover, a 200m length of the channel is already culverted, where river bed substrate diversity is limited. The invert level of the proposed culvert inlet is set approximately 0.2 to 0.3m below the existing river bed level, which will encourage the deposition of material within the culvert barrel. The proposed works are unlikely to have an impact on the existing river structure and substrate of the river bed. Therefore, this quality element will not be considered as part of the impact assessment for the Eamont (Lower) water body.	No
Morphology: Structure of the riparian zone	Not Assessed	The 32m extension of the existing culvert will involve the replacement of the existing riparian zone with an embankment to support the Existing A66. In addition, the replacement of a section of open channel with a	No

WFD Quality Element	Current Status	Potential Impact	Further assessment and/or mitigation required?
		culvert barrel will reduce the connectivity of the watercourse to the riparian zone and surrounding floodplain. Despite the loss of riparian zone in the immediate vicinity of the culvert, the existing condition of the riparian zone is already degraded. As such, the proposed works are unlikely to have an impact on the structure of the riparian zone. Therefore, this quality element will not be considered as part of the impact assessment for the Eamont (Lower) water body.	

Watercourse Crossing Point 3 (Lightwater Culvert)

14.4.3.29 The proposed works at this location include the extension of the existing box culvert 6.22m upstream and 7.51m downstream. As such, the culvert will have an extended footprint compared to the existing structure, with a total length of 28.77m. The internal clear span and height of the culvert extension upstream and downstream is to be the same as the existing structure. An additional maintenance culvert will be installed approximately 110m downstream of the existing Lightwater culvert outfall. A full description of the works is available in paragraph 14.4.3.2.

14.4.3.30 Table 12: Assessment of works at Watercourse Crossing Point 3 on the Lightwater against the hydromorphological quality elements for the Eamont (Lower) WFD water body catchment, assesses the potential impacts arising from proposed works at Watercourse Crossing Point 3 (Lightwater Culvert) on the Lightwater, which is within the Eamont (Lower) WFD water body catchment.

Table 12: Assessment of works at Watercourse Crossing Point 3 on the Lightwater against the hydromorphological quality elements for the Eamont (Lower) WFD water body catchment

WFD Quality Element	Current Status	Potential Impact	Further assessment and/or mitigation required?
Hydrology: Quantity and Dynamics of flow	Not Assessed	Areas of the Lightwater that are currently open channel will be culverted following the completion of the works, which will alter the dynamics of flow (e.g., flow velocity, water depth, wetted area etc.). Downstream of the existing culvert, the channel exhibits relatively good flow diversity and morphological condition. This is significant given that the total length of the Lightwater that exhibits good morphological condition is limited. The addition of a maintenance culvert 110m downstream of the existing Lightwater culvert outfall will lead to further disruption in the dynamics of flow. The proposed works represents a total loss of	Yes

WFD Quality Element	Current Status	Potential Impact	Further assessment and/or mitigation required?
		13.73m of this existing morphological functioning on the Lightwater, but it is likely that the influence on flow dynamics will extend further downstream than the culvert extension footprint as the channel adjusts to the modification. Therefore, this quality element will be considered as part of the impact assessment for the Eamont (Lower) water body.	
Hydrology: Connection to ground water bodies	Not Assessed	The proposed works are unlikely to impact the existing connectivity of the watercourse to ground water bodies. The extension of impermeable surface along the watercourse accounts for just 0.7% of the total length of the Lightwater. As such, this reduction in connectivity between the watercourse and ground water bodies is not significant enough to impact ground water connectivity at the water body scale of the Eamont (Lower) water body water body. Therefore, this quality element will not be considered as part of the impact assessment.	No
River Continuity	Not Assessed	The existing culvert already limits the conveyance of flow and sediment from upstream of the culvert to downstream reaches. Extending the length of this control on flow and sediment conveyance will not further restrict flow and sediment conveyance; the internal clear span and height of the proposed culvert extension to the north and south will match that of the existing Lightwater Culvert. The addition of a maintenance culvert 110m downstream of the exiting Lightwater culvert outfall is unlikely to further limit the continuity of the Lightwater. The existing control on sediment and flow conveyance from upstream to downstream reaches will remain in position, and the addition of another structure with the same dimensions 110m further downstream will not lead to increased restriction on longitudinal connectivity. As such, the proposed works are unlikely to lead to a degradation of the existing river continuity of the watercourse. Therefore, this quality element will not be considered as part of the impact assessment for the Eamont (Lower) water body.	No
Morphology: River width and depth	Not Assessed	The replacement of a section of open channel with a culvert will result in a change to the existing width and depth of the Lightwater. Following the completion of the culvert extension and the installation of the maintenance culvert 110m further downstream, the width and depth of the channel will be dictated by the geometry of the culvert barrel. The existing morphological characteristics on the	Yes

WFD Quality Element	Current Status	Potential Impact	Further assessment and/or mitigation required?
		Lightwater immediately downstream of the culvert are diverse in terms of river width and depth and exhibit relatively good morphological condition. This is significant given that the total length of the Lightwater that exhibits good morphological condition is limited. The proposed works represent a total loss of 13.73m of natural river width and depth on the Lightwater but it is likely the influence on the river width and depth will extend further downstream than the culvert extension footprint as the channel adjusts to the modification. As a result, this represents a degradation of the river width and depth compared to the current conditions. Therefore, this quality element will be considered as part of the impact assessment for the Eamont (Lower) water body.	
Morphology: Structure and substrate of the river bed	Not Assessed	The culvert extension and installation of the maintenance culvert 110m further downstream will result in a loss of river bed substrate. The existing structure and substrate of the river bed on the Lightwater immediately downstream of the culvert is relatively diverse and exhibits good morphological condition. This is significant given that the total length of the Lightwater that exhibits good morphological condition is limited. In addition, the installation of a new maintenance culvert will lead to further loss of natural river bed substrate. The proposed works represent a total loss of 13.73m of natural river bed on the Lightwater but it is likely that the influence on the structure and substrate of the river bed will extend further downstream than the culvert extension footprint and maintenance culvert footprint as the channel adjusts to the modification. Therefore, this quality element will be considered as part of the impact assessment for the Eamont (Lower) water body.	Yes
Morphology: Structure of the riparian zone	Not Assessed	The culvert extension and installation of the maintenance culvert will involve the replacement of the existing riparian zone with an embankment to support the existing A66. In addition, the replacement of a section of open channel with a culvert barrel will significantly reduce the connectivity of the watercourse to the riparian zone and surrounding floodplain. The existing structure of the riparian zone immediately downstream of the culvert is relatively good with a diversity of tree cover and understorey vegetation, and patches of wet woodland due to the good river-floodplain	Yes

WFD Quality Element	Current Status	Potential Impact	Further assessment and/or mitigation required?
		connectivity. This is significant given that the total length of the Lightwater that exhibits a good riparian zone is limited. The proposed works represent a total loss of 13.73m of riparian zone along the channel on both, but it is likely the influence on the riparian zone will extend further downstream than the culvert extension footprint due to access requirements. This combined loss of riparian zone and floodplain connectivity will lead to a degradation of the riparian zone on the Lightwater. Therefore, this quality element will be considered as part of the impact assessment for the Eamont (Lower) water body.	

Watercourse Crossing Point 4 (Culvert 301)

14.4.3.31 The proposed works at this location include the extension of the existing culvert 40m downstream. As such, the culvert will have an extended footprint compared to the existing structure, with a total length of 70m. The extended culvert will be a pipe culvert of 0.9m diameter; a variation in geometry compared to the existing box culvert with a 1.0m high by 0.6m wide opening. The gradient of the extended barrel is steeper (0.037) than the existing culvert gradient (0.016). A full description of the works is available in paragraph 14.4.3.2.

14.4.3.32 Table 13: Assessment of works at Watercourse Crossing Point 4 (Culvert 301) on the Unnamed Tributary of the Eamont 3.3 against the hydromorphological quality elements for the Eamont (Lower) WFD water body catchment, assesses the potential impacts arising from proposed works at Watercourse Crossing Point 4 (Culvert 301) on the Unnamed Tributary of the Eamont 3.3, which is within the Eamont (Lower) WFD water body catchment.

Table 13: Assessment of works at Watercourse Crossing Point 4 (Culvert 301) on the Unnamed Tributary of the Eamont 3.3 against the hydromorphological quality elements for the Eamont (Lower) WFD water body catchment

WFD Quality Element	Current Status	Potential Impact	Further assessment and/or mitigation required?
Hydrology: Quantity and Dynamics of flow	Not Assessed	This change in culvert gradient has the potential to increase flow velocity in the culvert barrel, at the culvert outfall, and in the channel downstream. The increase in flow velocity downstream of the proposed culvert outfall has the potential to initiate geomorphological change in the channel and on the floodplain; an increase in flow velocity can change sediment transfer dynamics, and rates of erosion and deposition. Given the	Yes

WFD Quality Element	Current Status	Potential Impact	Further assessment and/or mitigation required?
		already active nature of the Unnamed Tributary of the Eamont 3.3 and the steep channel gradient, this has the potential to impact the dynamics of flow. Therefore, this quality element will be considered as part of the impact assessment for the Eamont (Lower) water body.	
Hydrology: Connection to ground water bodies	Not Assessed	The extension of impermeable surface along the watercourse accounts for 1.27% of the Unnamed Tributary of the Eamont 3.3, and an 0.46% of the entire WFD waterbody. As such, this reduction in connectivity between the watercourse and ground water bodies is not significant enough to impact ground water connectivity at the water body scale of the Eamont (Lower) water body water body. Therefore, this quality element will not be considered as part of the impact assessment for the Eamont (Lower) water body.	No
River Continuity	Not Assessed	The existing culvert already limits the conveyance of flow and sediment from upstream of the culvert to downstream reaches. Extending the length of this control on flow and sediment conveyance will not further restrict flow and sediment conveyance. As such, the proposed works are unlikely to lead to a degradation of the existing river continuity of the watercourse. Therefore, this quality element will not be considered as part of the impact assessment for the Eamont (Lower) water body.	No
Morphology: River width and depth	Not Assessed	The replacement of a section of open channel with a culvert will result in a change to the existing width and depth of the Unnamed Tributary of the Eamont 3.3. Following the completion of the culvert extension, the width and depth of the channel will be dictated by the geometry of the culvert barrel. Despite this, the existing river width and depth on the Unnamed Tributary of the Eamont 3.3 immediately downstream of the existing culvert outfall is homogeneous and lacks geomorphological diversity. The small size of the watercourse further limits the diversity in channel geometry. As such, the proposed works are unlikely to lead to a degradation of the river width and depth. Therefore, this	No

WFD Quality Element	Current Status	Potential Impact	Further assessment and/or mitigation required?
		quality element will not be considered as part of the impact assessment for the Eamont (Lower) water body.	
Morphology: Structure and substrate of the river bed	Not Assessed	The change in gradient in the proposed extended culvert barrel has the potential to increase flow velocity in the culvert barrel, at the culvert outfall, and in the channel downstream. Site observations identified that river bed erosion is prevalent in this downstream river reach, and as such it is likely that the proposed works will increase rates of river bed erosion. Further increases to flow velocity in the channel also has the potential to exacerbate bank erosion in the reach downstream of the culvert. The channel gradient sharply increases downstream of the culvert before entering the Eamont floodplain adjacent to the confluence. As such, the proposed works have the potential to impact the structure and substrate of the river bed. Therefore, this quality element will be considered as part of the impact assessment for the Eamont (Lower) water body.	Yes
Morphology: Structure of the riparian zone	Not Assessed	The extension of the culvert will involve the replacement of the existing riparian zone with an embankment to support the existing A66. In addition, the replacement of a section of open channel with a culvert barrel will reduce the connectivity of the watercourse to the riparian zone and surrounding floodplain. Despite the loss of riparian zone in the immediate vicinity of the culvert, the existing condition of the riparian zone is already degraded. Riparian tree cover is sparse or non-existent in some reaches of the Unnamed Tributary of the Eamont 3.3. In addition, the surrounding agricultural land use has led to a further degradation to the condition of the riparian zone. As such, the proposed works are unlikely to lead to a degradation of the structure of the riparian zone. Therefore, this quality element will not be considered as part of the impact assessment for the Eamont (Lower) water body.	No

Watercourse Crossing Point 5 (Unnamed - Whinfell)

14.4.3.33 The proposed works at this location include the extension of the existing culvert 320m upstream. As such, the culvert will have an extended footprint compared to the existing structure, with a total length of 440m. The diameter of the culvert extension is to be the same as the existing diameter. The culvert extension is to be diverted around the proposed road embankment and away from the existing channel planform. A full description of the works is available in paragraph 14.4.3.2.

14.4.3.34 Table 14: Assessment of works at Watercourse Crossing Point 5 (Culvert Unnamed - Whinfell) on the Unnamed Tributary of the Eamont 3.4 against the hydromorphological quality elements for the Eamont (Lower) WFD water body catchment, assesses the potential impacts arising from proposed works at Watercourse Crossing Point 5 (Culvert Unnamed - Whinfell) on the Unnamed Tributary of the Eamont 3.4 to the north of Whinfell Park, which is within the Eamont (Lower) WFD water body catchment.

Table 14: Assessment of works at Watercourse Crossing Point 5 (Culvert Unnamed - Whinfell) on the Unnamed Tributary of the Eamont 3.4 against the hydromorphological quality elements for the Eamont (Lower) WFD water body catchment

WFD Quality Element	Current Status	Potential Impact	Further assessment and/or mitigation required?
Hydrology: Quantity and Dynamics of flow	Not Assessed	The proposed works on the Culvert Unnamed - Whinfell have the potential to impact the existing dynamics of flow of the Unnamed Tributary of the Eamont 3.4. Areas of the Unnamed Tributary of the Eamont 3.4 that are currently open channel will be culverted following the completion of the works, which will alter the dynamics of flow (e.g., flow velocity, water depth, wetted area etc.) and result in a loss of open channel. Although the current channel is relatively homogenous in terms of geomorphological condition and processes, there were small areas of flow diversity. Given that the total length of open channel on the Unnamed Tributary of the Eamont 3.4 is approximately 260m, and 130m of existing open channel is to be lost, this represents a 50% loss of open channel as well as future opportunity for geomorphological improvement. Therefore, this quality element will be considered as part of the impact assessment for the Eamont (Lower) water body.	Yes
Hydrology: Connection to	Not Assessed	The extension of impermeable surface along the watercourse as a result of the proposed works accounts for 3.72% of the total length	No

WFD Quality Element	Current Status	Potential Impact	Further assessment and/or mitigation required?
ground water bodies		of the Eamont (Lower) water body. As such, this reduction in connectivity between the watercourse and ground water bodies is not considered to represent a significant impact on ground water connectivity. Therefore, this quality element will not be considered as part of the impact assessment for the Eamont (Lower) water body.	
River Continuity	Not Assessed	The existing culvert already limits the conveyance of flow and sediment from upstream of the culvert to downstream reaches. Extending the length of this control on flow and sediment conveyance will not further restrict flow and sediment conveyance; the internal clear span and height of the proposed culvert extension to the north will match that of the existing culvert. In addition, existing geomorphological features and processes occurring downstream of the proposals are unlikely to be affected, as the existing culvert will prevent impacts from propagating downstream. As such, the proposed works are unlikely to lead to a degradation of the existing river continuity of the watercourse. Therefore, this quality element will not be considered as part of the impact assessment for the Eamont (Lower) water body.	No
Morphology: River width and depth	Not Assessed	The replacement of a section of open channel with a culvert will result in a change to the existing width and depth of the watercourse. Given that the total length of open channel on the Unnamed Tributary of the Eamont 3.4 is approximately 260m, and 130m of existing channel is to be lost, this represents a 50% loss of open channel. Following the completion of the culvert extension, the width and depth of the channel will be dictated by the geometry of the culvert barrel. As a result, this reflects a degradation of the existing river width and depth. Therefore, this will be considered as part of the impact assessment for the Eamont (Lower) water body.	Yes
Morphology: Structure and substrate of the river bed	Not Assessed	The existing river bed substate in the Unnamed Tributary of the Eamont 3.4 is degraded and lacks morphological diversity. Fine sediment inputs from the surrounding	No

WFD Quality Element	Current Status	Potential Impact	Further assessment and/or mitigation required?
		agricultural land and cattle poaching on the riverbanks has led to the river bed being choked with fine material. In addition, existing geomorphological features, processes and sediment transport dynamics occurring downstream of the proposals are unlikely to be affected, as the existing culvert will prevent impacts from propagating downstream. As such, replacement of the existing degraded river bed substrate with the proposed culvert extension will not lead to a degradation of the existing river bed substrate. Therefore, this quality element will not be considered as part of the impact assessment for the Eamont (Lower) water body.	
Morphology: Structure of the riparian zone	Not Assessed	The existing condition of the riparian zone on the Unnamed Tributary of the Eamont 3.4 is already degraded. The watercourse is culverted for most of its length, with just a 260m length of open channel available for the growth of riparian vegetation. Of this length of open channel, riparian tree cover is very sparse; sporadic tree lines the riverbank, and the majority of the riverbanks are unvegetated. Cattle poaching has further degraded the condition of the riverbanks. As such, the replacement of part of the open channel with the proposed culvert extension will not lead to further degradation of the structure of the riparian zone compared to the existing condition. Therefore, this quality element will not be considered as part of the impact assessment for the Eamont (Lower) water body.	No

Watercourse Crossing Point 6 (Culvert 302)

14.4.3.35 The proposed works at this location include the extension of the existing culvert 50m downstream. As such, the culvert will have an extended footprint compared to the existing structure, with a total length of 80m. The diameter of the extension is to be the same as the existing diameter. The culvert extension is to be realigned approximately 10m to the west. A full description of the works is available in paragraph 14.4.3.2

14.4.3.36 Table 15: Assessment of works at Watercourse Crossing Point 6 (Culvert 302) on the Unnamed Tributary of the Eamont 3.5 against the hydromorphological quality elements for the Eamont (Lower) WFD water body catchment, assesses the potential impacts arising from proposed works at watercourse crossing point 6 (Culvert 302) on the Unnamed Tributary of the Eamont 3.5, which is within the Eamont (Lower) WFD water body catchment.

Table 15: Assessment of works at Watercourse Crossing Point 6 (Culvert 302) on the Unnamed Tributary of the Eamont 3.5 against the hydromorphological quality elements for the Eamont (Lower) WFD water body catchment

WFD Quality Element	Current Status	Potential Impact	Further assessment and/or mitigation required?
Hydrology: Quantity and Dynamics of flow	Not Assessed	A 50m length of the Unnamed Tributary of the Eamont 3.5 that is currently open channel will be culverted following the completion of the works, which will alter the dynamics of flow (e.g., flow velocity, water depth, wetted area etc.) on a local scale at the Unnamed Tributary of the Eamont 3.5. This accounts for 7.84% of the total watercourse length and 0.58% of the total waterbody length. Despite this, the existing flow dynamics on the watercourse lack geomorphological diversity and can be described as already degraded as a result of anthropogenic and agricultural pressures. The small size of the watercourse further limits flow dynamics. As such, the proposed works are unlikely to lead to a degradation of the quantity and dynamics of flow. Therefore, this quality element will not be considered as part of the impact assessment for the Eamont (Lower) water body.	No
Hydrology: Connection to ground water bodies	Not Assessed	The extension of impermeable surface along the watercourse accounts for 7.84% of the Unnamed Tributary of the Eamont 3.5, and 0.58% of the entire WFD waterbody. As such, this reduction in connectivity between the watercourse and ground water bodies is not significant enough to impact ground water connectivity. Therefore, this quality element will not be considered as part of the impact assessment for the Eamont (Lower) water body.	No
River Continuity	Not Assessed	The existing culvert already limits the conveyance of flow and sediment from upstream of the culvert to downstream reaches. Extending the length of this control will not further restrict flow and sediment conveyance; the internal clear span and height of the proposed culvert extension to	No

WFD Quality Element	Current Status	Potential Impact	Further assessment and/or mitigation required?
		the north will match that of the existing culvert. As such, the proposed works are unlikely to lead to a degradation of the existing river continuity of the watercourse. Therefore, this quality element will not be considered as part of the impact assessment for the Eamont (Lower) water body.	
Morphology: River width and depth	Not Assessed	The replacement of a section of open channel with a culvert will result in a change to the existing width and depth of the Unnamed Tributary of the Eamont 3.5. Following the completion of the culvert extension, the width and depth of the channel will be dictated by the geometry of the culvert barrel. Despite this, the existing river width and depth on the Unnamed Tributary of the Eamont 3.5 immediately downstream of the existing culvert outfall is homogeneous and lacks geomorphological diversity. The small size of the watercourse (approximate channel width of 1m) further limits the diversity in channel geometry. As such, the proposed works are unlikely to lead to a degradation of the river width and depth. Therefore, this quality element will not be considered as part of the impact assessment for the Eamont (Lower) water body.	No
Morphology: Structure and substrate of the river bed	Not Assessed	The proposed works will involve the loss of a 50m length of open channel, which will result in a loss of river bed substrate. Moreover, there is the potential for river bed substrate change in the downstream reach of the Unnamed Tributary of the Eamont 3.5. Despite the loss of river bed substrate in the immediate vicinity of the culvert, the existing condition of the river bed is already degraded and lacks geomorphological diversity and character. Fine material and dense vegetation choke the river bed, resulting in homogeneous characteristics. As such, the proposed works are unlikely to lead to a degradation of the river structure and substrate of the river bed. Therefore, this quality element will not be considered as part of the impact assessment for the Eamont (Lower) water body.	No

WFD Quality Element	Current Status	Potential Impact	Further assessment and/or mitigation required?
Morphology: Structure of the riparian zone	Not Assessed	The channel planform downstream of the existing structure is to be realigned approximately 10m to the west, and as such the culvert extension will need to dog leg to the west to ensure the culvert outfall is situated at the realigned channel. Despite the potential loss in riparian habitat and structure, the existing condition of the riparian zone on the Unnamed Tributary of the Eamont 3.5 is poor; the riverbanks lack riparian tree cover and are overgrown with grasses. As such, any modification to the riverbanks as a result of the channel realignment will not lead to a further degradation of the condition of the riverbanks. The proposed works are unlikely to lead to a degradation of the structure of the riparian zone. Therefore, this quality element will not be considered as part of the impact assessment for the Eamont (Lower) water body.	No

Hydromorphological quality elements of the Eden Lyvennet to Eamont water body

Watercourse Crossing Point 7 (Swine Gill Culvert)

14.4.3.37 The proposed works at this location include the extension of the existing culvert 39.10m downstream. As such, the culvert will have an extended footprint compared to the existing structure, with a total length of 103m. The diameter of the extension is to be the same as the existing diameter. The culvert extension is to be realigned approximately 10m to the west. The gradient of the existing culvert will be extended and maintained through the proposed culvert extension. A full description of the works is available in paragraph 14.4.3.2.

14.4.3.38 Table 16: Assessment of works at Watercourse Crossing Point 7 (Swine Gill Culvert) on the Swine Gill, against the hydromorphological quality elements for the Eden Lyvennet to Eamont water body catchment, presents an assessment of the proposed works against the hydromorphological quality elements of the Eden Lyvennet to Eamont water body catchment, within which the Swine Gill Culvert is located as part of the Penrith to Temple Sowerby Scheme.

Table 16: Assessment of works at Watercourse Crossing Point 7 (Swine Gill Culvert) on the Swine Gill, against the hydromorphological quality elements for the Eden Lyvennet to Eamont water body catchment

WFD Quality Element	Current Status	Potential Impact	Further assessment and/or mitigation required?
Hydrology: Quantity and Dynamics of flow	Not Assessed	Areas of the Swine Gill that are currently open channel will be culverted following the completion of the works, which will alter the dynamics of flow (e.g., flow velocity, water depth, wetted area etc.). Immediately upstream and downstream of the culvert, the channel exhibits relatively good flow diversity and morphological condition. A diverse range of flow biotopes were identified during survey of the watercourse. This is significant given that the total length of the Swine Gill that exhibits good morphological condition is limited to approximately 450m. The proposed works represents a total loss of 39.10m of this existing morphological functioning, but it is likely the influence on the flow dynamics will extend further downstream than the culvert extension footprint as the channel adjusts to the modification. Therefore, this quality element will be considered as part of the impact assessment for the Eden Lyvennet to Eamont water body.	Yes
Hydrology: Connection to ground water bodies	Not Assessed	The proposed works involve the extension of the existing Swine Gill Culvert by 39.10m to the north, including the installation of a new culvert outfall and pre-cast concrete headwall further to the north. This is unlikely to impact the existing connectivity of the watercourse to ground water bodies. The extension of impermeable surface along the watercourse accounts for just 0.16% of the total length of the Swine Gill. As such, this reduction in connectivity between the watercourse and ground water bodies is not significant enough to impact ground water connectivity. Therefore, this quality element will not be considered as part of the impact assessment for the Eden Lyvennet to Eamont water body.as part of the impact assessment.	No
River Continuity	Not Assessed	The existing culvert on the Swine Gill already limits the conveyance of flow and sediment from upstream of the culvert to downstream reaches. Extending the length of this control on flow and sediment conveyance will not further restrict flow and sediment conveyance; the internal clear span and height of the proposed culvert extension to	No

WFD Quality Element	Current Status	Potential Impact	Further assessment and/or mitigation required?
		the northwill match that of the existing Swine Gill Culvert. As such, the proposed works are unlikely to lead to a degradation of the existing river continuity of the watercourse. Therefore, this quality element will not be considered as part of the impact assessment for the Eden Lyvennet to Eamont water body.	
Morphology: River width and depth	Not Assessed	The replacement of a section of open channel with a culvert will result in a change to the existing width and depth of the Swine Gill. Following the completion of the culvert extension, the width and depth of the channel will be dictated by the geometry of the culvert barrel. The existing morphological characteristics on the Swine Gill immediately downstream of the culvert are diverse in terms of river width and depth and exhibit relatively good morphological condition. This is significant given that the total length of the Swine Gill that exhibits good morphological condition is limited. The proposed works represent a total loss of 39.10m of natural river width and depth on the Swine Gill but it is likely the influence on the river width and depth will extend further downstream than the culvert extension footprint as the channel adjusts to the modification. As a result, this represents a degradation of the river width and depth compared to the current conditions. Therefore, this quality element will not be considered as part of the impact assessment for the Eden Lyvennet to Eamont water body.	Yes
Morphology: Structure and substrate of the river bed	Not Assessed	The proposed works will result in a loss of river bed substrate. The existing structure and substrate of the river bed on the Swine Gill immediately upstream and downstream of the culvert is relatively diverse and exhibits good morphological condition. A diverse range of river bed forms were identified during survey of the watercourse. This is significant given that the total length of the Swine Gill that exhibits good morphological condition is limited to approximately 450m. The proposed works represents a total loss of 39.10m of open channel, but it is likely the influence on the river bed substrate will	Yes

WFD Quality Element	Current Status	Potential Impact	Further assessment and/or mitigation required?
		extend much further downstream than just the culvert extension as the channel adjusts to the modification. Therefore, this will be considered as part of the impact assessment for the Eden Lyvennet to Eamont water body.	
Morphology: Structure of the riparian zone	Not Assessed	The extension of the Swine Gill Culvert will involve the replacement of the existing riparian zone with an embankment to support the existing A66. In addition, the replacement of a section of open channel with a culvert barrel will significantly reduce the connectivity of the watercourse to the riparian zone and surrounding floodplain. The existing condition of the riparian zone on the Swine Gill immediately upstream and downstream of the culvert is relatively good, exhibiting a diversity of habitats. A dense buffer strip of riparian woodland exists downstream of the culvert, and a wet woodland exists upstream of the culvert. This is significant given that the total length of the Swine Gill that exhibits a good riparian zone is limited to approximately 450m. The proposed works represents a total loss of 39.10m of riparian zone, but it is likely that the influence on the riparian zone will extend further downstream than the culvert extension footprint due to access requirements. This combined loss of riparian zone and floodplain connectivity will lead to a degradation of the riparian zone on the Swine Gill. Therefore, this will be considered as part of the impact assessment for the Eden Lyvennet to Eamont water body.	Yes

Impact assessment

14.4.3.39 The Impact Assessment needs to consider if there is a pathway linking the pressure to the quality element. If there is no pathway there can be no impact on the quality element and there is no need for any further assessment of that quality element to be carried out. If there is a potential pathway the assessment must consider if the activity, and the pressure it creates, may cause deterioration of the quality element.

14.4.3.40 In order to effectively assess the potential impacts of the proposed works and decide upon suitable mitigation measures, a good understanding of the proposed scheme and design is required. Should any revisions be made to the proposed works that could impact any of the WFD quality elements, this section must be revised.

14.4.3.41 The mitigation measures stipulated within the impact assessment are secured by the Project Design Principles (Application Document 5.11) and the Environmental Management Plan (Application Document 2.7), which are certified documents under DCO.

Impact Assessment of the Eamont (Lower) water body

14.4.3.42 Table 17: Impacts and mitigation measures of Watercourse Crossing Point 3 (Lightwater Culvert) to Table 19: Impacts and mitigation measures of Watercourse Crossing Point 5 (Culvert Unnamed - Whinfell) discuss each of the quality elements identified as being potentially at risk in the scoping assessment from each proposed structure on the Eamont (Lower) WFD water body. Mitigation measures are stipulated to mitigate the effects of the proposed works. It should be noted that these mitigation measures differ to the Mitigation Measures identified for any Heavily Modified water body.

14.4.3.43 Provided the mitigation measures stipulated within the impact assessment are implemented at the detailed design stage, cumulative impacts from all the proposed works to the hydromorphology quality elements of the Eamont (Lower) WFD water body will be mitigated sufficiently.

Watercourse Crossing Point 3 (Lightwater Culvert)

14.4.3.44 Table 17: Impacts and mitigation measures of Watercourse Crossing Point 3 (Lightwater Culvert), explores the mitigation measures required to offset the impacts arising from the proposed works on the Lightwater Culvert.

Table 17: Impacts and mitigation measures of Watercourse Crossing Point 3 (Lightwater Culvert)

WFD Quality Element	Pathway (direct / indirect / none)	Potential Impact/ Mitigation measures
Hydrology: Quantity and Dynamics of flow	Direct	**Permanent Impact:** The proposed works will lead to a loss of open channel on the Lightwater. The subsequent extension of the Lightwater culvert will alter the dynamics of flow (e.g., flow velocity, water depth, wetted area etc.) **Mitigation:** To compensate for the loss of natural flow dynamics and diversity on the Lightwater, riparian planting of tree cover is to be undertaken and a buffer strip will be created in a currently degraded section of the watercourse. The introduction of a dense riparian buffer strip along the riverbanks upstream of the structure will provide a natural source of woody material to the watercourse. Naturally occurring woody material in the channel increases flow and sediment diversity, which encourages localised variation in flow velocities. This develops a natural pattern of river width and depth diversity over time, which contributes to naturally sinuous flow mechanics developing across a river reach. The natural introduction of woody material into the channel can be assisted by installing root wads or securing large wood at strategic locations along

WFD Quality Element	Pathway (direct / indirect / none)	Potential Impact/ Mitigation measures
		the Lightwater. This would restore the potential loss of flow diversity as a result of the proposed culvert extension. The compensation will be applied over a length of river channel equivalent to twice that impacted by the proposed works.
Morphology: River width and depth	Direct	**Permanent Impact:** The replacement of open channel with the proposed culvert extension will result in a change to the existing width and depth of the Lightwater. Following the completion of the culvert extension, the width and depth of the channel will be dictated by the geometry of the culvert barrel. As a result, this reflects a degradation of the river width and depth compared to the current conditions. **Mitigation:** To compensate the loss of natural diversity in channel width and depth on the Lightwater, riparian planting of tree cover will be undertaken and a buffer strip will be created. The introduction of a dense riparian buffer strip along the riverbanks of both watercourses upstream of the structure will provide a natural source of woody material to the watercourse. Naturally occurring woody material in the channel increases flow diversity and encourages localised scour of riverbanks and deposition of sediment in the channel. This aids the development of a more natural pattern of river width and depth over time. The natural introduction of woody material into the channel can be assisted by installing root wads or securing large wood at strategic locations along the Lightwater. The compensation will be applied over a length of river channel equivalent to twice that impacted by the proposed works.
Morphology: Structure and substrate of the river bed	Direct	**Permanent Impact:** The replacement of open channel with the proposed culvert extension will result in a change to the existing condition of the river bed substrate on the Lightwater. Following the completion of the culvert extension, the natural river bed substrate will be replaced with the culvert barrel. **Mitigation:** To compensate the loss and degradation of the natural river bed substrate on the Lightwater, riparian planting of tree cover will be undertaken and a buffer strip will be created. The introduction of a dense riparian buffer strip along the riverbanks of both watercourses upstream of the structure will provide a natural source of woody material to the watercourse. Naturally occurring woody material in the channel creates localised diversity in sediment transport mechanics. This encourages localised pockets of sediment deposition and erosion, generating a heterogeneous river bed structure. The natural introduction of woody material into the channel can be assisted by installing root wads or securing large wood at strategic locations along the Lightwater. The compensation will be applied over a length of river channel equivalent to twice that impacted by the proposed works.

WFD Quality Element	Pathway (direct / indirect / none)	Potential Impact/ Mitigation measures
Morphology: Structure of the riparian zone	Direct	**Permanent Impact:** The extension of the Lightwater Culvert will involve the replacement of the existing riparian zone with an embankment to support the existing A66. In addition, the replacement of a section of open channel with a culvert barrel will significantly reduce the connectivity of the watercourse to the riparian zone and surrounding floodplain. This combined loss of riparian zone and floodplain connectivity will lead to a degradation of the riparian zone on the Lightwater. **Mitigation:** To compensate the loss of riparian habitat and structure, riparian planting of tree cover will be undertaken and a buffer strip will be created. On the Lightwater, the most suitable location for this is the river reach upstream (south) of the existing A66 culvert to Hallsteads Wood, 200m upstream. Establishing a buffer strip on the left and right bank floodplain will provide additional riparian habitat benefits and improve geomorphological function. Planting riparian woodland in this reach will compensate for the degradation of riparian habitat associated with the proposed culvert extension. Moreover, riparian planting in this reach will provide geomorphological benefits, such as the potential for woody debris recruitment to the channel and the potential improved floodplain connectivity as a result. The compensation will be applied over a length of river channel equivalent to twice that impacted by the proposed works.

Watercourse Crossing Point 4 (Culvert 301)

14.4.3.45 Table 18: Impacts and mitigation measures of Watercourse Crossing Point 4 (Culvert 301) explores the mitigation measures required to offset the impacts arising from the proposed works on Watercourse Crossing Point 4 (Culvert 301).

Table 18: Impacts and mitigation measures of Watercourse Crossing Point 4 (Culvert 301)

WFD Quality Element	Pathway (direct / indirect/ none)	Potential Impact/ Mitigation measures
Hydrology: Quantity and Dynamics of flow	Direct	**Permanent Impact:** This change in culvert gradient has the potential to increase flow velocity in the culvert barrel, at the culvert outfall, and in the channel immediately downstream. The increase in flow velocity downstream of the proposed culvert outfall has the potential to initiate geomorphological change in the channel and on the floodplain; an increase in flow velocity can change sediment transfer dynamics, and rates of erosion and deposition. Given the already active nature of the Unnamed Tributary of the Eamont 3.3 and the steep channel gradient, this has the potential to impact the dynamics of flow.

WFD Quality Element	Pathway (direct / indirect/ none)	Potential Impact/ Mitigation measures
		Mitigation: Mitigation will consist of the following options: • riparian tree planting and buffer strip creation • creation of a pool at the culvert outlet to dissipate flows • a baffle installed downstream of the culvert The options are to be confirmed during detailed design after further data is available. Hydraulic modelling will be needed to identify any change in flow velocity in the channel downstream of the culvert outlet as a result of the proposed works. Hydromorphic interpretation of modelling results will need be carried out to understand impacts on river process, such as erosion. If an increase in velocity that has the potential to increase erosion is identified then measures to mitigate this impact will be required. Further details on the options are given below. The creation of a buffer strip and riparian planting will increase the structural integrity of the riverbanks compared to existing, which will increase resistance to riverbank erosion. The introduction of a dense riparian buffer strip along the river banks downstream of the structure will provide a natural source of woody material to the watercourse. Naturally occurring woody material in the channel increases flow and sediment diversity, which encourages localised variation in flow velocities. Creation of a pool using large, boulder sized material will dissipate flows discharging from the proposed culvert outlet. Adequate bank protection surrounding the pool will be required to prevent flows outflanking the pool and exacerbating bank erosion. As flows enter the pool, flow energy will be dissipated and flow velocities will be reduced, managing the potential for increased flow velocities as a result of the proposed culvert extension. This option is a more natural approach, as a pool is a naturally occurring feature in river systems of similar characteristics. As such, this option is more favourable. A baffle structure installed directly downstream of the culvert outfall may also help to dissipate flow energy. As the flows discharges out of the culvert barrel, the flow velocities will be reduced significantly as flow is dispersed around the baffle structure. The reduction in flow velocities will ensure that existing flow dynamics at the outfall of the existing culvert and in the channel are maintained. This option uses fewer natural techniques and is less favourable than the pool option outlined above.
Morphology: Structure and Substrate of the river bed	Direct	**Permanent Impact:** The change in gradient in the proposed extended culvert barrel has the potential to increase flow velocity in the culvert barrel, at the culvert outfall, and in the channel downstream. Site observations identified that river bed erosion is prevalent in this downstream river reach, and as such it is likely that the proposed works will increase rates of river bed erosion. Further increases to

WFD Quality Element	Pathway (direct / indirect/ none)	Potential Impact/ Mitigation measures
		flow velocity in the channel also has the potential to exacerbate bank erosion in the reach downstream of the culvert. The channel gradient sharply increases downstream of the culvert before entering the Eamont floodplain adjacent to the confluence. **Mitigation:** Mitigation will consist of the following options: • Riparian tree planting and buffer strip creation • Creation of a pool at the culvert outlet to dissipate flows • A baffle installed downstream of the culvert The options are to be confirmed during detailed design after further data is available. Hydraulic modelling will need to be conducted to identify any change in flow velocity in the channel downstream of the culvert outlet as a result of the proposed works. Hydromorphic interpretation of modelling results will need be carried out to understand impacts on river process, such as erosion. If an increase in velocity that has the potential to increase erosion is identified then measures to mitigate this impact will be required. Further details on the options are given below. The creation of a buffer strip and riparian planting will increase the structural integrity of the riverbanks compared to their existing integrity, which will increase resistance to riverbank erosion. The introduction of a dense riparian buffer strip along the riverbanks downstream of the structure will provide a natural source of woody material to the watercourse. Naturally occurring woody material in the channel increases flow and sediment diversity, which encourages localised variation in flow velocities. Creation of a pool using large, boulder sized material will dissipate flows discharging from the proposed culvert outlet. Adequate bank protection surrounding the pool will be required to prevent flows outflanking the pool and exacerbating bank erosion. As flows enter the pool, flow energy will be dissipated and flow velocities will be reduced, managing the potential for increased flow velocities as a result of the proposed culvert extension. This option is a more natural approach, as a pool is a naturally occurring feature in river systems of similar characteristics. As such, this option is more favourable. A concrete baffle structure installed directly downstream of the culvert outfall may also help to dissipate flow energy. As the flows discharges out of the culvert barrel, the flow velocities will be reduced significantly as flow is dispersed around the baffle structure. The reduction in flow velocities will ensure that existing flow dynamics at the outfall of the existing culvert and in the channel are maintained. This option uses fewer natural techniques and is less favourable than the pool option outlined above.

Watercourse Crossing Point 5 (Culvert Unnamed - Whinfell)

14.4.3.46 Table 19: Impacts and mitigation measures of Watercourse Crossing Point 5 (Culvert Unnamed - Whinfell) explores the mitigation measures required to offset the impacts arising from the proposed works on Watercourse Crossing Point 5 (Culvert Unnamed - Whinfell).

Table 19: Impacts and mitigation measures of Watercourse Crossing Point 5 (Culvert Unnamed - Whinfell)

WFD Quality Element	Pathway (direct / indirect/ none)	Potential Impact/ Mitigation measures
Hydrology: Quantity and Dynamics of flow	Direct	**Permanent Impact:** The proposed works involve the extension of the existing culvert by 320m upstream of the existing structure, and the diversion of the watercourse around the proposed road embankment away from the existing 130m of open channel. Areas of the Unnamed Tributary of the Eamont 3.4 that are currently open channel will be culverted following the completion of the works, which will alter the dynamics of flow (e.g., flow velocity, water depth, wetted area etc.). **Mitigation:** To compensate for the loss of natural flow dynamics and diversity in the Unnamed Tributary of the Eamont 3.4, riparian planting and buffer strip creation will be carried out. The creation of a riparian buffer strip and riparian planting will increase the structural integrity of the riverbanks compared to their existing integrity, which will increase resistance to riverbank erosion. It will also provide a natural source of woody material to the watercourse. Naturally occurring woody material in the channel increases flow and sediment diversity, which encourages localised variation in flow velocities. There is space within the order limits downstream of the culvert outfall to implement this mitigation, as outlined in Table 18: Impacts and mitigation measures of Watercourse Crossing Point 4 (Culvert 301).
Morphology: River width and depth	Direct	**Permanent Impact:** The replacement of a section of open channel with a culvert will result in a change to the existing width and depth of the Unnamed Tributary of the Eamont 3.4. Given that the total length of open channel on the Unnamed Tributary of the Eamont 3.4 is approximately 260m, and 130m of existing channel is to be lost, this represents a 50% loss of open channel. Following the completion of the culvert extension, the width and depth of the channel will be dictated by the geometry of the culvert barrel. **Mitigation:** To compensate for the changes to river width and depth in the Unnamed Tributary of the Eamont 3.4, riparian planting and buffer strip creation will be carried out. The creation of a riparian buffer strip and riparian planting will increase the structural integrity of the riverbanks compared to their existing integrity, which will increase resistance to riverbank erosion. It will also provide a natural source

WFD Quality Element	Pathway (direct / indirect/ none)	Potential Impact/ Mitigation measures
		of woody material to the watercourse. Naturally occurring woody material in the channel increases flow and sediment diversity, which encourages localised variation in flow velocity and the development of natural river morphology and geometry. There is space within the order limits downstream of the culvert outfall to implement this mitigation, as outlined in Table 18: Impacts and mitigation measures of Watercourse Crossing Point 4 (Culvert 301).

Impact Assessment of the Eden Lyvennet to Eamont water body

Watercourse Crossing Point 7 (Swine Gill Culvert)

14.4.3.47 Table 20: Impacts and mitigation measures at Watercourse Crossing Location 7 (Swine Gill Culvert) discuss each of the quality elements identified as being potentially at risk in the scoping assessment each structure assessed in the Eden Lyvennet to Eamont WFD water body. Mitigation measures are required to mitigate the effects of the proposed works. It should be noted that these mitigation measures differ to the Mitigation Measures identified for any Heavily Modified water body.

14.4.3.48 Provided the mitigation measures stipulated within the impact assessment are implemented at the detailed design stage, cumulative impacts from all the proposed works to the hydromorphology quality elements of the Eden Lyvennet to Eamont WFD water body will be mitigated sufficiently.

14.4.3.49 Table 20: Impacts and mitigation measures at Watercourse Crossing Location 7 (Swine Gill Culvert) explores the mitigation measures required to offset the impacts arising from the proposed works on the Swine Gill Culvert

Table 20: Impacts and mitigation measures at Watercourse Crossing Location 7 (Swine Gill Culvert)

WFD Quality Element	Pathway (direct / indirect/ none)	Potential Impact/ Mitigation measures
Hydrology: Quantity and Dynamics of flow	Direct	**Permanent Impact:** Areas of the Swine Gill that are currently open channel will be culverted following the completion of the works, which will alter the dynamics of flow (e.g., flow velocity, water depth, wetted area etc.). Immediately upstream and downstream of the culvert, the channel exhibits relatively good flow diversity and morphological condition. A diverse range of flow biotopes were identified during survey of the watercourse. This is significant given that the total length of the Swine Gill that exhibits good morphological condition is limited to approximately 450m. The proposed works represents a total loss of 39.10m of this existing morphological functioning, but it is likely the influence

WFD Quality Element	Pathway (direct / indirect/ none)	Potential Impact/ Mitigation measures
		on the flow dynamics will extend further downstream than the culvert extension footprint as the channel adjusts to the modification. **Mitigation:** To offset the loss of natural flow dynamics and diversity immediately downstream of the Swine Gill Culvert riparian planting of tree cover is to be undertaken and a buffer strip will be created. On the Swine Gill, the most appropriate location for this riparian woodland planting is either 150 m downstream of the Swine Gill Culvert, or 300 m upstream of the Swine Gill Culvert. Establishing a buffer strip on the left and right bank floodplain will provide additional riparian habitat benefits and improve geomorphological function. In addition, a buffer strip must be established from the top of the left and right banks to provide additional riparian habitat benefits and improve geomorphological function. The introduction of a dense riparian buffer strip along the riverbanks upstream of the structure will provide a natural source of woody material to the watercourse. Naturally occurring woody material in the channel increases flow and sediment diversity, which encourages localised variation in flow velocities. This develops a natural pattern of river width and depth diversity over time, which contributes to naturally sinuous flow mechanics developing across a river reach. The natural introduction of woody material into the channel can be assisted by installing root wads or securing large wood at Swine Gill This would restore the potential loss of flow diversity as a result of the proposed culvert extension. The compensation must aim to be applied over a length of watercourse equivalent to twice that impacted by the proposed works.
Morphology: River width and depth	Direct	**Permanent Impact:** The replacement of open channel with the proposed culvert extension will result in a change to the existing width and depth of the Swine Gill. Following the completion of the culvert extension, the width and depth of the channel will be dictated by the geometry of the culvert barrel. As a result, this reflects a degradation of the river width and depth compared to the current conditions. **Mitigation:** To offset the loss of natural diversity in channel width and depth on the Swine Gill, riparian planting of tree cover is to be undertaken and a buffer strip will be created. On the Swine Gill, the most appropriate location for this riparian woodland planting is either 150 m downstream of the Swine Gill Culvert, or 300 m upstream of the Swine Gill Culvert. Establishing a buffer strip on the left and right bank floodplain will provide additional riparian

WFD Quality Element	Pathway (direct / indirect/ none)	Potential Impact/ Mitigation measures
		habitat benefits and improve geomorphological function. In addition, a buffer strip must be established from the top of the left and right banks to provide additional riparian habitat benefits and improve geomorphological function. The introduction of a dense riparian buffer strip along the riverbanks of both watercourses upstream of the structure will provide a natural source of woody material to the watercourse. Naturally occurring woody material in the channel increases flow diversity and encourages localised scour of riverbanks and deposition of sediment in the channel margins. This develops a natural pattern of river width and depth diversity over time. The natural introduction of woody material into the channel can be assisted by installing root wads or securing large wood at strategic locations along the Swine Gill. The compensation must aim to be applied over a length of watercourse equivalent to twice that impacted by the proposed works.
Morphology: Structure and substrate of the river bed	Direct	**Permanent Impact:** The proposed works will result in a loss of river bed substrate. The existing structure and substrate of the river bed on the Swine Gill immediately upstream and downstream of the culvert is relatively diverse and exhibits good morphological condition. A diverse range of river bed forms were identified during survey of the watercourse. This is significant given that the total length of the Swine Gill that exhibits good morphological condition is limited to approximately 450m. The proposed works represents a total loss of 39.10m of open channel, but it is likely the influence on the river bed substrate will extend much further downstream than just the culvert extension as the channel adjusts to the modification. **Mitigation:** To offset the loss and degradation of the natural river bed substrate on the Swine Gill, riparian planting of tree cover is to be undertaken and a buffer strip will be created. On the Swine Gill, the most appropriate location for this riparian woodland planting is either 150 m downstream of the Swine Gill Culvert, or 300 m upstream of the Swine Gill Culvert. Establishing a buffer strip on the left and right bank floodplain will provide additional riparian habitat benefits and improve geomorphological function. In addition, a buffer strip must be established from the top of the left and right banks to provide additional riparian habitat benefits and improve geomorphological function. The introduction of a dense riparian buffer along the riverbanks of both watercourses upstream of the structure will provide a natural source of woody material to the watercourse. Naturally occurring woody material in the channel increases the localised diversity in sediment transport mechanics, encouraging localised pockets of sediment

WFD Quality Element	Pathway (direct / indirect/ none)	Potential Impact/ Mitigation measures
		deposition and erosion, generating a heterogeneous river bed structure. The natural introduction of woody material into the channel can be assisted by installing root wads or securing large wood at strategic locations along the Swine Gill. The compensation should aim to be applied over a length of watercourse equivalent to twice that impacted by the proposed works.
Morphology: Structure of the riparian zone	Direct	**Permanent Impact:** The replacement of open channel with the proposed culvert extension will involve the replacement of the existing riparian zone with an embankment and culvert barrel to support the existing A66. The replacement of a section of open channel with a culvert barrel will result in the direct loss of riparian vegetation. There is the risk that any modification to the existing Swine Gill Structure will alter the retention of water directly upstream of the culvert, which currently supports the wet woodland and riparian zone. Changes to the water retention or water level within this wet woodland would lead to a significant deterioration of the riparian zone in this location. **Mitigation:** To compensate the loss of riparian habitat and structure, riparian planting of tree cover is to be undertaken and a buffer strip will be created. On the Swine Gill, the most suitable location for this is either 150 m downstream of the Swine Gill Culvert, or 300m upstream. Establishing a buffer strip on the left and right bank floodplain will provide additional riparian habitat benefits and improve geomorphological function. Planting riparian woodland in this reach will mitigate against the risk of riparian habitat degradation associated with the extension of the Swine Gill Culvert. Moreover, riparian planting will provide additional geomorphological benefits such as improved floodplain connectivity, improved riverbank integrity and resistance to scour, and improved habitat space for the watercourses. The compensation must aim to be applied over a length of watercourse equivalent to twice that impacted by the proposed works. To reduce the risk of changes in the existing water level of the wet woodland directly upstream of the existing culvert, the invert level and culvert dimensions of the upstream face of the culvert beneath the existing A66 should not be changed as part of the proposed works. This will ensure that the existing riparian habitat conditions in the wet woodland are preserved.

Water body mitigation measures

14.4.3.50 The Eamont (Lower) and Eden Lyvennet to Eamont water bodies are not classified as heavily modified or artificial. Therefore, there are no hydromorphology mitigation measures assigned to either of these water bodies identified in the Solway Tweed River Basin Management Plan 2021.

WFD hydromorphology assessment objectives

Table 21: Hydromorphology assessment of proposed works against WFD objectives for the Solway Tweed River Basin Management Plan 2021

WFD Hydromorphology Assessment Objectives	Hydromorphology Assessment of works
Objective 1: The proposed works do not cause deterioration in the Status of the Hydromorphology quality elements of the water body	Provided the required mitigation measures detailed in Table 17: Impacts and mitigation measures of Watercourse Crossing Point 3 (Lightwater Culvert) to Table 20: Impacts and mitigation measures at Watercourse Crossing Location 7 (Swine Gill Culvert) and section 14.4.9 are adhered to, the proposed works will not cause a deterioration in the status of the hydromorphology quality elements of the Eamont (Lower) or Eden Lyvennet to Eamont water bodies.
Objective 2: The proposed works do not compromise the ability of the water body to achieve its WFD status objectives	The proposed works do not compromise the ability of the Eamont (Lower) water body to achieve Good hydromorphology status or the ability of the Eden Lyvennet to Eamont water body to achieve Good ecological status, provided the mitigation measures detailed in Table 17: Impacts and mitigation measures of Watercourse Crossing Point 3 (Lightwater Culvert) to Table 20: Impacts and mitigation measures at Watercourse Crossing Location 7 (Swine Gill Culvert) and section 14.4.9 are adhered to.
Objective 3: The proposed works do not cause a permanent exclusion or compromised achievement of the WFD objectives in other bodies of water within the same RBD	Impacts arising from the proposals at the scheme will be direct and local to the fluvial environment on site. The impacts arising from the proposed works will not impact on areas elsewhere in the catchment and will not impact other WFD waterbodies within the RBMP.
Objective 4: The proposed works contribute to the delivery of the WFD objectives	The proposed works will contribute to the delivery of the WFD objectives by ensuring no detrimental impact to the water body at the water body scale, and by providing localised hydromorphological enhancements, provided the mitigation measures detailed in Table 17: Impacts and mitigation measures of Watercourse Crossing Point 3 (Lightwater Culvert) to Table 20: Impacts and mitigation

WFD Hydromorphology Assessment Objectives	Hydromorphology Assessment of works
	measures at Watercourse Crossing Location 7 (Swine Gill Culvert) and section 14.4.9 are adhered to.

Penrith to Temple Sowerby key considerations

14.4.3.51 The impact assessment determines whether the proposed works have the potential to significantly impact any of the hydromorphology quality elements screened into the assessment. Specific mitigation measures required to prevent the deterioration of specific quality elements are considered in Table 17: Impacts and mitigation measures of Watercourse Crossing Point 3 (Lightwater Culvert),Table 18: Impacts and mitigation measures of Watercourse Crossing Point 4 (Culvert 301),Table 19: Impacts and mitigation measures of Watercourse Crossing Point 5 (Culvert Unnamed - Whinfell) and Table 20: Impacts and mitigation measures at Watercourse Crossing Location 7 (Swine Gill Culvert). Additional mitigation measures that must be considered at each of the proposed structures screened into the assessment are listed in section 14.4.9.

14.4.3.52 The mitigation measures stipulated within the impact assessment are secured by the Project Design Principles (Application Document 5.11) and the Environmental Management Plan (Application Document 2.7), which are certified documents under DCO.

14.4.3.53 Provided the mitigation measures stipulated within the impact assessment and in section 14.4.9 are implemented at the detailed design stage, cumulative impacts from all the proposed works to the hydromorphology quality elements of the Eamont (Lower) and Eden Lyvennet to Eamont WFD water bodies will be mitigated sufficiently.

Summary

14.4.3.54 The WFD scoping (Stage 2) stage identified that the proposed works at the following watercourse crossing points assessed will have a detrimental impact to the Eamont (Lower) and Eden Lyvennet to Eamont WFD water bodies without appropriate **mitigation:**

- WCP 3 (Lightwater Culvert)
- WCP 4 (Culvert 301)
- WCP 5 (Culvert Unnamed - Whinfell)
- WCP 7 (Swine Gill Culvert)

14.4.3.55 The works proposed at Scheme 3, Penrith to Temple Sowerby, are likely to directly impact the following hydromorphology quality elements for the Eamont (Lower) and Eden Lyvennet to Eamont water bodies without appropriate **mitigation:**

- Hydrology: Quantity and Dynamics of flow
- Morphology: River width and depth
- Morphology: Structure and substrate of the river bed

- Morphology: Structure of the riparian zone

14.4.3.56 The mitigation and compensation measures required to achieve the WFD objectives include:

- Hydraulic modelling to understand the impact on quantity and dynamics of flow
- Riparian tree planting and buffer strip creation
- Creation of a pool at the culvert outlet to dissipate flows
- A baffle installed downstream of the culvert

The assessment reported in this assessment is based on a precautionary worst case scenario. As such, the mitigation identified in this assessment as being required to mitigate the likely significant effects reported are based on this worst case scenario. It may be the case that as detailed design of the Project evolves, it becomes apparent that a lesser form of mitigation is required to achieve the same outcome. As such, the EMP secures the 'maximum' extent of mitigation required (as identified in this assessment) but also, where appropriate, includes mechanisms (e.g. by way of further surveys or modelling) to establish, pre-construction and during detailed design, whether the identified mitigation can be refined such that a lesser extent is required to achieve the outcome reported in this assessment. The fundamental point is that the mitigation identified in this assessment is secured by the EMP, where required to achieve the outcome reported in this assessment.

14.4.4 Temple Sowerby to Appleby

Scheme overview and proposed works

Scheme location

14.4.4.1 The scheme location for Temple Sowerby to Appleby, and the proposed watercourse crossing points, are shown in Plate 7: Scheme location for Temple Sowerby to Appleby and the proposed watercourse crossing points.

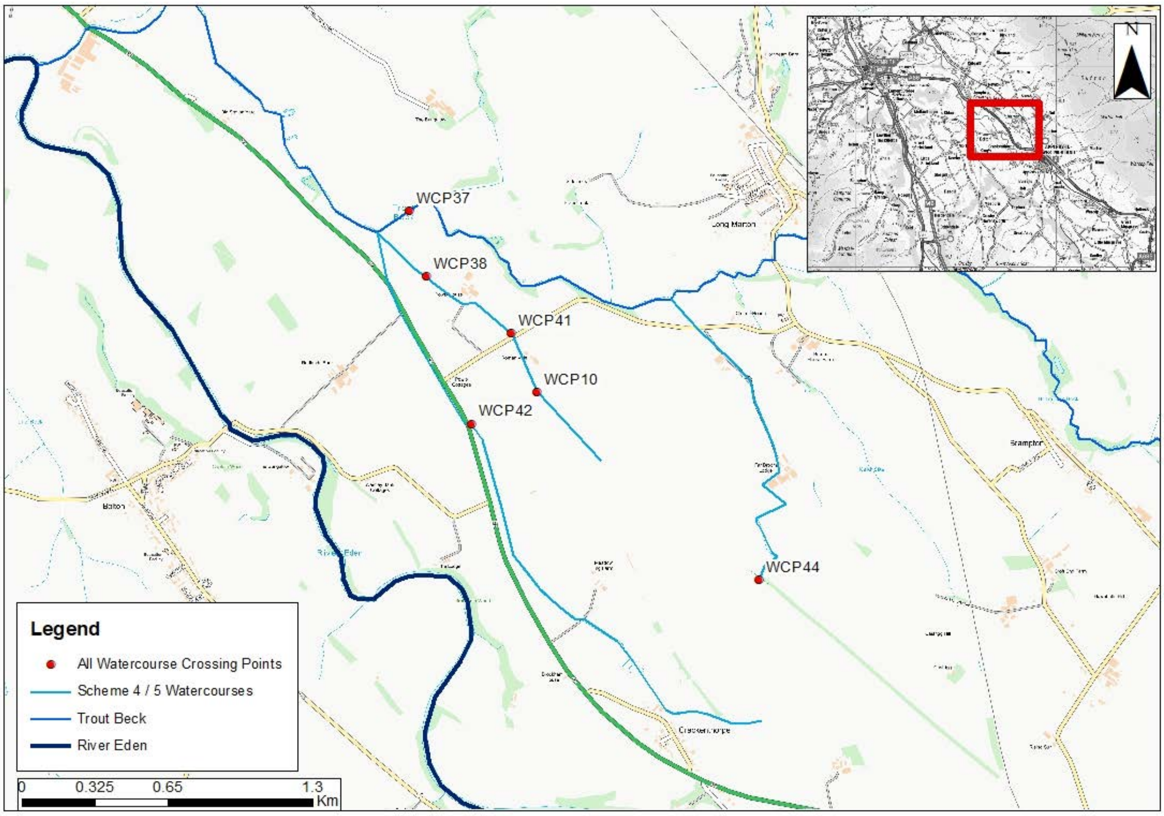

Plate 7: Scheme location for Temple Sowerby to Appleby and the proposed watercourse crossing points

Proposed works

14.4.4.2 The proposed works at each identified Watercourse Crossing Point in Plate 7: Scheme location for Temple Sowerby to Appleby and the proposed watercourse crossing points are summarised below.

Watercourse Crossing Point 37

- There is currently no structure over Trout Beck at the location of Watercourse Crossing Point 37.
- The proposed Trout Beck Viaduct crossing of Trout Beck involves the installation of a bridge with a span of 400m and a deck width of 28m.
- To support the viaduct eight piers will be installed on the left and right bank floodplain.
- An embankment will be constructed on the left and right bank of Trout Beck floodplain (200m from the left bank and 170m from the right bank respectively), to tie into the bridge deck levels.

Watercourse Crossing Point 38, 41 and 10

14.4.4.3 The description of the works at Watercourse Crossing Points 38, 41 and 10 have been divided into two; the western portion of the works from Powis House Farm to Trout Beck, and the eastern portion from Long Marton Road to Roman Vale.

14.4.4.4 The proposed works in the vicinity of Powis House Farm and Trout Beck are as follows:

- The proposed existing A66 embankment that spans the left bank of Trout Beck to the south of Far Broom Lodge crosses the Unnamed Tributary of Trout Beck 4.6.
- The existing A66 embankment crosses the Unnamed Tributary of Trout Beck 4.6 at three locations; two to the north of Long Marton Road at Powis House and one to the south at Roman Vale.
- At -Powis House Farm, the 250m length of open channel from Long Marton Road to Powis House will remain unchanged.
- The width of open channel to the north-west of the Powis House access track will remain the same.
- A new pipe culvert will replace a 17.5m length of existing open channel adjacent to Powis House with a diameter of 0.45m.
- Downstream of this, the Unnamed Tributary of Trout Beck 4.6 will be realigned, with a new 394m length of open channel watercourse being constructed to the north-west of Powis House Farm.
- The new channel planform will flow in a north westerly direction, compared to the existing western direction.
- A new pipe culvert will be installed along a 17.5m length of the proposed realigned open channel, with a diameter of 0.45m.
- The existing culvert that conveys the Unnamed Tributary of Trout Beck 4.6 from Powis House Farm to the discharge location on Trout Beck will be discontinued.
- The new discharge location of the Unnamed Tributary of Trout Beck 4.6 will be approximately 180m further upstream on the left bank of Trout Beck. The design of the discharge point of Unnamed Tributary of Trout Beck 4.6 into Trout Beck will not involve a culvert or control structure; instead, the discharge location will behave as a confluence between two watercourses.
- This proposal will involve the replacement of 25m of culverted channel with 400m of new open channel. The overall length of the watercourse will remain similar despite the channel realignment.

14.4.4.5 The proposed works in the vicinity of Long Marton and Roman Vale are as follows:

- To the south of Roman Vale, the Unnamed Tributary of Trout Beck 4.6 flows adjacent to the Roman Road in a north westerly direction.
- The Unnamed Tributary of Trout Beck 4.6 is subsequently culverted beneath the Roman Road and remains culverted for approximately 300m beneath Roman Vale Farm and Long Marton Road, before transitioning back to open channel in the vicinity of Watercourse Crossing Point 41, directly north-west of Long Marton Road.
- The proposed existing A66 embankment and road junction will occupy the section of open channel of the Unnamed Tributary of Trout Beck 4.6 to the south-east of Roman Vale. As such, the Unnamed Watercourse will be realigned and culverted.
- The channel will be realigned approximately 20 - 40m further to the north away from the proposed road embankment and junction and will be culverted using a pipe culvert across an approximate 176m length.

The culvert barrel will 0.6m in diameter. The proposed culvert will be joined to the existing culvert to the south of Roman Vale.

14.4.4.6 Overall, at Watercourse Crossing Points 38, 41 and 10 there will be a total reduction in culverted channel length by 30m. The total length of the watercourse will remain approximately the same despite the channel realignment.

Watercourse Crossing Point 42

- To the south-east of Powis Cottages, adjacent to the existing A66, the Unnamed Tributary of Trout Beck 4.2 flows in a north westerly direction for approximately 2km from Crackenthorpe towards Powis Cottages, before the watercourse is culverted beneath the existing A66. Downstream of the culvert, the watercourse name changes to Unnamed Tributary of Trout Beck 4.5.
- The Unnamed Tributary of Trout Beck 4.5 remains culverted for approximately 1km, where it joins the Unnamed Watercourse west of Powis House Farm and subsequently discharges into Trout Beck.
- The proposed works involve the installation of a road junction, connecting the new A66 alignment and embankment with Long Marton Road to the north and the existing A66 to the south. The connecting road will pass beneath the proposed existing A66 embankment.
- The road that connects the new A66 alignment with the existing A66 to the south will cross over the Unnamed Tributary of Trout Beck 4.2.
- As such, a pipe culvert will be installed in the existing open channel across a length of 56.150m, with a diameter of 1.5m.

Watercourse Crossing Point 44

- To the south of Far Broom Lodge, adjacent to the Roman Road embankment, the Unnamed Tributary of Trout Beck 4.3 flows in a northern direction for approximately 1.5km towards Castrigg Lane, before discharging into Trout Beck in the vicinity of Church House.
- The Unnamed Tributary of Trout Beck 4.3 is culverted for approximately the last 3m before discharging into Trout Beck.
- The proposed A66 embankment will pass adjacent to the source of the Unnamed Tributary of Trout Beck 4.3 directly to the south and will not cross the watercourse.
- There are no additional proposed works to be undertaken to the Unnamed Tributary of Trout Beck 4.3.

Baseline hydromorphology desktop study

Survey scope

14.4.4.7 The scheme watercourse crossing points are located within Trout Beck water body catchment (ES Figure 14.3: WFD Surface Water Bodies (Application Document 3.3). The following sections provide a summary of the geomorphological characteristics of this catchment.

Catchment and character

14.4.4.8 Trout Beck rises in the North Pennines AONB, north-east of Murton at an elevation of approximately 469m AOD. Trout Beck waterbody drains an area of 16.50 km^2 and flows in a northerly direction towards Long Marton. At Long Marton, Trout Beck flows east for approximately 3.4km. Trout Beck continues to flow in a north easterly direction for approximately 2.2km towards Kirkby Thore.

14.4.4.9 Trout Beck flows through rural landscapes, where land use is dominated by livestock, arable farmland and isolated areas of woodland. The most notable settlements in the vicinity of Trout Beck include Kirkby Thore, Long Marton and Broom.

14.4.4.10 The bedrock geology of Trout Beck is varied, with a complex system of limestone, mudstone and slate formations occupying the headwaters of Trout Beck at Murton Fell. Downstream of Murton to the confluence with the River Eden, the bedrock geology is dominated by the Penrith Sandstone Formation. In terms of superficial deposits, Trout Beck flows over a mixture of silts, sands and gravels.

Historic trend analysis

14.4.4.11 Historic OS mapping has been used to examine the extent of historic channel change within the water body catchment. The watercourse routes illustrated in the 1888 OS mapping (the earliest OS mapping available online) have been compared to current watercourses to identify areas of channel migration and realignment.

14.4.4.12 At the upstream extent of Trout Beck, the watercourse has remained largely in the same location in the c. 130 years since the earliest mapping available online. A lack of change to the waterbody planform can be attributed to urban management in the village of Long Marton and agricultural management further downstream.

14.4.4.13 There has been significant planform change to Trout Beck to the east of Kirkby Thore and parallel to the existing A66. It is suspected that the meanders have been lost due to anthropogenic modification (i.e. straightening) rather than a natural process of meander cut-through and channel migration. The channel straightening has resulted in channel incision as the increase in in-channel energy, generated by the shortening of the planform and increase in its gradient, has led to the river cutting downwards into its river bed. Historic mapping reveals that channel sinuosity reduced within this period (Area 1 of Plate 8: Assessment of historic planform change on Trout Beck.

14.4.4.14 In Area 2, the channel planform is very straight and lacks natural meander bends or sinuosity (Plate 8: Assessment of historic planform change on Trout Beck). As such, it is probable that the channel planform has been artificially modified and straightened in the past. Historic mapping suggests that the channel was modified between 1897 and 1957.

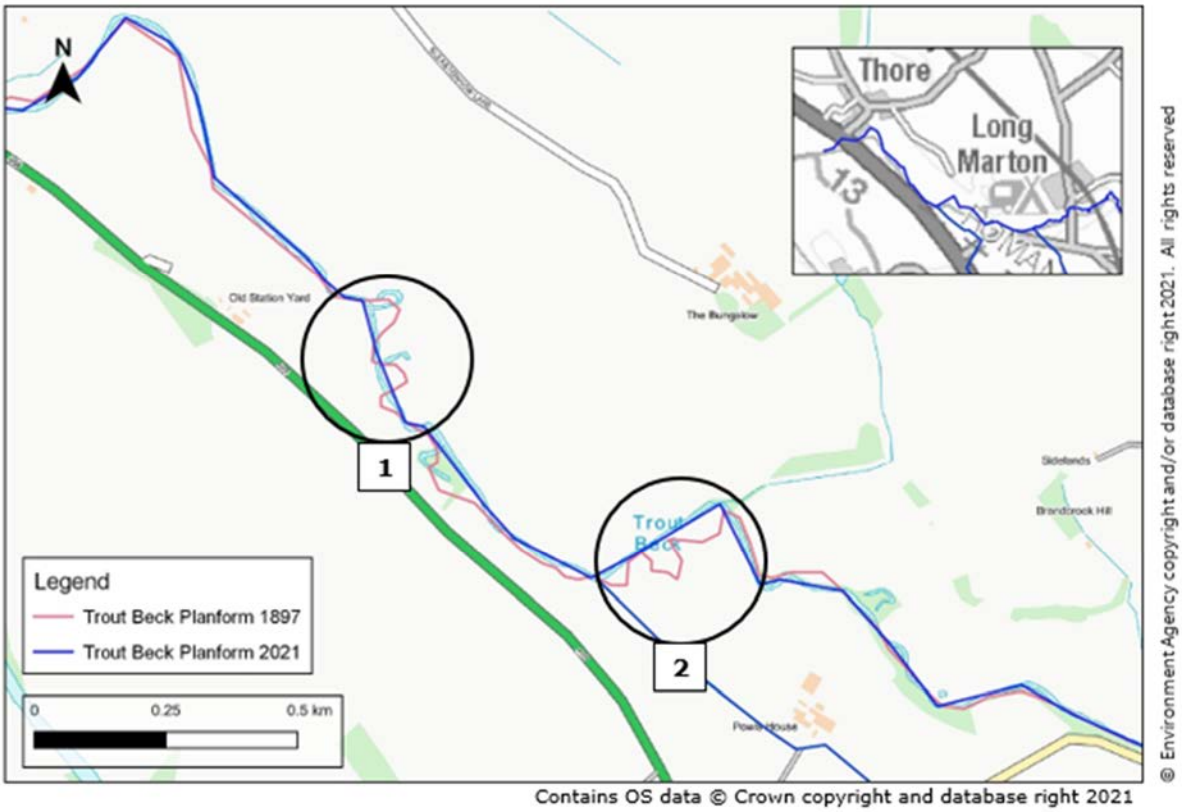

Plate 8: Assessment of historic planform change on Trout Beck

Assessment of LiDAR data

14.4.4.15 There are several palaeo channels identified on the left and right bank floodplain which have become disconnected from Trout Beck. Over time, channel sinuosity has significantly decreased. In the past, channel straightening in Area 1 and Area 2 created a shorter planform and corresponding increase in gradient (Plate 9: Assessment of palaeo channels in the vicinity of Temple Sowerby to Appleby). This led to channel incision as the river used the excess energy generated as a result to cut down into the river bed. The process of incision has left palaeo channels isolated and raised above the existing bed level.

14.4.4.16 The palaeo channels identified in Area 3 are not observed in the 1897 Trout Beck planform, and as such likely pre-date 1897 (Plate 9: Assessment of palaeo channels in the vicinity of Temple Sowerby to Appleby. In Area 3, palaeo channels can be found on the right bank floodplain of Trout Beck. This suggests that Trout Beck previously meandered across the open floodplain. It is likely that the channel has been straightened and moved to the left side of the valley to increase the amount of agricultural land available on the right bank floodplain. Alterations to Trout Beck planform has reduced sinuosity and increased the gradient of the watercourse. This has increased channel energy and encouraged bed incision within the reach. As a result, the palaeo channels in Area 3 have become disconnected from the main channel and sit at a higher level on the floodplain than the existing level of Trout Beck.

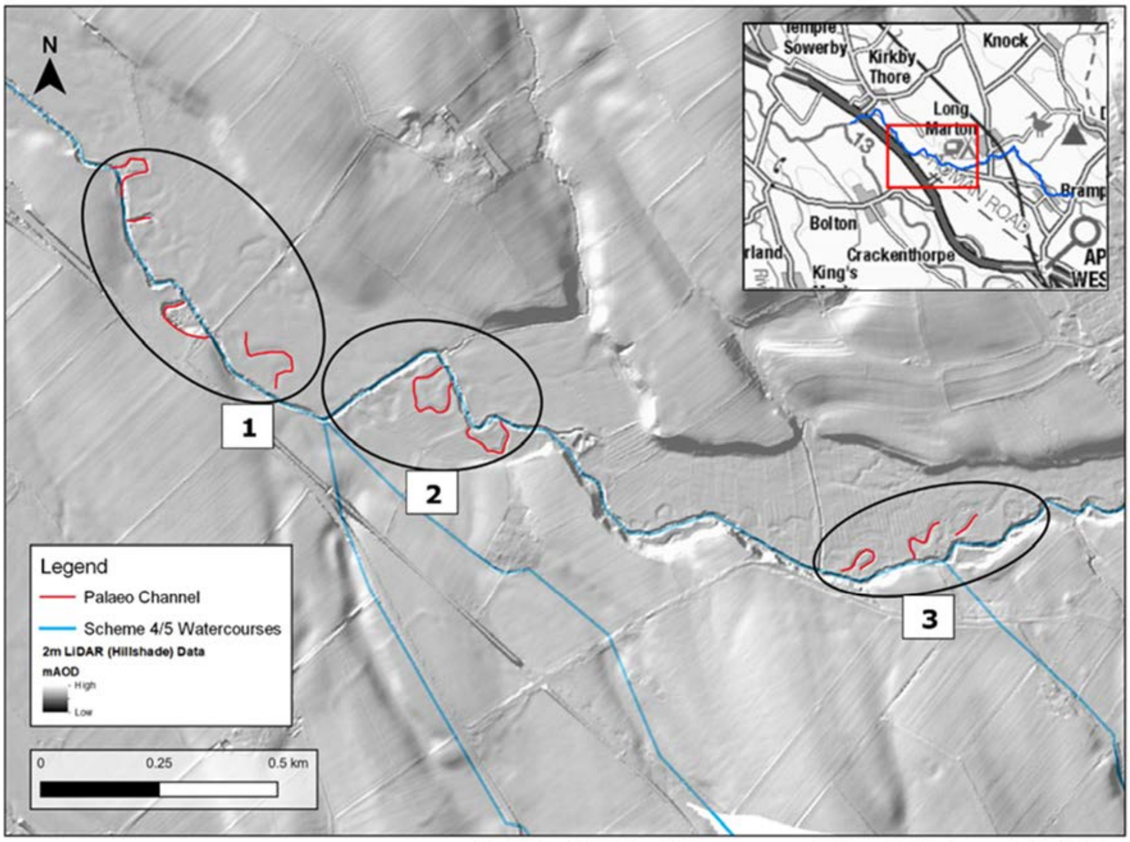

Plate 9: Assessment of palaeo channels in the vicinity of Temple Sowerby to Appleby

Baseline hydromorphology site observations

Table 22: Baseline hydromorphology for each watercourse with a crossing point

Crossing Point/ Watercourse	Site Observations
WCP 38, WCP41, WCP10 Unnamed Tributary of Trout Beck 4.6 at Powis House Farm	**Wider Catchment Characteristics:** The Unnamed Tributary of Trout Beck 4.6 at Powis House Farm rises on the hill situated to the south-east of Powis House Farm and the west of Far Broom Lodge Farm, before flowing in a generally north westerly direction. The Unnamed Tributary of Trout Beck 4.6 discharges into Trout Beck to the north-west of Powis House Farm. The channel is culverted for a considerable distance in the vicinity of Roman Vale Farm, before discharging to the northwest of Long Marton Road. Photographs of the location are shown in Annex A: Site Photograph Locations. **Observed In-Channel Modifications:** • Culvert in the vicinity of Roman Vale and beneath Long Marton Road. • Culvert conveying the flow from the north-west of Powis House Farm to Trout Beck. **Typical Flow Biotopes:**

Crossing Point/ Watercourse	Site Observations
	The Unnamed Tributary of Trout Beck 4.6 in the vicinity of Powis House Farm has a relatively shallow gradient, and as such the flow energy in the channel is low. The bed of the channel is overgrown with grass, which further reduces the flow energy of the watercourse. As such, gliding flows and run biotopes are dominant. The flow energy significantly reduces on the approach to the culvert that conveys the flow to Trout Beck, with movement of water almost imperceptible. This is likely a result of a blockage in the culvert, which impounds the flow upstream. **Typical Bed Substrate:** The bed substrate is primarily fine silty material. The low flow energy of the watercourse leads to fine material suspended in the water column being deposited on the river bed. This is further compounded by additional inputs of fine sediment from livestock poaching of the riverbanks and the conveyance of soil from the surrounding agricultural land into the watercourse during heavy rainfall events. Directly downstream of the culvert beneath Long Marton Road the bed material is slightly coarse, ranging from sands to gravels. The culvert traps fine material upstream and limits the transportation of fine material from upstream reaches to downstream. **Typical Riparian Composition:** Riparian cover across the extent of the Unnamed Tributary of Trout Beck 4.6 is generally poor. In areas of open channel, riparian tree cover is sporadic, and long stretches remain unvegetated. As such, cattle poaching of the riverbanks is widespread, leaving the riverbanks in a degraded condition and providing a supply of fine material to the watercourse. **Typical Floodplain Connectivity:** In areas of open channel, floodplain connectivity to the unnamed drain is moderate. It is likely that during high flow events flood waters from the watercourse are able to spill out onto the floodplain, despite the channel planform being artificially straightened.
WCP42 Unnamed Tributary of Trout Beck 4.5to the south-east of Powis Cottages	**Wider Catchment Characteristics**: The Unnamed Tributary of Trout Beck 4.2 at Powis Cottages rises to the north-east of Crackenthorpe and flows in a north westerly direction towards Powis Cottages. The watercourse name changes to Unnamed Tributary of Trout Beck 4.5 after it is culverted beneath the A66 and continues to flow in a north westerly direction along the western side of the existing A66 past Redlands Bank Farm. Approximately 1km downstream, the Unnamed Tributary of Trout Beck 4.5 is culverted beneath the existing A66, and ultimately discharges into Trout Beck to the north-west of Powis House Farm. Photographs of the location are shown in Annex A: Site Photograph Locations. **Observed In-Channel Modifications:** • Culvert beneath the existing A66 to the south of Powis Cottages.

Crossing Point/ Watercourse	Site Observations
	• Culverted beneath the existing A66 to the north-west of Powis House Farm. **Typical Flow Biotopes:** On the day of the site visit (Table 1: Hydromorphology survey dates) the flow within the Unnamed Tributary of Trout Beck 4.2 was low, despite the recent heavy rainfall. As such the flow velocities within the channel were low, with the dominant flow biotopes ranging from glides to runs. The channel gradient in the vicinity of the existing A66 is shallow, which further contributes to the low flow energy of the Unnamed Tributary of Trout Beck 4.2. The low flow energy characteristics continue downstream of the existing A66 culvert. **Typical Bed Substrate:** The densely vegetated river bed and riverbanks made observations of the river bed substrate difficult; however, in areas where vegetation was light the bed substrate ranged from silts and sands to gravels. The low flow velocities within the channel cause fine material suspended within the water column to deposit on the river bed in this watercourse, resulting in the accumulation of fine material on the bed of the river. This fine material has likely been input into the channel from the surrounding agricultural land during heavy rainfall events. **Typical Riparian Composition:** Both upstream and downstream of crossing point WCP42 the riparian strip is overgrown, and comprised of long grasses and rushes. There is a distinct lack of riparian tree cover on both banks. The surrounding agricultural land is arable farmland. **Typical Floodplain Connectivity:** Floodplain connectivity to the Unnamed Tributary of Trout Beck 4.2 is generally poor in the vicinity of WCP 42. The channel has been artificially straightened and realigned historically to provide improved drainage and space for the arable farming in the adjacent fields. As such, the channel has been designed to retain flow within the channel and prevent water from entering the adjacent floodplain to protect the crops on the surrounding floodplain.
WCP37 Trout Beck	**Wider Catchment Characteristics:** Trout Beck is located in Eden District, Cumbria where it rises at Murton Fell, to the North of the village of Murton. Trout Beck flows in a generally north westerly direction towards Kirkby Thore, where it ultimately discharges into the River Eden. WCP37 is located downstream of the confluence with the Keld Sike, a tributary of Trout Beck. A more detailed assessment of hydromorphological conditions on Trout Beck can be found in Appendix 14.9: Detailed Geomorphological Modelling (Application Document 3.4). Photographs of the location are shown in Annex A: Site Photograph Locations.

Crossing Point/ Watercourse	Site Observations
	Typical Flow Biotopes Alternating riffle, pool and run sequences have developed in Trout Beck upstream of WCP37 (Work no. 0405-1E) and upstream of the Keld Sike confluence. River width varies between 5 and 7 metres approximately. The steep channel gradient of Trout Beck, combined with a highly sinuous channel planform has facilitated the development of this diverse range of flow biotopes. Large woody material is present across Trout Beck generating localised flow diversity. In the immediate vicinity of WCP37 (Work no. 0405-1E) and downstream, the flow diversity decreases as channel planform sinuosity decreases as a result of artificial straightening. Plane bed glide and run biotopes are prevalent in the channel. **Typical Bed Substrate** The typical bed substrate identified in the channel on Trout Beck ranges from sands to gravels and cobbles. Large volumes of coarse material have been deposited in the channel and channel margins in the vicinity of the Keld Sike confluence, leading to the formation of large riffle features, mid channel deposits and marginal deposits of gravels and cobbles. The river bed substrate is clean as fine material, such as silts, is transported to downstream reaches. **Typical Riparian Composition** Upstream of WCP37 and the Keld Sike confluence, the composition of the riparian corridor is good, with a buffer strip of riparian trees on both the left and right bank of the channel. A wet woodland exists on the right bank of the channel. Riparian vegetation on both sides of the bank through this straightened reach of Trout Beck in the vicinity of WCP37 area is mixed, with a thick buffer of tree cover on the left bank, but sporadic tree cover on the right bank. As such, bank stability on the left bank was substantial and the banks exhibited less signs of bank erosion. On the right bank areas of bank erosion, bank toe undercutting, and bank slumping were identified. It is likely that these erosional pressures on the riverbanks were triggered as a consequence of the channel straightening and has been further compounded by the lack of riparian vegetation. **Typical Floodplain Connectivity** Trout Beck in the vicinity of WCP37 has been historically straightened for approximately 300m. Channel straightening has resulted in a reduction in channel length and a corresponding increase in channel gradient. These anthropogenic changes have increased in-channel energy, causing the river to cut down into its bed, resulting in channel incision through this reach. The floodplain is disconnected from the channel, and the tops of the riverbanks sit approximately 2m above the water level. J' shaped trees lining the riverbank of Trout Beck downstream of the farm access bridge

Crossing Point/ Watercourse	Site Observations
	provides further evidence to support conclusions that the watercourse has undergone bed incision.
WCP44 Unnamed Tributary of Trout Beck 4.3 to the South of Castrigg Lane (No Proposed Works)	**Wider Catchment Characteristics:** The Unnamed Tributary of Trout Beck 4.3 to the south of Castrigg Lane rises on the hills to the south of Far Broom Lodge Farm and the East of Powis House Farm and flows in a generally northern direction, before joining Trout Beck to the South of Long Marton Photographs of the location are shown in Annex A: Site Photograph Locations. **Observed In-Channel Modifications:** • Culverted for the entire length of Castrigg Lane from Far Broom Lodge to the fields north of Castrigg Lane, before discharging into Trout Beck **Typical Flow Biotopes:** Upstream of the existing A66, the typical flow biotopes ranged from runs to glides heavily choked with vegetation. the overgrown nature of the channel in most areas significantly slowed down any flow observed and disrupted the natural flow dynamics in the channel. Downstream of the existing A66, the low flow conditions continued and there were no discernible flow biotopes. The overgrown nature of the channel continued to slow down the flow and reduce flow energy significantly. **Typical Bed Substrate:** Upstream of the existing A66, the bed substrate is difficult to discern due to the overgrown nature of the channel. However, in areas where the bed is exposed, the bed substrate is predominantly fine material, ranging from sands to silts. This fine material has likely be input into the channel from the surrounding agricultural land during heavy rainfall events. Downstream of the existing A66, significant poaching of the riverbanks has resulted in a large volume of fine material being conveyed into the channel and depositing on the bed, leaving a homogeneous river bed comprised of fine material. Fine sediment deposition on the river bed is further compounded by the low flow energy in the channel, which results in additional fine material dropping out of the water column and depositing on the river bed. **Typical Riparian Composition:** Upstream of the existing A66, the riparian strip is overgrown, and comprised of long grasses. There is a distinct lack of riparian tree cover on both banks. Downstream of the existing A66, the riparian cover on both banks deteriorates significantly, and as such cattle poaching has occurred unchecked. The result is the degradation of the riverbanks, additional input of fine material into the channel and the development of a trapezoidal channel geometry.

Crossing Point/ Watercourse	Site Observations
	Typical Floodplain Connectivity: Upstream of the existing A66, the connectivity of the floodplain to the channel is moderate. The presence of rushes on the floodplain suggests that the floodplain becomes regularly wetted during heavy rainfall events. Downstream of the existing A66, the connectivity of the floodplain to the channel becomes significantly degraded compared to the upstream reach. The channel has undergone straightening, which has resulted in bed incision and a reduction in channel bed level. This is further compounded by the trapezoidal channel shape, which reduces the ability of water to spill out onto the floodplain.

Stage 1: Hydromorphology screening

14.4.4.17 The screening assessment aims to screen in any works that require WFD assessment and to identify which WFD water bodies are within and near to the proposed works.

14.4.4.18 Drainage channel outfalls have been screened out of the assessment as their design is secured by the Environmental Management Plan (Application Document 2.7), which is a certified document under DCO. Where hard outfalls currently exist, new drainage channel outfalls will be tied into the existing structure. Drainage channels in areas with natural banks will be designed as a natural outfall (i.e. without hard bank protection).

14.4.4.19 Table 23: Screening of each water body indicates which water bodies have been screened in or out of the assessment and the reasons for this decision.

14.4.4.20 The baseline status of the hydromorphology quality elements within the water bodies screened into the assessment are discussed in this section. If there is potential for the proposed works to cause deterioration in the status of a water body or prevent it from achieving its status objectives as defined in the Solway Tweed River Basin Management Plan, the relevant water body and its quality elements have been taken forward and considered further in the scoping assessment at Stage 2.

Table 23: Screening of each water body

Water body/ies	Reason	Screening outcome
Eden - Scandal Beck to Lyvennet	The waterbody is located approximately 2.5 km downstream of the southernmost point of WCP38. As such the waterbody is located far enough downstream from the works to not be impacted.	Screened Out
Trout Beck	The proposed works are located within the waterbody and therefore, direct impact on this waterbody is possible.	Screened In

Baseline status of screened-in water bodies

14.4.4.21 Table 24: Current WFD status of connected water body catchments in Cycle 2 (2019) summarises the water body ID, hydromorphological designation current ecological status / potential and ecological objective for each water body screened into the assessment. This information is provided by the Solway Tweed River Basin Management Plan 2021.

Table 24: Current WFD status of connected water body catchments in Cycle 2 (2019)

Water body ID	Name of water body	Hydromorphological designation	Current Ecological Status/ Potential	Ecological Objective
GB102076070930	Trout Beck	Not designated artificial or heavily modified	Good	Good by 2027

14.4.4.22 The tables below outline the current status of the hydromorphological quality elements and reasons for not achieving good status (RNAGS) for each water body screened into the assessment according to the most recent WFD cycle.

Table 25: Hydromorphological quality element of Trout Beck Cycle 2 (2019)

Hydromorphological Quality Element	Current Status	Objective
Hydrological Regime	High	High by 2015
Morphology	Supports good	Not available

Table 26: RNAGS for Trout Beck Cycle 2 (2019)

SWMI*	Activities	Classification Element
Diffuse Source	Poor nutrient management	Fish

*Significant water management issue

Stage 2: Hydromorphology scoping

14.4.4.23 The scoping assessment identifies whether the water body catchment's quality elements, identified during the screening assessment, are at risk from the proposed works. The proposed development works have been appraised in terms of their impact on WFD status and objectives. If any quality elements are found to be at risk of detrimental impact, further assessment and / or mitigation may be required.

Hydromorphological quality elements of Trout Beck water body

14.4.4.24 The following Watercourse Crossing Points were identified as falling within Trout Beck water body catchment:

- Watercourse Crossing Point 37
- Watercourse Crossing Point 38, 41 and 10
- Watercourse Crossing Point 42
- Watercourse Crossing Point 44.

14.4.4.25 As such, the potential impacts of the proposed works at each identified crossing point will have on Trout Beck water body have been assessed. Where there is the potential for the proposed works to impact the geomorphological condition of watercourses within Trout Beck water body, the requirement for a further assessment within paragraph 14.4.3.38 to 14.4.3.39 has been stipulated.

Watercourse Crossing Point 37

14.4.4.26 The proposed works at this location include the installation of a bridge over Trout Beck, with a span of 400m and a deck width of 28m. Eight piers will be installed on the floodplain (four on each side of the watercourse) to support the weight of the bridge. An embankment will be constructed on the left and right bank of Trout Beck to tie into each end of the bridge.

14.4.4.27 Table 27: Assessment of works at Watercourse Crossing Point 37 on Trout Beck, against the hydromorphological quality elements for Trout Beck WFD water body catchment assesses the potential impacts arising from proposed works at Watercourse Crossing Point 37 on Trout Beck, which is within Trout Beck WFD water body catchment.

Table 27: Assessment of works at Watercourse Crossing Point 37 on Trout Beck, against the hydromorphological quality elements for Trout Beck WFD water body catchment

WFD Quality Element	Current Status	Potential Impact	Further assessment and/or mitigation required?
Hydrology: Quantity and Dynamics of flow	Not Assessed	There are no proposed works to take place in the channel of Trout Beck. As such, there are unlikely to be changes to the existing flow conditions within the channel during flow events confined to the channel. Localised variations in flow dynamics are expected in the immediate vicinity of each of piers, as the placement of the piers on the floodplain will disrupt existing out of bank flow routes. However, the road embankment is out with the 1-in-100 Year + Climate Change flood extent and has no interaction with flow dynamics on the floodplain. This was identified during an assessment of hydraulic modelling results (ES Appendix 14.2: Flood Risk Assessment and Outline Drainage Strategy (Application Document 3.2) and ES Appendix 14.9: Detailed Geomorphological Modelling (Application Document 3.4)). Overall, variations in flow dynamics are expected to be negligible. Therefore, this quality element will not be considered as part of the impact assessment for Trout Beck water body.	No

WFD Quality Element	Current Status	Potential Impact	Further assessment and/or mitigation required?
Hydrology: Connection to ground water bodies	Not Assessed	The proposed works do not include alteration of the river bed of Trout Beck. The proposed works do include installation of impermeable surfaces on the floodplain in the form of the bridge piers and road embankment however the footprint of the piers these structures is minimal, and the road embankment is out with the 1-in-100 Year + Climate Change flood extent. As such, there will not be a significant change to the existing connectivity between surface and fluvial flow paths with ground water bodies. Therefore, this quality element will not be considered as part of the impact assessment for Trout Beck water body.	No
River Continuity	Not Assessed	There are no proposed works to take place in the channel of Trout Beck. As such, there are unlikely to be changes to the existing continuity of the watercourse during flow events confined to the channel. Localised variations in continuity are expected in the immediate vicinity of each of piers, as the placement of the piers on the floodplain will disrupt existing out of bank flow routes. The road embankment is out with the 1-in-100 Year + Climate Change flood extent and has no interaction with overland flow routes on the floodplain. This was identified during an assessment of hydraulic modelling results (ES Appendix 14.2: Flood Risk Assessment and Outline Drainage Strategy (Application Document 3.2) and ES Appendix 14.9: Detailed Geomorphological Modelling (Application Document 3.4)). Overall, variations in the flow and sediment continuity of overland flow routes are expected to be negligible. The proposed works are therefore unlikely to influence the existing conveyance of flow and sediment in Trout Beck, and consequently there will be no change to the existing river continuity of the watercourse. Therefore, this quality element will not be considered as part of the impact assessment for Trout Beck water body.	No

WFD Quality Element	Current Status	Potential Impact	Further assessment and/or mitigation required?
Morphology: River width and depth	Not Assessed	There are no proposed works to take place in the channel of Trout Beck. An assessment of hydraulic modelling results has shown that installation of bridge piers within the floodplain is unlikely to cause significant changes to hydraulic conditions in channel or on the floodplain (ES Appendix 14.2: Flood Risk Assessment and Outline Drainage Strategy (Application Document Number 3.2) and Appendix 14.9: Detailed Geomorphological Modelling (Application Document 3.4)). Consequently, the risk of channel change in response to the proposed works, including changes in river width and depth, is low. Therefore, this quality element will not be considered as part of the impact assessment for Trout Beck water body.	No
Morphology: Structure and substrate of the river bed	Not Assessed	There are no proposed works to take place in the channel of Trout Beck. An assessment of hydraulic modelling results (ES Appendix 14.2: Flood Risk Assessment and Outline Drainage Strategy (Application Document 3.2) and ES Appendix 14.9: Detailed Geomorphological Modelling (Application Document 3.4)) has shown that installation of bridge piers within the floodplain is unlikely to cause significant changes to hydraulic conditions in channel or on the floodplain. Hydraulic modelling identified small variations in sediment transport dynamics in the channel of Trout Beck in the vicinity of the proposed works, with the maximum size of material that can be entrained at one cross section increasing from coarse gravels to very coarse gravels. Despite this, it is unlikely to result in significant changes to the river bed composition in Trout Beck, given the existing river bed substrate is comprised of gravels and cobbles. As such, there is minimal risk of change to the existing structure and composition of the river bed. Therefore, this quality element will not be considered as part of the impact assessment for Trout Beck water body.	No

WFD Quality Element	Current Status	Potential Impact	Further assessment and/or mitigation required?
Morphology: Structure of the riparian zone	Not Assessed	The proposed embankments as part of the proposed works are positioned far back from the riparian zone of Trout Beck and are unlikely to influence the existing condition of the riparian zone. Therefore, this quality element will not be considered as part of the impact assessment for Trout Beck water body.	No

Watercourse Crossing Point 38, 41 and 10

14.4.4.28 The proposed works at this location include the installation of the existing A66 embankment from Trout Beck to Far Brook Lodge, which crosses the Unnamed Watercourse of Trout Beck 4.6 at three locations. The Unnamed Tributary of Trout Beck 4.6 between Powis House farm and Trout Beck will be realigned and will be open channel for 394m. The existing culvert will be discontinued. The realigned channel will discharge into Trout Beck further upstream on the left bank. Along this realigned watercourse two piped culverts will be installed. To the east of Roman Vale, the Unnamed Tributary of Trout Beck 4.6 will be realigned 20-40m to the north and will be culverted for 176m. The proposed realigned channel and culvert here will subsequently join the existing culvert beneath Roman Vale.

14.4.4.29 Table 28: Assessment of works at Watercourse Crossing Points 38, 41 and 10 on the Unnamed Tributary of Trout Beck 4.6 in the vicinity of Powis House Farm, against the hydromorphological quality elements for Trout Beck WFD water body catchment presents an assessment of the proposed works against the hydromorphological quality elements of Trout Beck water body catchment, within which the Watercourse Crossing Points 38, 41 and 10 is located as part of the Temple Sowerby to Appleby Scheme.

Table 28: Assessment of works at Watercourse Crossing Points 38, 41 and 10 on the Unnamed Tributary of Trout Beck 4.6 in the vicinity of Powis House Farm, against the hydromorphological quality elements for Trout Beck WFD water body catchment

WFD Quality Element	Current Status	Potential Impact/ Mitigation Measures	Further assessment and/or mitigation required?
Hydrology: Quantity and Dynamics of flow	Not Assessed	The realignment of the channel at Powis House Farm and replacement of a culvert with open channel will benefit the existing flow dynamics of the watercourse; the flow dynamics of an open channel are more diverse compared to those within a culvert barrel. However, the replacement of a section of open channel with a new culvert to the east of Roman Vale will significantly offset any immediate benefits observed as a result of the channel	Yes

WFD Quality Element	Current Status	Potential Impact/ Mitigation Measures	Further assessment and/or mitigation required?
		realignment at Powis House Farm. Taking into account the total culverted length on the Unnamed Tributary of Trout Beck 46 at present compared to the proposed total length of culverts, there will be an approximate 16m reduction in culvert length. Therefore, the proposed works will provide an opportunity for a small improvement to the flow dynamics on the Unnamed Tributary of Trout Beck 4.6. When considering the impact on flow dynamics at the confluence with Trout Beck, the proposal is likely to have an impact. The proposed works involve the reinstatement of a more natural discharge point between the Unnamed Tributary of Trout Beck 4.6 and Trout Beck, resulting in a more natural tributary connection. However, the current direction of discharge from the Unnamed Tributary of Trout Beck 4.6 is upstream on Trout Beck, and into the oncoming flow. This is an unnatural interaction between converging flow from two watercourses and may result in scour of the riverbanks on Trout Beck and the Unnamed Tributary of Trout Beck 4.6. However, this is unlikely to have an impact on Trout Beck at the water body scale, as the proposed works account for 0.64% of the entire water body length will be impacted. Despite the reduction in culverted length on the Unnamed Tributary of Trout Beck 4.6 and the inherent benefits regarding flow dynamics which accompany this, there is still the potential for the flow dynamics within the channel to be negatively impacted by changes in channel length, and therefore gradient, associated with the channel realignment. Mitigation measures will need to be considered to offset potential impacts associated with this. Therefore, this quality element will be considered as part of the impact assessment for Trout Beck water body.	

WFD Quality Element	Current Status	Potential Impact/ Mitigation Measures	Further assessment and/or mitigation required?
Hydrology: Connection to ground water bodies	Not assessed	The realignment of the channel at Powis House Farm and replacement of a culvert with open channel will reduce the length of impermeable surfaces between fluvial and ground water sources. However, the replacement of a section of open channel with a new culvert to the east of Roman Vale will significantly offset any immediate benefits observed as a result of the channel realignment and day lighting at Powis House Farm. Taking into account the total culverted length on the Unnamed Watercourse at present compared to the proposed total length of culverts, there will be an approximate 16m reduction in culvert length. Therefore, the proposed works will provide at minimum no change to the connectivity between fluvial and ground water bodies. As such, there will be negligible impact to Trout Beck water body and this quality element. Therefore, this quality element will not be considered as part of the impact assessment for Trout Beck water body.	No
River Continuity	Not assessed	There is unlikely to be an impact on the continuity of the Unnamed Tributary of Trout Beck 4.6 as a result of the works. Despite a total reduction in culverted length of watercourse by 16m, the culvert beneath Long Marton Road will still remain in place following the completion of the works. This culvert will still act as a barrier to sediment transport from upstream to downstream reaches, maintaining the existing degraded condition of river continuity. As such, the proposed works will have no detrimental impact on the existing condition of the river continuity. Therefore, this quality element will not be considered as part of the impact assessment for Trout Beck water body.	No
Morphology: River width and depth	Not assessed	The existing morphological condition of the Unnamed Tributary of Trout Beck 4.6 in terms of river width and depth is poor, with 562m of existing culvert severely restricting the river's geometry. Taking into account the total culverted length on the Unnamed Tributary of Trout Beck 4.6	No

WFD Quality Element	Current Status	Potential Impact/ Mitigation Measures	Further assessment and/or mitigation required?
		at present compared to the proposed total length of culverts, there will be an approximate 16m reduction in culvert length. Whilst this reduction is minimal, it will ensure that the proposed works will not negatively impact the existing river width and depth of the Unnamed Tributary of Trout Beck 4.6, and Trout Beck. Therefore, this quality element will not be considered as part of the impact assessment for Trout Beck water body.	
Morphology: Structure and substrate of the river bed	Not assessed	There is the potential for impacts on the structure and substrate of the river bed in the Unnamed Tributary of Trout Beck 4.6. The existing condition of the river bed substrate was largely degraded; fine sediment choked the river bed, bedform diversity was very limited and homogeneous sediment sizes were observed. The replacement of open channel sections of the Unnamed Tributary of Trout Beck 4.6 to the east of Roman Vale will be offset by the introduction of open channel reaches of the watercourse to the west of Powis House. Therefore, there will be no overall loss in total open channel and river bed substrate; the total length of culverted reaches will be reduced by approximately 16m following the completion of the works. Despite this, the channel realignment works have the potential to increase river bed scour or fine material deposition and ultimately alter the structure of the river bed substrate. Variations in the channel gradient of the realigned channel, associated with variations in channel length and bed levels, have the potential to increase river bed scour processes or fine sediment deposition processes on the river bed. As such, the proposed works have the potential to lead to further degradation of the existing condition of the river bed substrate of the Unnamed Tributary of Trout Beck 4.6. Therefore, this quality element will be considered as part of the impact assessment for Trout Beck water body.	Yes

WFD Quality Element	Current Status	Potential Impact/ Mitigation Measures	Further assessment and/or mitigation required?
Morphology: Structure of the riparian zone	Not Assessed	The loss of open channel on the Unnamed Tributary of Trout Beck 4.6 to the east of Roman Vale will largely be offset by the re-introduction of open sections of channel to the west of Powis House Farm. In total, there will be a reduction in total length of culverts by 16m following the completion of the works, which represents an improvement to the structure of the riparian zone. Riparian buffer corridor must be established along both banks of the de-culverted channel, and riparian tree cover must be planted to improve the quality of the riparian zone following the completion of the proposed works. Therefore, this quality element will not be considered as part of the impact assessment for Trout Beck water body.	No

Watercourse Crossing Point 42

14.4.4.30 The proposed works at this location include the installation of a road junction, connecting the new A66 alignment and embankment with Long Marton Road to the north and the existing A66 to the south. The road that connects the new A66 alignment with the existing A66 to the south will cross over the Unnamed Tributary of Trout Beck 4.2. A pipe culvert will be installed in the existing open channel across a length of 56.15m, with a diameter of 1.5m.

14.4.4.31 Table 29: Assessment of works at Watercourse Crossing Point 42 on the Unnamed Tributary of Trout Beck 4.2 in the vicinity of Powis Cottages, against the hydromorphological quality elements for Trout Beck WFD water body catchment assesses the potential impacts arising from proposed works at Watercourse Crossing Point 42 on the Unnamed Tributary of Trout Beck 45 in the vicinity of Powis Cottages, which is within Trout Beck WFD water body catchment.

Table 29: Assessment of works at Watercourse Crossing Point 42 on the Unnamed Tributary of Trout Beck 4.2 in the vicinity of Powis Cottages, against the hydromorphological quality elements for Trout Beck WFD water body catchment

WFD Quality Element	Current Status	Potential Impact	Further assessment and/or mitigation required?
Hydrology: Quantity and Dynamics of flow	Not Assessed	The proposed new pipe culvert is unlikely to alter the existing dynamics or quantity of flow on the Unnamed Tributary of Trout Beck 4.2. The watercourse is already culverted for approximately 1km downstream of the existing A66 to the confluence with Trout Beck. This represents approximately 33% of	No

WFD Quality Element	Current Status	Potential Impact	Further assessment and/or mitigation required?
		the total length of the Unnamed Watercourse. An additional 56.15m of culvert will not lead to a significant degradation of the flow dynamics. Moreover, the diameter of the pipe culvert is large (1.5m), which will ensure that restrictions on flow and sediment conveyance through the new structure are relatively small. As such, there is unlikely to be an impact on the existing quantity and dynamics of flow of the Unnamed Watercourse or on Trout Beck Water body. Therefore, this quality element will not be considered as part of the impact assessment for Trout Beck water body.	
Hydrology: Connection to ground water bodies	Not Assessed	The proposed new pipe culvert, with a length of 56.15m, does not represent a significant increase in the total amount of impermeable surfaces limiting connectivity between fluvial and ground water systems. As such, there is unlikely to be a significant impact on the connectivity to ground water bodies of the Unnamed Tributary of Trout Beck 4.2 or Trout Beck Water Body at the water body scale. Therefore, this quality element will not be considered as part of the impact assessment for Trout Beck water body.	No
River Continuity	Not Assessed	The proposed new pipe culvert will be installed in a section of the watercourse that is currently open channel. This is unlikely to impact the existing continuity of the Unnamed Tributary of Trout Beck 4.2. The watercourse is already culverted for approximately 1km downstream of the existing A66 to the confluence with Trout Beck. This represents approximately 33% of the total length of the Unnamed Tributary of Trout Beck 4.2. This already represents a barrier to sediment and flow transfer across the watercourse. The addition of another 56.15m of culvert will not lead to a significant degradation of the existing continuity of the Unnamed Tributary of Trout Beck 4.2, or Trout Beck Water Body at the water body scale. Therefore, this quality element will not be considered as part of the impact assessment for Trout Beck water body.	No

WFD Quality Element	Current Status	Potential Impact	Further assessment and/or mitigation required?
Morphology: River width and depth	Not Assessed	The proposed new pipe culvert will be installed in a section of the watercourse that is currently open channel. The watercourse is already culverted for approximately 1km downstream of the existing A66 to the confluence with Trout Beck. This represents approximately 33% of the total length of the Unnamed Tributary of Trout Beck 4.2 and is a severe control on the width and depth of the watercourse. An additional 56.15m of culvert will not lead to a significant degradation in the river width and depth compared to the already degraded nature of the watercourse. Consequently, there will be no significant impact to the condition of the river width and depth on the Unnamed Tributary of Trout Beck 4.2 or Trout Beck Water Body at the water body scale as a result of the proposed works. Therefore, this quality element will not be considered as part of the impact assessment for Trout Beck water body.	No
Morphology: Structure and substrate of the river bed	Not Assessed	The proposed new pipe culvert will be installed in a section of the watercourse that is currently open channel. The watercourse is already culverted for approximately 1km downstream of the existing A66 to the confluence with Trout Beck. This represents approximately 33% of the total length of the Unnamed Tributary of Trout Beck 4.2 and is the primary reason why the existing condition of the river bed structure and substrate is degraded. The addition of 56.15m of new culvert will not lead to a significant degradation to the existing poor condition of the river bed substrate. Consequently, there will be no detrimental impact on the existing condition and structure of the river bed substrate on the Unnamed Tributary of Trout Beck 4.2, or on Trout Beck Water Body at the water body scale. Therefore, this quality element will not be considered as part of the impact assessment for Trout Beck water body.	No
Morphology: Structure of the riparian zone	Not Assessed	The proposed new pipe culvert will be installed in a section of the watercourse that is currently open channel. The watercourse is already culverted for approximately 1km	No

WFD Quality Element	Current Status	Potential Impact	Further assessment and/or mitigation required?
		downstream of the existing A66 to the confluence with Trout Beck. This represents approximately 33% of the total length of the Unnamed Tributary of Trout Beck 4.2. This is a fundamental reason why the existing condition of the riparian zone is poor, combined with the arable land use up to the riverbank. Therefore, the addition of 56.15m of new culvert will not have a significant impact on the condition of the overall riparian zone. Moreover, land use in the location of the proposed culvert is arable farmland, meaning the riparian zone is already poor. Consequently, the proposed works are unlikely to have an impact on the structure of the riparian zone on the Unnamed Tributary of Trout Beck 4.2 and on Trout Beck Water Body at the water body scale. Therefore, this quality element will not be considered as part of the impact assessment for Trout Beck water body.	

Watercourse Crossing Point 44 (No Works)

14.4.4.32 The proposed works in the vicinity of Watercourse Crossing Point 44 are set back from the fluvial environment, and there is no proposed crossing over the Unnamed Tributary of Trout Beck 4.3. As such, there are no proposed works at Watercourse Crossing Point 44 and it will not be assessed at the hydromorphology scoping stage (stage 2).

Impact assessment

14.4.4.33 The impact assessment needs to consider if there is a pathway linking the pressure to the quality element. If there is no pathway there can be no impact on the quality element and there is no need for any further assessment of that quality element to be carried out. If there is a potential pathway the assessment must consider if the activity, and the pressure it creates, may cause deterioration of the quality element.

14.4.4.34 In order to effectively assess the potential impacts of the proposed works and decide upon suitable mitigation measures, a good understanding of the proposed scheme and design is required. Should any revisions be made to the proposed works that could impact any of the WFD quality elements, this section must be revised.

14.4.4.35 The mitigation measures stipulated within the impact assessment are secured by the Project Design Principles (Application Document 5.11) and the Environmental Management Plan (Application Document 2.7), which are certified documents under DCO.

14.4.4.36 Provided the mitigation measures stipulated within the impact assessment and in section 14.4.9 are implemented at the detailed design stage, cumulative impacts from all the proposed works to the hydromorphology quality elements of the Trout Beck water body will be mitigated sufficiently.

Impact assessment of Trout Beck water body

14.4.4.37 Table 30: Impacts and mitigation measures of Watercourse Crossing Points 38, 41 and 10 discusses each of the quality elements identified as being potentially at risk in the scoping assessment each structure assessed in Trout Beck WFD water body. Mitigation measures are required to mitigate the effects of the proposed works. It should be noted that these mitigation measures differ to the Mitigation Measures identified for any Heavily Modified water body.

Watercourse Crossing Points 38, 41 and 10

14.4.4.38 Table 30: Impacts and mitigation measures of Watercourse Crossing Points 38, 41 and 10 explores the mitigation measures required to offset the impacts arising from the proposed works at Watercourse Crossing Points 38, 41 and 10. A full description of the works is available in paragraph 14.4.4.2.

Table 30: Impacts and mitigation measures of Watercourse Crossing Points 38, 41 and 10

WFD Quality Element	Pathway (direct / indirect/ none)	Potential Impact/ Mitigation measures
Hydrology: Quantity and Dynamics of flow	Direct	**Permanent Impact:** The proposed works involve the reinstatement of a more natural discharge point between the Unnamed Tributary of Trout Beck 4.6 and Trout Beck, resulting in a more natural tributary connection. However, the current direction of discharge from the Unnamed Tributary of Trout Beck 4.6 is upstream on Trout Beck, and into the oncoming flow. This is an unnatural interaction between converging flow from two watercourses and has the potential to result in scour of the riverbanks of Trout Beck and the Unnamed Tributary of Trout Beck 4.6. In addition, there is still the potential for the flow dynamics within the channel being negatively impacted by the proposed works. The channel gradient is likely to change following variations in channel length and bed levels associated with the realignment and de-culverting. This has the potential to impact upon flow velocities and shear stresses within the channel, which can lead to changes in sediment processes such as erosion and / or deposition. **Mitigation:** It is recognised that the reinstatement of a more natural discharge point between the Unnamed Tributary of Trout Beck 4.6 and Trout Beck represents an improvement in

WFD Quality Element	Pathway (direct / indirect/ none)	Potential Impact/ Mitigation measures
		geomorphological character. However, a new alignment for the diverted watercourse using the palaeo channels on the left bank floodplain will need to be confirmed during detailed design to ensure that the outfall of the Unnamed Tributary of Trout Beck 4.6 discharges into Trout Beck at a more appropriate angle and direction. . Selection of a more appropriate discharge location and angle will reduce the detrimental impact that the proposed works will have on the quantity and dynamics of flow of the Unnamed Tributary of Trout Beck 4.6 and Trout Beck water body. To understand the impact on the quantity and dynamics of flow, additional hydraulic modelling analysis using both low flows and flood flows will be needed. Using shear stress, velocity and water level analysis, the implications of de-culverting and realigning the Unnamed Tributary of Trout Beck 4.6 can be fully understood. Modifications to the realigned channel geometry, including the width and depth of the channel, and channel gradient can then be designed appropriately during the detailed design phase to encourage natural geomorphological processes to be maintained and improved.
Morphology: Structure and substrate of the river bed	Direct	**Permanent Impact:** There is the risk that the condition of the bed substrate within the realigned and de-culverted channel may be degraded as part of these works. Appropriate river bed substrate will need to be placed on the river bed to ensure that the existing structure and substrate of the river bed is maintained or improved as part of the works, and that the risk of bed scour or fine sediment deposition is not exacerbated. **Mitigation:** Comparisons of existing and post-development shear stresses and flow velocities within the realigned and de-culverted channel through a range of flows from low flows to flood flows will be necessary during detailed design to identify a suitable D50 size of bed material. This will facilitate and encourage natural geomorphological processes to be maintained and improved within the channel.

Water body mitigation measures

14.4.4.39 Trout Beck water body is not designated as heavily modified or artificial. Therefore, there are no hydromorphology mitigation measures assigned to the water body identified in the Solway Tweed River Basin Management Plan 2021.

WFD hydromorphology assessment objectives

Table 31: Hydromorphology assessment of proposed works against WFD objectives for the Solway Tweed River Basin Management Plan 2021

WFD Hydromorphology Assessment Objectives	Assessment of works
Objective 1: The proposed works do not cause deterioration in the Status of the Hydromorphology Elements of the water body	Provided the required mitigation measures detailed in Table 30: Impacts and mitigation measures of Watercourse Crossing Points 38, 41 and 10 and Section 14.4.9are adhered to, the proposed works will not cause a deterioration in the status of the hydromorphology quality elements of Trout Beck water body.
Objective 2: The proposed works do not compromise the ability of the water body to achieve its WFD status objectives	The proposed works do not compromise the ability of Trout Beck water body to achieve Good hydromorphological status, provided the mitigation measures detailed in Table 30: Impacts and mitigation measures of Watercourse Crossing Points 38, 41 and 10 and Section 14.4.9 are adhered to.
Objective 3: The proposed works do not cause a permanent exclusion or compromised achievement of the WFD objectives in other bodies of water within the same RBD	Impacts arising from the proposals at the scheme will be direct and local to the fluvial environment on site. The impacts arising from the proposed works will not impact on areas elsewhere in the catchment and will not impact other WFD waterbodies within the RBMP.
Objective 4: The proposed works contribute to the delivery of the WFD objectives	The proposed works will contribute to the delivery of the WFD objectives by ensuring no detrimental impact to the water body at the water body scale, and by providing localised hydromorphological enhancements, provided the mitigation measures detailed in Table 30 and Section 14.4.9 are adhered to.

Temple Sowerby to Appleby key considerations

14.4.4.40 The impact assessment determines whether the proposed works have the potential to significantly impact any of the hydromorphology quality elements screened into the assessment. Specific mitigation measures required to prevent the deterioration of specific quality elements are considered in Table 30: Impacts and mitigation measures of Watercourse Crossing Points 38, 41 and 10. Additional mitigation measures that must be considered at each of the proposed structures screened into the assessment are listed in section 14.4.9.

14.4.4.41 The mitigation measures stipulated within the impact assessment are secured by the Project Design Principles (Application Document 5.11) and the Environmental Management Plan (Application Document 2.7), which are certified documents under DCO.

14.4.4.42 Provided the mitigation measures stipulated within the impact assessment and in section 14.4.9 are implemented at the detailed design stage, cumulative impacts from all the proposed works to the hydromorphology quality elements of the Trout Beck water body will be mitigated sufficiently.

14.4.4.43 As part of National Highway's maintenance, inspections of potential scour on the Trout Beck Viaduct crossing piers will be conducted. Should any adverse changes be reported, appropriate mitigation plans to address this will be developed and implemented by National Highways, the Enviornment Agency and Natural England will be consulted on impacts to geomorphology.

Summary

14.4.4.44 The WFD scoping (Stage 2) stage identified that the proposed works at the following watercourse crossing points will have a detrimental impact to the Trout Beck WFD water bodies without appropriate **mitigation:**

- WCP 38, 41, 10

14.4.4.45 The works proposed at Temple Sowerby to Appleby are likely to directly impact the following hydromorphology quality elements for the Trout Beck water bodies without appropriate **mitigation:**

- Hydrology: Quantity and Dynamics of flow
- Morphology: Structure and substrate of the river bed.

14.4.4.46 The mitigation and compensation measures required to achieve the WFD objectives include:

- Hydraulic modelling to understand the impact on quantity and dynamics of flow and structure and substrate of the river bed
- Channel realignment
- Continued monitoring of the Trout Beck crossing to assess the rate of bank erosion, retreat and channel planform migration. At detailed design, further modelling of the proposed bridge crossing piers and refinement of design will be required to ensure no change in potential effect on geomorphology.

14.4.4.47 The assessment reported in this assessment is based on a precautionary worst case scenario. As such, the mitigation identified in this assessment as being required to mitigate the likely significant effects reported are based on this worst case scenario. It may be the case that as detailed design of the Project evolves, it becomes apparent that a lesser form of mitigation is required to achieve the same outcome. As such, the EMP secures the ‘maximum’ extent of mitigation required (as identified in this assessment) but also, where appropriate, includes mechanisms (e.g. by way of further surveys or modelling) to establish, pre-construction and during detailed design, whether the identified mitigation can be refined such that a lesser extent is required to achieve the outcome reported in this assessment. The fundamental point is that the mitigation identified in this assessment is secured by the EMP, where required to achieve the outcome reported in this assessment.

14.4.5 Appleby to Brough

Scheme overview and proposed works

Scheme location

14.4.5.1 The scheme location for Appleby to Brough, and the proposed watercourse crossing points, are shown in Plate 10: Scheme location for Appleby to Brough and the proposed watercourse crossing points.

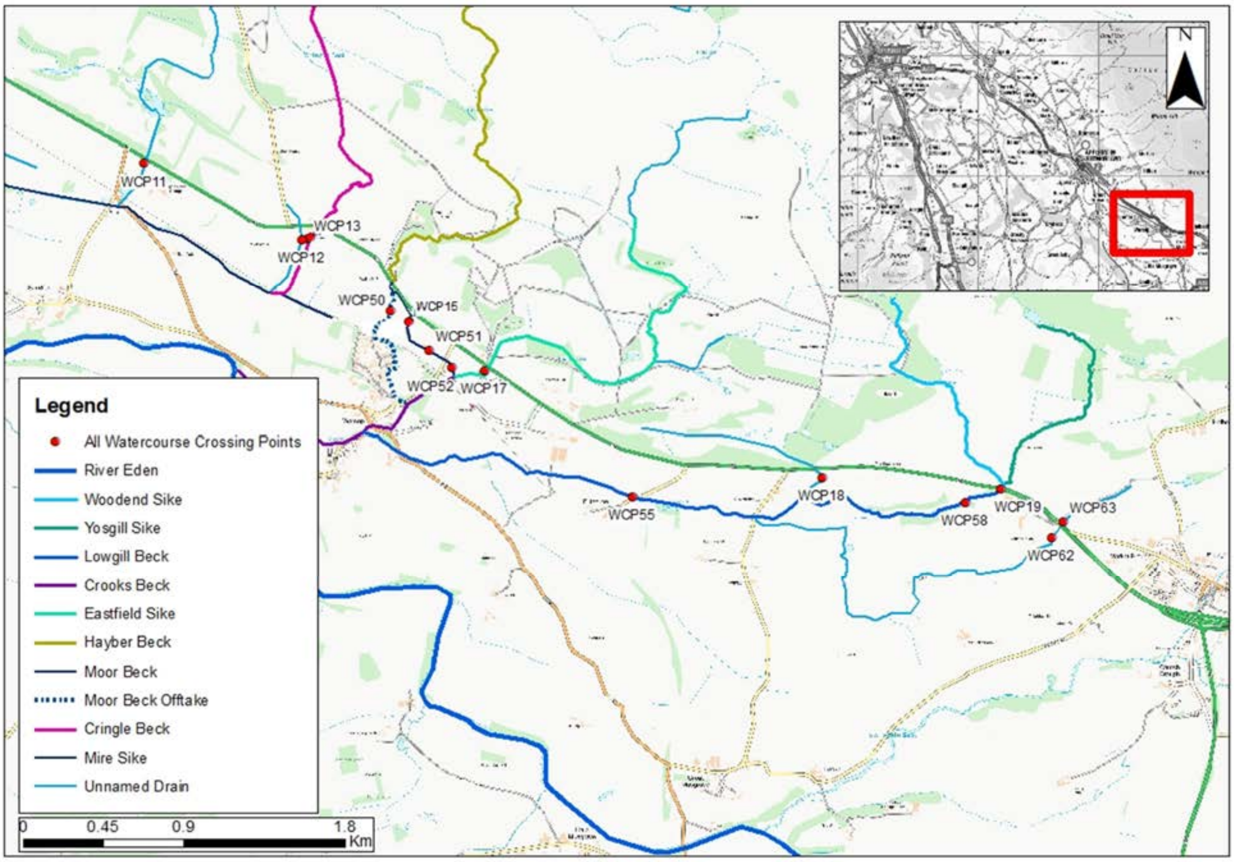

Plate 10: Scheme location for Appleby to Brough and the proposed watercourse crossing points

Proposed works

14.4.5.2 The proposed works at each identified Watercourse Crossing Point in Plate 10: Scheme location for Appleby to Brough and the proposed watercourse crossing points are summarised below. Design drawings and specifications have been referenced if additional detail is required.

Watercourse Crossing Point 11 (Dike Culvert)

- The existing box culvert on the Unnamed Tributary of the Mire Sike 6.12 has a total length of 19.1m, and the culvert barrel has a width of 1.83m and height of 1.9m.
- The proposed culvert extension involves an 8m extension upstream of existing culvert (north) and 32m extension downstream (south).
- The extensions are to involve a precast concrete box culvert of 0.2m thickness. Precast concrete headwalls are to be installed at the inlet

and outlet of the culvert extension, with erosion protection measures considered.
- The culvert barrel dimensions of the proposed culvert extension are to be the same as the existing culvert.
- The Unnamed Tributary of the Mire Sike 6.12 downstream of the proposed culvert outfall is to be realigned to accommodate the culvert extension.
- At the culvert outfall, the watercourse is set to bend to the east to re-join the existing channel planform.

Watercourse Crossing Points 12 and 13 (Cringle Beck River Crossing)

- There are currently no structures present on the reaches of the Unnamed Tributary of the Cringle Beck 6.1 and the Cringle Beck in the vicinity of Watercourse Crossing Points 12 and 13, respectively.
- The proposal involves installing a bridge structure spanning 108m across both the watercourses.
- A total of 5 bridge piers will be installed on the floodplain to support the bridge; one pier between the two watercourses, one on the right bank of the Unnamed Tributary of the Cringle Beck 6.1, one on the left bank of the Cringle Beck and one each to support the concrete parapet on the eastern and western extents of the bridge as it ties into the proposed road embankment.
- An opening width of 31m and height of 13.46m will be available in the bridge openings over the Unnamed Tributary of the Cringle Beck 6.1 and the Cringle Beck.
- The bridge deck width will be 43.3m.

Watercourse Crossing Points 50 and 15 (Moor Beck Viaduct)

- There is an existing box culvert of 3.77m width and 1.45m height which conveys the Hayber Beck (before the watercourse splits into the Moor Beck and Moor Beck (Offtake)) beneath the existing A66.
- The proposed structures involve the installation of a viaduct structure spanning 259.75m across the Moor Beck and the Moor Beck (Offtake), approximately 100m downstream of the existing box culvert on the existing A66.
- Six pier locations exist across the span of the viaduct, with five bridge openings between each of the pier locations. From east to west, an opening width of 63m will be available over the Moor Beck; an opening of 49m occupying the floodplain between the Moor Beck and Moor Beck (Offtake); and an opening of 49.25m will be available over the Moor Beck (Offtake); and two openings of 49.25m will be available on the right bank floodplain of the Moor Beck (Offtake).
- At each pier location, five plinths will be installed across the width of the bridge deck to support the viaduct. These will be spaced at 32.5m intervals across the bridge soffit.
- Viaduct deck width will be 32.69m.

Watercourse Crossing Point 51 (Warcop Junction West)

- There is an existing road bridge which crosses the Moor Beck approximately 100m downstream of Watercourse Crossing Point 51. This structure will remain in situ following the completion of the works in the vicinity of Warcop.
- The proposed structure involves the installation of an underbridge structure spanning 25m across the width of the Moor Beck for a total length of 25m, to convey the A66 junction carriageway across the Moor Beck.
- Road embankments occupying the left and right bank of the Moor Beck will tie into the left and right extent of the underbridge structure. Reinforced earth granular backfill will be used to fill the space between the end of the road embankment and the underbridge structure. This will leave a 25m wide combined area of channel and floodplain for the Moor Beck to utilise.
- A flood compensation structure will be added on the floodplain area between the left bank of the Moor Beck and the right bank of the Moor Beck offtake, and on the left bank floodplain of the Moor Beck. Water will be captured and stored within this structure across a range of flood events, reducing the conveyance of flood water across the floodplain on the left bank of the Moor Beck on the approach to the embankments associated with Warcop Junction.
- An embankment will be installed on the eastern extent of the flood compensation structure to improve retention of flood waters. Stored flood water will be conveyed back into the Moor Beck on the right bank of the channel, directly upstream of the embankment associated with the flood compensation structure. The existing banks of the Moor Beck will not be modified to facilitate the installation of the flood compensation structure.

Watercourse Crossing Point 52 (Warcop Junction East)

- There is an existing road bridge which crosses the Moor Beck approximately 60m upstream of Watercourse Crossing Point 52. This structure will remain in situ following the completion of the works in the vicinity of Warcop.
- The proposed structure involves the installation of an underbridge structure spanning 25m across the width of the Moor Beck for a total length of 19.6m, to convey the A66 junction carriageway across the Moor Beck.
- Road embankments occupying the left and right bank of the Moor Beck will tie into the left and right extent of the underbridge structure. Reinforced earth granular backfill will be used to fill the space between the end of the road embankment and the underbridge structure. This will leave a 25m wide combined area of channel and floodplain for the Moor Beck to utilise.

- A flood compensation structure will be added on the floodplain area between the left bank of the Moor Beck and the right bank of the Moor Beck offtake, and on the left bank floodplain of the Moor Beck. Water will be captured and stored within this structure across a range of flood events, reducing the conveyance of flood water across the floodplain on the left bank of the Moor Beck on the approach to the embankments associated with Warcop Junction.
- An embankment will be installed on the eastern extent of the flood compensation structure to improve retention of flood waters. Stored flood water will be conveyed back into the Moor Beck on the right bank of the channel, directly upstream of the embankment associated with the flood compensation structure. The existing banks of the Moor Beck will not be modified to facilitate the installation of the flood compensation structure.

Watercourse Crossing Point 17 (Eastfield Sike Underbridge)

- There is an existing culvert structure conveying the Eastfield Sike beneath the existing A66. This is comprised of two circular culvert barrels with a diameter of 1.05m for a total length of 18m. Another structure conveys the Eastfield Sike beneath the access road located approximately 50m upstream of the existing A66.
- The proposed structure involves the replacement of the existing culvert structure beneath the A66 with an underbridge structure spanning 19m across the width of the Eastfield Sike for a total length of 50.6m to convey the A66 carriageway across the Eastfield Sike.
- Road embankments occupying the left and right bank of the Eastfield Sike will tie into the left and right extent of the underbridge structure. Reinforced earth granular backfill will be used to fill the space between the end of the road embankment and the underbridge structure. This will leave a 19m wide combined area of channel and floodplain for the Eastfield Sike to utilise.

Watercourse Crossing Point 55 and 58 (Flitholme Underbridge)

- There is an existing arched bridge structure which conveys the road over the Lowgill Beck in the vicinity of Flitholme, with a clear space height of 1.5m and a span of 4m.
- There are no proposals to modify or replace this bridge structure as part of the proposed works.

Watercourse Crossing Point 18 (Broomrigg Culvert)

- There is an existing culvert structure conveying the Unnamed Tributary of the Lowgill Beck 6.1 beneath the existing A66. This is comprised of one circular culvert barrel.
- The proposed structure involves the replacement of the existing culvert structure with a portal culvert structure, spanning 6m across the width

of the Unnamed Tributary of the Lowgill Beck 6.1 with a height of 2m. The total length of the portal culvert is 41.7m.

- The Unnamed Tributary of the Lowgill Beck 6.1 will need to be realigned to align with the position and direction of the proposed portal culvert.
- The culvert design does not include the addition of a concrete bed and will facilitate the opportunity for a more natural river bed substrate.
- The portal culvert will tie into the proposed A66 carriageway on the left and right extent of the structure.

Watercourse Crossing Points 19, 59 and 60 (Low Gill Culvert Extension)

- The existing pipe culvert on the Lowgill Beck has a total length of 42.5m, and the culvert barrel has a diameter of 1m.
- The proposed culvert extension involves a 16m upstream (north) installation of the existing structure.
- The extension is to involve a precast concrete pipe culvert of 0.2m thickness.
- Precast concrete headwall is to be installed at the inlet of the culvert extension, with erosion protection measures considered.
- The culvert barrel dimensions of the proposed culvert extension are to be the same as the existing culvert.
- The Yosgill Sike and Woodend Sike upstream of the existing culvert inlet are to be realigned to accommodate the proposed culvert extension.

Watercourse Crossing Point 62 and 63 (Bullistone Bridge Precast Reinforced Concrete Culvert)

- The existing pipe culvert on the Unnamed Tributary of the Lowgill Beck 6.7 has a total length of 42.5m, and the diameter of the culvert barrel has a diameter of 1.05m.
- The proposed culvert extension involves a 23m upstream (north) installation of the existing structure.
- Extension is to involve a precast concrete pipe culvert of 0.2m thickness. Precast concrete headwall is to be installed at the inlet of the culvert extension, with erosion protection measures considered.
- The culvert barrel diameter of the proposed culvert extension is the same as the existing culvert barrel.

Baseline hydromorphology desktop study

Survey scope

14.4.5.3 The scheme watercourse crossing points are located within the Low Gill (Crooks Beck) and Eden - Scandal Beck to Lyvennet water body catchments (Figure 14.3: WFD Surface Water Bodies (Application Document 3.3). The following sections provide a summary of the geomorphological characteristics of this catchment.

Catchment and character

Low Gill (Crooks Beck)

14.4.5.4 The Low Gill (Crooks Beck) water body lies in the North Pennines AONB, east of the village of Hilton, Appleby-in-Westmorland. The Low Gill (Crooks Beck) waterbody watercourses drain an area of 23.99km^2 and rises at an elevation of approximately 305mAOD. The Low Gill (Crooks Beck) water body, also known as Hayber Beck, flows downstream in a southerly direction for 5.6km. The Hayber Beck watercourse flows into Moor Beck towards Warcop. At Warcop, the Moor Beck watercourse discharges into Crooks Beck. Crooks Beck flows through Warcop in a westerly direction for approximately 1.3km before it discharges into the River Eden.

14.4.5.5 The Low Gill Beck Watercourse discharges into Crooks Beck at Warcop. Low Gill Beck Watercourse rises to the north of Brough and flows in a westerly direction for approximately 5km.

14.4.5.6 The following watercourses are located within the Low Gill (Crooks Beck) water body:

- Moor Beck (WCP15, WCP51, WCP52)
- Moor Beck (Offtake (WCP50)
- Eastfield Sike (WCP17)
- Crooks Beck
- Lowgill Beck (WCP55, WCP58)
- Unnamed Tributary of the Lowgill Beck 6.1 (WCP18)
- Yosgill Sike (WCP19, WCP60)
- Woodend Sike (WCP59)
- Unnamed Tributary of the Lowgill Beck 6.7 (WCP63, WCP62).

14.4.5.7 The waterbody catchment Low Gill (Crooks Beck) lies in the Pennine hills and flows through MoD (Ministry of Defence) land. The area is primarily rural with steep hills and areas of grassland.

14.4.5.8 The geology within the Low Gill (Crooks Beck) waterbody catchment is mixed. The geology to the east of the catchment is predominantly St Bees Sandstone Member. To the west of the catchment, the geology is Great Scar Limestone Group.

Eden - Scandal Beck to Lyvennet

14.4.5.9 The water body catchment Eden - Scandal Beck to Lyvennet Watercourses an area of 46.71km^2. The Scandal Beck watercourse discharges into the River Eden to the east of Soulby and flows in a northerly direction towards Great Musgrave for approximately 3.1km. At Great Musgrave, the River Eden begins to flow in a north westerly direction for approximately 27.2km, crossing through the town of Appleby-in-Westmorland.

14.4.5.10 The Cringle Beck watercourse discharges into the River Eden to the east of Great Ormside. The source of the Cringle Beck watercourse lies in the Pennine hills and rises at an elevation of approximately 206mAOD. The Cringle Beck flows in a southern direction towards

Warcop for approximately 4km. At Warcop, the Cringle Beck flows in a north westerly direction for approximately 3.5km before discharging into the River Eden.

14.4.5.11 The following watercourses are located within the Eden – Scandal Beck to Lvennet water body:

- Unnamed Tributary of the Mire Sike 6.12 (WCP11)
- Unnamed Tributary of the Cringle Beck 6.1 (WCP12)
- Cringle Beck (WCP13).

14.4.5.12 The water body catchment Eden - Scandal Beck to Lyvennet is mostly rural with areas of grassland, woodland and farmland. In addition to rural land, the catchment consists of urban centres including the town of Appleby-in-Westmorland.

14.4.5.13 The geology within the Eden - Scandal Beck to Lyvennet water body is predominantly Penrith Sandstone Formation. In the south of the catchment, the geology is mixed with Alston Formation and Penrith Sandstone Formation. Alston formation is characterised by Limestone, Sandstone, Siltstone and Mudstone.

Historic trend analysis

14.4.5.14 Historic OS mapping has been used to examine the extent of historic channel change within the water body catchment. The watercourse routes illustrated in the 1888 OS mapping (the earliest OS mapping available online) have been compared to current watercourses to identify areas of channel migration and realignment.

Moor Beck/Hayber Beck

14.4.5.15 There has been little change upstream to the Moor Beck/Hayber Beck in the c. 130 years since the earliest mapping available online. The watercourse has largely remained in the same location since 1888. The upstream reach of the Hayber Beck can be characterised by a steep, upland river. As such, the narrow valley shape limits lateral channel planform migration.

14.4.5.16 The extent of anthropogenic modification to the Hayber Beck and Moor Beck watercourses has changed over time. Upstream of Warcop, historic mapping identifies a weir structure along the Hayber Beck that is no longer in operation. Further downstream, the flow in the Moor Beck channel continues to be controlled by a weir structure which directs flow to a mill race.

Lowgill Beck

14.4.5.17 There has been significant planform change to the Lowgill Beck watercourse in the c. 130 years since the earliest mapping available online (Plate 11: Assessment of historic planform change on the Lowgill Beck). To the east of Warcop, the Lowgill Beck appears to have been managed sometime after 1956. In Area 1, a meander bend on the left bank floodplain has been cut off from the channel. In Area 2, near the hamlet of Flitholme, the Lowgill Beck planform has been straightened.

These changes are most likely to be a result of anthropogenic modification and historic channel straightening.

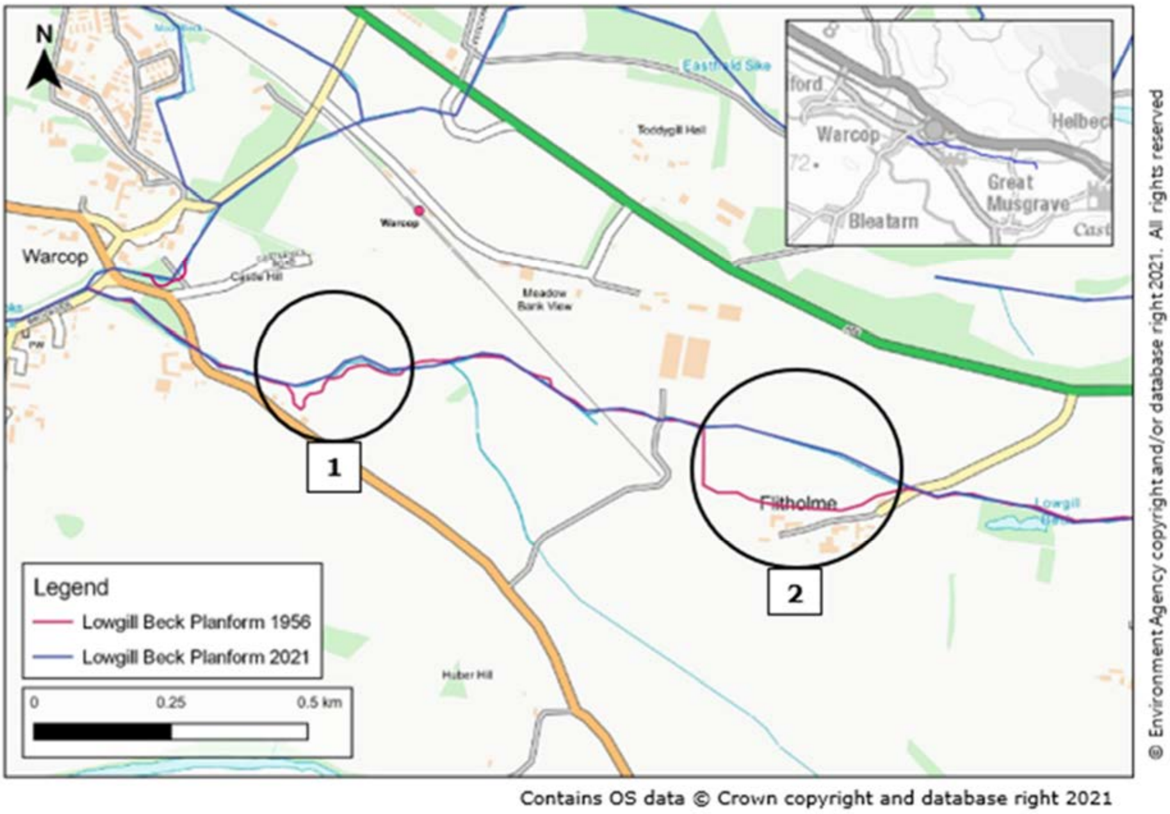

Plate 11: Assessment of historic planform change on the Lowgill Beck

Eden - Scandal Beck to Lyvennet

14.4.5.18 There has been little change to the River Eden planform in the c. 130 years since the earliest mapping available online. Insignificant change to the River Eden planform can be attributed to the topography of the waterbody catchment. The waterbody rises and meanders through an area of hills, resulting in a narrow valley shape and the watercourse being confined to a limited floodplain. In addition to topography, urban development has artificially confined the channel. The River Eden flows through the town of Appleby-in-Westmorland and has been managed and restricted to prevent damage to property and infrastructure from flooding.

14.4.5.19 Historic flow paths indicate a slight change to the Cringle Beck planform, upstream of the A66 (Area 1 of Plate 12: Assessment of historic planform change on the Cringle Beck). It is likely that the channel planform has been historically straightened, resulting in a loss of natural channel sinuosity. There has been no change to the Cringle Beck planform further downstream. Artificial confinement of the watercourse channel can be attributed to urban management. The Cringle Beck flows beneath two road networks and has been restricted from migrating across the floodplain.

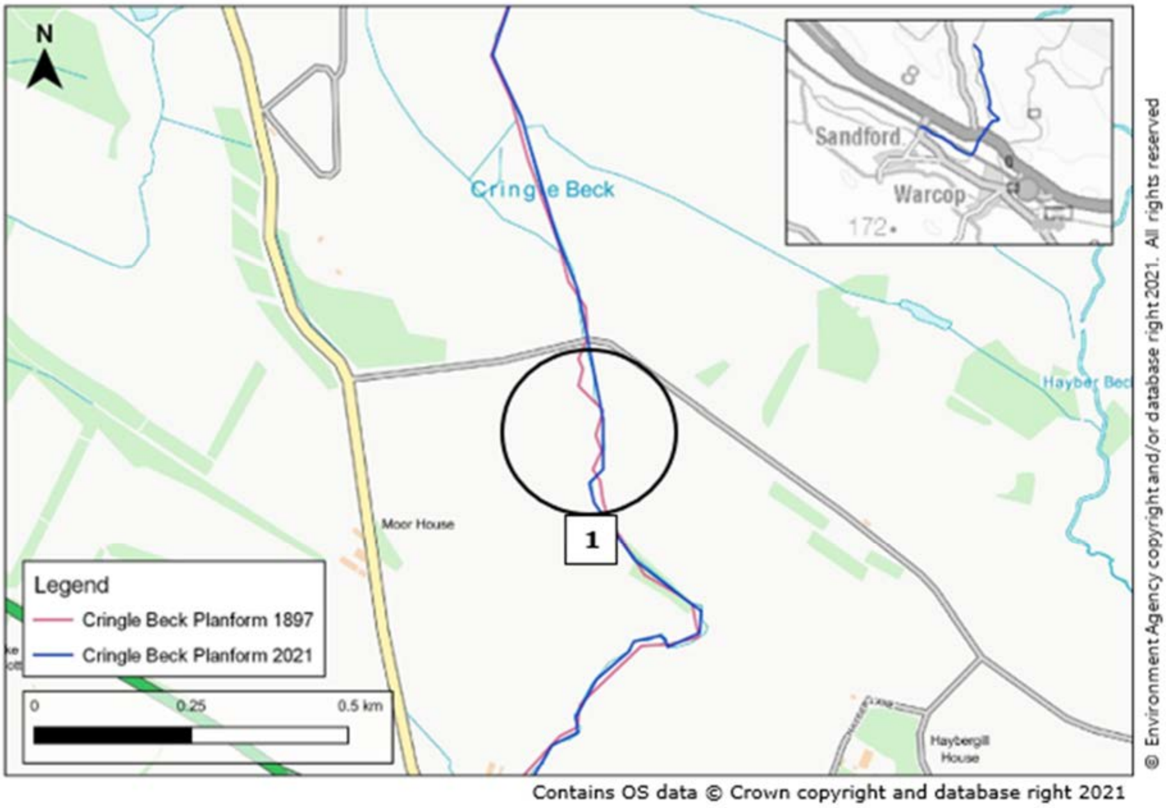

Plate 12: Assessment of historic planform change on the Cringle Beck

Assessment of LiDAR data

Low Gill (Crooks Beck)

14.4.5.20 In Area 1 (Plate 13: Assessment of LiDAR data in the vicinity of Warcop), there are palaeo channels on the floodplain of the Hayber Beck, suggesting that the channel has migrated over time. This can be attributed to the high-energy nature of the upstream reach. In Area 2 (Plate 13: Assessment of LiDAR data in the vicinity of Warcop), a palaeo channel on the right bank floodplain of the Moor Beck suggests a reduction in sinuosity and channel complexity over time. The meander bend is not visible in historic mapping, and as such likely pre-dates 1897, the earliest available historic mapping online. In Area 3 (Plate 13: Assessment of LiDAR data in the vicinity of Warcop), palaeo channels can be seen on the left bank floodplain of the Crooks Beck. Little change to the Crooks Beck planform is observed in historic mapping which suggests that the Crooks Beck has previously been more active.

14.4.5.21 In Area 1 (Plate 14: Assessment of LiDAR data on the Lowgill Beck) a palaeo channel can be observed on the floodplain of the Lowgill Beck. This suggests that the Lowgill Beck previously meandered across the open floodplain. It is likely that the channel has been straightened and moved to the right side of the floodplain to increase the amount of agricultural land available on the left bank floodplain. Alteration of the watercourse planform has reduced sinuosity and increased the river gradient. Over time, the channel sinuosity has significantly decreased.

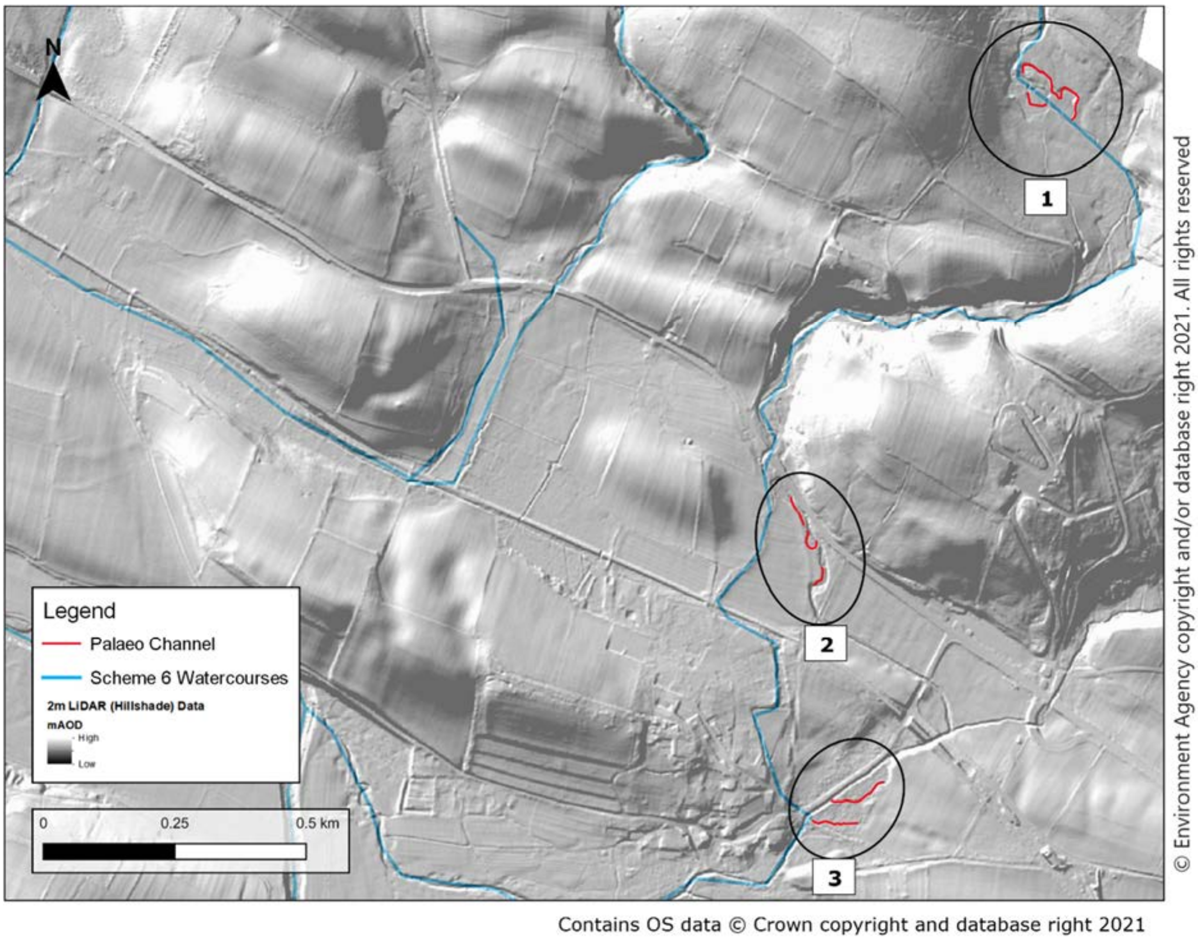

Plate 13: Assessment of LiDAR data in the vicinity of Warcop

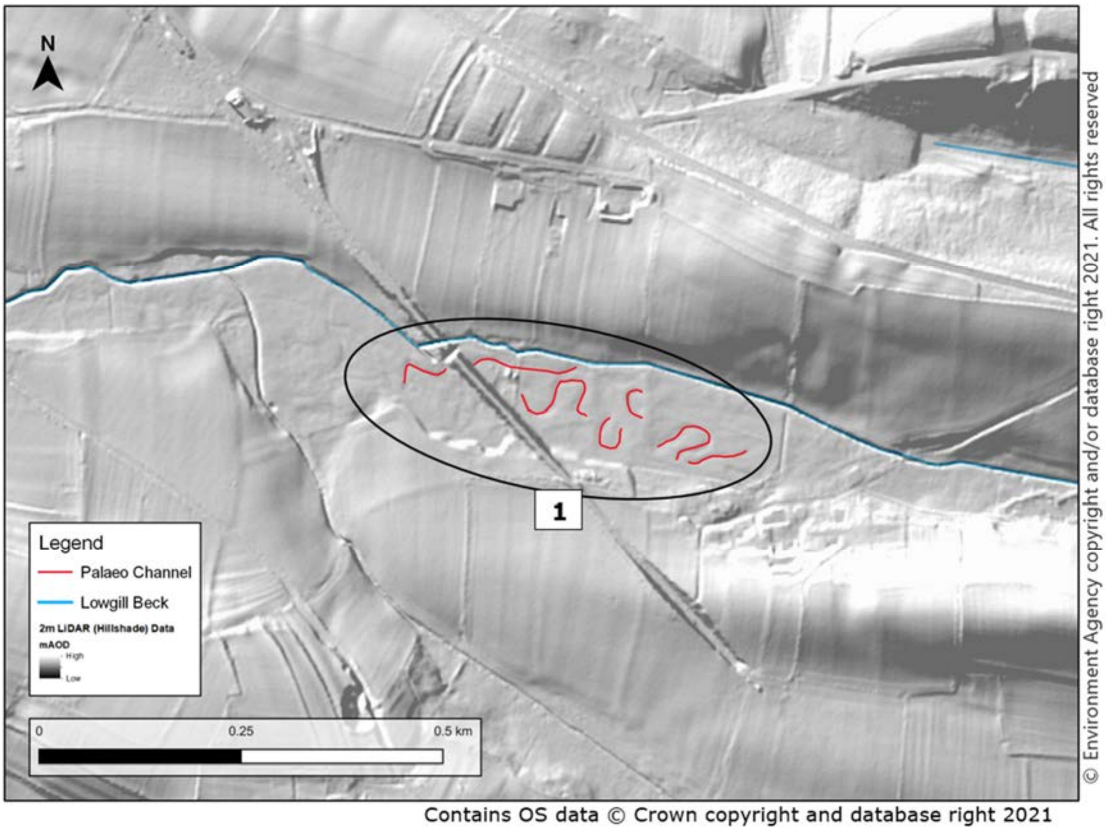

Plate 14: Assessment of LiDAR data on the Lowgill Beck

Baseline hydromorphology site observations

Table 32: Baseline hydromorphology for each watercourse with a crossing point

Crossing Point/ Watercourse	Site Observations
WCP11, Unnamed Tributary of the Mire Sike 6.12 Farm (Dike Culvert)	**Wider Catchment Characteristics:** The Unnamed Tributary of the Mire Sike 6.12 rises on the south slope of Roman Fell at an approximate elevation of 400 meters and flows in a generally southern direction towards Sandford. The Unnamed Tributary of the Mire Sike 6.12 is culverted beneath the A66, and discharges into the Mire Sike to the north of Sandford. Photographs of the location are shown in Annex A: Site Photograph Locations. **Observed In-Channel Modifications:** Culvert beneath the A66 Culvert beneath the farm access track to the Taylor and Braithwaite Farm Weir directly downstream of the farm access track to the Taylor and Braithwaite Farm Culvert beneath the rail line Culvert beneath the B6259 road **Typical Flow Biotopes:** In the vicinity of the A66 culvert the dominant flow biotope is a riffle, indicating moderate flow energy. Further downstream, this transitions to a

Crossing Point/ Watercourse	Site Observations
	glide, as flow energy decreases due to a reduction in channel gradient, flow impoundment from the weir and heavily overgrown riverbanks and channel. Downstream of the weir, the flow energy increases again, and riffle biotopes become more dominant. **Typical Bed Substrate:** In the vicinity of WCP11, the bed substrate is primarily a mix of cobbles and gravels, with sands occupying the channel margins. Reductions in flow energy due to a reduction in channel gradient, impoundment on the flow from the weir and heavily overgrown riverbanks and channel lead to the typical bed substrate transitioning from coarse material to sands and silts. Downstream of the weir, the bed substrate size increases back to cobbles and gravels, with fine sediments flushed from the bed, and preferential deposition of fines in the impoundment zone upstream of the weir. **Typical Riparian Composition:** In the vicinity of the watercourse crossing point there is a narrow strip of riparian planting on both banks. Wooden fencing on both banks mitigates against the risk of livestock poaching on the riverbanks where riparian planting is lacking. As distance downstream increases, the channel becomes overgrown with dense vegetation, which covers both the riverbanks and the bed of the channel. The lower channel energy in this reach leads to the deposition of finer bed material, which facilitates the colonisation of vegetation on the bed. Downstream of the rail line to the confluence with the Mire Sike, the riparian corridor improves with an isolated woodland area surrounding the confluence. **Typical Floodplain Connectivity:** The channel has incised downwards into the river bed over time, which has left the floodplain disconnected from the channel. It is likely that the anthropogenic straightening of the channel has resulted in a steeper channel gradient and higher flow energy in the channel leading to an increased ability for the watercourse to erode the river bed and incise downwards. On the approach to the confluence with the Mire Sike the floodplain connectivity improves as the gradient of the channel reduces and the channel becomes less incised due to the interaction between the Unnamed Tributary of the Mire Sike 6.12 and the Mire Sike.
Mire Sike	**Wider Catchment Characteristics:** The Mire Sike rises to the north west of Warcop Training Centre and flows in a generally westerly direction past Sandford toward the River Eden. The Cringle Beck and a number of Unnamed Tributary of the Mire Sike 6.12 join the Mire Sike to the north. Refer to Plate A-34: Mire Sike Downstream of WCP11 site photograph locations for photographs of geomorphological conditions on the Mire Sike. **Observed In-Channel Modifications:** Culvert beneath the B6259 road Culvert beneath Haregate road

Crossing Point/ Watercourse	Site Observations
	Typical Flow Biotopes: The Mire Sike, downstream of the Unnamed Tributary of the Mire Sike 6.12 WCP11 is located on, has a series of alternating riffle and glide biotopes upstream of the Unnamed Tributary of the Mire Sike 6.12 confluence. The diversity in flow biotopes is a result of the sinuous nature of the Mire Sike which generates localised variations in flow energy. On the approach to the confluence, the flow biotope diversity reduces, and a continuous riffle feature becomes dominant as channel sinuosity significantly reduces. **Typical Bed Substrate:** The bed material in the Mire Sike, downstream of the Unnamed Tributary of the Mire Sike 6.12 WCP11 is located on, is a mix of coarse cobbles and gravels in the areas characterised by riffle flows, and finer material ranging between gravels and sands in areas characterised by glide flows. The bed is armoured immediately upstream of the confluence with the Unnamed Tributary of the Mire Sike 6.12, as the straight channel planform, gradient and resulting riffled flow characteristics act to flush finer material further downstream leaving behind a matrix of coarser bed material. Downstream of the confluence with the Unnamed Tributary of the Mire Sike 6.12, the typical bed substrate becomes less diverse, with coarse cobbles and gravels dominating the river bed. **Typical Riparian Composition:** The riparian zone of the Mire Sike, downstream of the Unnamed Tributary of the Mire Sike 6.12 WCP11 is located on, varies considerably. Upstream of the confluence with the unnamed Tributary of the Mire Sike 6.12, the riparian cover on the Mire Sike is poor, with almost no vegetation lining the riverbanks. As a result, there has been significant poaching of the riverbanks by the sheep occupying the field. In the vicinity of the confluence and further downstream, riparian cover improves significantly, with an isolated woodland area surrounding the confluence. Downstream of this woodland, riparian cover remains good. **Typical Floodplain Connectivity:** The floodplain connectivity of the Mire Sike, downstream of the Unnamed Tributary of the Mire Sike 6.12 WCP11 is located on, varies significantly. Upstream of the confluence with the Unnamed Tributary of the Mire Sike 6.12, the Mire Sike is very incised, as the channel has been historically modified and straightened for agricultural purposes. As such, the floodplain connectivity to the channel is poor. This is further compounded by the trapezoidal channel shape of the Mire Sike upstream of the confluence, which has further reduced floodplain connectivity. Downstream of the confluence with the Unnamed Tributary of the Mire Sike 6.12, the connectivity of the Mire Sike improves moderately. The trapezoidal channel shape transitions to a more natural geometry, and bed incision is less prominent.

Crossing Point/ Watercourse	Site Observations
WCP12 Unnamed Tributary of the Mire Sike 6.1 (Cringle Beck River Crossing)	**Wider Catchment Characteristics:** The Unnamed Tributary of the Mire Sike 6.1 to the west of Wheat Sheaf Farm rises to the south of Moor House Farm, before flowing in a generally southern direction towards the Mire Sike. The Unnamed Tributary of the Mire Sike 6.1 is culverted beneath the A66 and the rail line, before joining the Mire Sike. Photographs of the location are shown in Annex A: Site Photograph Locations**Error! Not a valid result for table.**. **Typical Flow Biotopes:** Upstream of the existing A66, there were no distinguishable flow biotopes in the channel. Despite recent heavy rainfall there was very little flow in the channel in this reach, and the overgrown nature of the channel in most areas significantly slowed down any flow observed. Downstream of the existing A66, the low flow conditions continued and there were no discernible flow biotopes. The overgrown nature of the channel continued to slow down the flow and reduce flow energy significantly. **Typical Bed Substrate:** Upstream of the existing A66, the bed substrate is difficult to discern due to the overgrown nature of the channel. However, in areas where the bed is exposed, the bed substrate is predominantly fine material, ranging from sands to silts. This fine material has likely been input into the channel from the surrounding agricultural land during heavy rainfall events. Downstream of the existing A66, significant poaching of the riverbanks has resulted in a large volume of fine material being conveyed into the channel and depositing on the bed, leaving a homogeneous river bed comprised of fine material. Fine sediment deposition on the river bed is further compounded by the low flow energy in the channel, which results in additional fine material dropping out of the water column and depositing on the river bed rather than being flushed through the system. **Typical Riparian Composition**: Upstream of the existing A66, the riparian strip is overgrown, and comprised of long grasses. There is a distinct lack of riparian tree cover on both banks. Downstream of the existing A66, the riparian cover on both banks deteriorates significantly, and as such cattle poaching has occurred unchecked. The result is the degradation of the riverbanks, additional input of fine material into the channel and the development of a trapezoidal channel geometry. **Typical Floodplain Connectivity:** Upstream of the existing A66, the connectivity of the floodplain to the channel is moderate. The presence of rushes on the floodplain suggests that it becomes regularly inundated during heavy rainfall events.

Crossing Point/ Watercourse	Site Observations
	Downstream of the existing A66, the connectivity of the floodplain to the channel is significantly degraded compared to the upstream reach. The channel has undergone straightening, which has resulted in bed incision and therefore a lowering of the channel bed compared to surrounding ground levels.
WCP13 (Cringle Beck) (Cringle Beck River Crossing)	**Wider Catchment Characteristics:** The Cringle Beck rises on the southern slopes of Roman Fell and flows in a generally southern direction between Moorhouse Farm to the west and Haybergill Lane to the east. The Cringle Beck is culverted beneath the existing A66 at Wheat Sheaf Farm and the rail line further south, before discharging into the Mire Sike. Photographs of the location are shown in Annex A: Site Photograph Locations. **Typical Flow Biotopes:** The Cringle Beck upstream of the existing A66 can be characterised as an upland river, with a steep channel gradient, narrow valley shape and high energy flow biotopes. The flow biotope in this upland reach is predominantly riffles. As the Cringle Beck approaches the existing A66 from the north, the channel gradient becomes less steep and the valley opens up, reducing confinement and providing the channel with the space to adopt a more sinuous, active planform across the fields between Moorhouse Farm and Hayber Lane. Due to the sinuous channel planform, flow biotope diversity increases, with sequences of riffles and runs being observed in the channel. Downstream of the existing A66, the gradient decreases further, resulting in a reduction in flow energy and the typical flow biotopes observed in the channel. Riffle features are accompanied by alternating sequences of glide features. Flow velocities continue to decrease on the approach to the Mire Sike confluence, as water levels on the Mire Sike influence the flow velocities on the Cringle Beck. **Typical Bed Substrate:** Upstream of the existing A66, the bed substrate is a mix of coarse cobbles and gravels. The high flow velocities in the channel are able to mobilise and transport finer material such as sands and silts to downstream reaches, leaving coarse material to occupy the river bed. As such this upstream reach of the Cringle Beck can be categorised as a transfer reach. Downstream of the A66, the predominant bed substrate becomes finer, as the channel gradient reduces, and flow velocities reduce. The bed substrate ranges from some cobbles and gravels at riffle features, and finer material such as sands and silts in low flow biotopes such as glides. The accumulation of finer material such as sands increases on the approach to the Mire Sike confluence, as water levels on the Mire Sike influence the flow velocities on the Cringle Beck. The accumulation of fine material is further compounded by bank poaching on the Cringle Beck both upstream and downstream of the existing A66, which acts as a source of fine material from the riverbanks.

Crossing Point/ Watercourse	Site Observations
	Typical Riparian Composition: Riparian cover on the Cringle Beck is mixed. Riparian cover is poor upstream of the existing A66, with a lack of tree cover or vegetation on the riverbanks between the source of the Cringle Beck and the culvert at the existing A66. Isolated thickets of trees and rushes were observed at some locations. As such, there was widespread evidence of livestock poaching of the riverbanks, as the lack of riparian tree cover facilitates access to the watercourse from cattle and sheep in the surrounding agricultural fields. This has ultimately led to a degradation of the riparian zone and riverbanks on the Cringle Beck upstream of the existing A66. The riparian buffer strip on the left bank of the channel provides the riverbank with enhanced structural integrity, and as such rates of bank erosion and undercutting on the left bank was significantly less compared to the unvegetated right bank. **Typical Floodplain Connectivity:** Upstream of the existing A66, the connectivity of the floodplain to the channel is moderate. The presence of rushes on the floodplain suggests that the floodplain becomes regularly inundated during heavy rainfall events. Downstream of the existing A66, the connectivity remains moderate. Despite the straightened channel planform, the channel has not undergone excessive bed incision. Evidence of wetted areas of the floodplain suggest that the flood waters from the Cringle Beck are able to spill out onto the floodplain.
WCP50 (Moor Beck (Offtake))	**Wider Catchment Characteristics:** The Moor Beck (Offtake) is an artificial channel, with flow diverted from the Moor Beck directly downstream of the existing A66. A series of three weir structures control the flow on the Moor Beck and convey flow from the Moor Beck to the Moor Beck (Offtake). The Moor Beck (Offtake) flows in a generally southern direction towards Warcop and flows beneath the rail bridge. The Moor Beck (Offtake) subsequently flows around northern perimeter of Warcop Training Centre, before being culverted and ultimately discharging into the Crooks Beck. Photographs of the location are shown in Annex A: Site Photograph Locations. **Typical Flow Biotopes:** The flow within the Moor Beck (Offtake) on the day of the site visit (Table 1: Hydromorphology survey dates) was very low, resulting in low flow energy. This was further compounded by the overgrown nature of the channel, which further reduced flow velocities in the channel. As such typical flow biotopes observed within the channel were glides. Downstream of the rail bridge, the flow within the Moor Beck (Offtake) increases compared to upstream; it is likely that additional discharges from local field drains and drainage outfalls supplement the flow within the channel. Despite the increase in flow, the flow velocity remains low, with gliding flows being the predominant flow biotope. It is likely a number of

Crossing Point/ Watercourse	Site Observations
	structures within the channel, such as culverts and access tracks within the grounds of the Training Centre impound the water and reduce the flow velocity. In addition, the impoundment on the flow encourages water to enter the wet woodland to the north east of Warcop Training Centre. This low flow energy system continues to the confluence with the Crooks Beck. **Typical Bed Substrate:** The typical bed substrate in the Moor Beck (Offtake) varies from gravels to very fine material. The low flow velocities within the channel result in fine material suspended in the water column dropping out of transport and depositing on the river bed. The result is the accumulation of fine bed material. Material coarser than gravels is unable to be transported to the Moor Beck (Offtake), as flow velocities are not sufficient to mobilise and transport large clasts. **Typical Riparian Composition:** Riparian cover on the Moor Beck (Offtake) is mixed. Upstream of the rail embankment, riparian tree cover is non-existent on both riverbanks. As such, bank stability and cohesion is reduced, and livestock has free access to the river, leading to bank poaching and ultimately the degradation of the riverbanks. Downstream of the rail embankment, riparian tree cover improves significantly in the vicinity of Warcop Training Centre. Trees occupy both riverbanks, and the channel meanders through a wet woodland area to the north east of the training centre. **Typical Floodplain Connectivity:** Floodplain connectivity to the Moor Beck (Offtake) is reasonable compared to other reaches of the Moor Beck. Due to the low flow conveyance to the Moor Beck (Offtake), combined with the low flow velocities, the channel has not undergone bed incision. The result is the water level of the Moor Beck (Offtake) being close to the top of the riverbank. It is likely during higher flow events or heavy rainfall events that flow is able to spill into the floodplain. Upstream of the existing A66, the connectivity of the floodplain to the channel is moderate. The presence of rushes on the floodplain suggests that the floodplain becomes regularly inundated during heavy rainfall events. Downstream of the rail bridge, connectivity to the floodplain reduces. The right bank of the channel has been raised to protect the training centre from flooding, and as such the right bank floodplain is disconnected from the Moor Beck (Offtake). Further downstream, a wet woodland area exists in the north eastern corner of the training centre. Floodplain connectivity is excellent, and water is able to regularly enter the woodland from the channel throughout the year.
WCP15 WCP51 WCP52	**Wider Catchment Characteristics:** The Hayber Beck rises on the southern slopes of Long Fell and flows in a generally southern direction past Hayber Beck House towards the existing A66. After the Hayber Beck is culverted beneath the existing A66, the

Crossing Point/ Watercourse	Site Observations
(Hayber Beck / Moor Beck)	watercourse is renamed the Moor Beck, and continues in an easterly direction towards the confluence with the Eastfield Sike to the north East of Warcop. Photographs of the location are shown in Annex A: Site Photograph Locations. **Typical Flow Biotopes:** The Hayber Beck upstream of the existing A66 can be characterised as an upland river, with a steep channel gradient, narrow valley shape and high energy flow biotopes. Flow biotopes vary between long riffle features and a limited number of rapid features. As the Hayber Beck approaches the existing A66, the gradient begins to reduce, and as such the flow energy of the watercourse reduces. This facilitates the development of alternating riffle and glide sequences, as local variations in channel sinuosity generate flow biotope diversity. Downstream of the existing A66, the alternating sequences of riffles and glides continue to the confluence with the Eastfield Sike. **Typical Bed Substrate:** The Hayber Beck upstream of the existing A66 is dominated by very coarse bed material, ranging from boulders to coarse cobbles. The steep channel gradient and high flow energy transfers smaller material to downstream reaches where flow energy is reduced. On the approach to the existing A66 where the channel gradient reduces, the typical bed substrate size reduces, ranging from cobbles and gravels at riffle features and gravels and sands in glide biotopes. Downstream of the existing A66, the diverse range of bed substrate observed in the Hayber Beck continues, with alternating riffle, glide and run features facilitating the development of distinct reaches comprising of cobble, gravel and sand bed substrate. On the approach to the confluence with the Eastfield Sike, the size of the bed substrate decreases to gravels and sands, as the flow energy decreases, and finer material transported from upstream reaches drops out of the water column and settles on the river bed. **Typical Riparian Composition:** The Hayber Beck upstream of the existing A66 has excellent riparian cover, with a forest present on both the left and right bank of the channel. This riparian cover provides enhanced structural integrity for the riverbanks. Downstream of the existing A66 on the Moor Beck, Riparian cover is significantly poorer, with a lack of trees on the riverbanks and evidence of livestock poaching in some areas. As such, the riverbanks have become degraded and are more susceptible to bank erosion and collapse. Poor Riparian cover continues to the confluence with the Eastfield Sike.

Crossing Point/ Watercourse	Site Observations
	Typical Floodplain Connectivity: The steep upland nature of the Hayber Beck means that the valley is naturally narrow, and the channel gradient is steep, and as such the watercourse is naturally confined in the narrow space within the valley. Downstream of the A66, the steep sided valley observed upstream gives way to a more open floodplain on both banks of the Moor Beck. Realignment and straightening of the channel has led to river bed incision as a result of the increased in-channel energy, leaving the floodplain disconnected from the channel. Areas of fresh bank collapse and bank slumping were observed during the site visit, indicating that the riverbanks are unstable as a result of the bed incision that has occurred in this reach.
WCP17 (Eastfield Sike)	**Wider Catchment Characteristics:** The Eastfield Sike rises on the southern slopes of Middle Fell and flows in a generally southern direction through Warcop Training Centre, before joining the Moor Beck to the north of Warcop. Photographs of the location are shown in Annex A: Site Photograph Locations. **Typical Flow Biotopes:** The Eastfield Sike upstream of the existing A66 can be characterised as an upland river, with a steep channel gradient and a narrow valley geometry. As a result, the flow energy is high, leading to the development of high energy flow biotopes such as riffles. On the approach to the existing A66, the channel gradient reduces, and as such the flow energy reduces. This led to the development of alternating riffle and run sequences. Downstream of the existing A66 on the approach to the confluence with the Moor Beck, the flow energy reduces further, and the alternating riffle and run sequences give way to riffle and glide sequences. **Typical Bed Substrate:** The Eastfield Sike upstream of the existing A66 is dominated by very coarse bed material, ranging from coarse cobbles to gravels. The steep channel gradient and high flow energy transfers smaller material to downstream reaches where flow energy is reduced. As such this upstream reach can be categorised as a sediment transport reach. Downstream of the existing A66, the typical size of bed substrate reduces compared to upstream reaches, as the channel gradient and flow energy decreases. This provides an opportunity for finer material to drop out of the water column and deposit on the river bed. As such, the bed material ranges from gravels to sands. Finer material such as silts continues to be transported to downstream reaches downstream of the confluence with the Moor Beck. **Typical Riparian Composition:** Across the Eastfield Sike the riparian cover is generally poor. In upstream reaches on the southern slopes of the Middle Fell and in the Warcop Training Centre, riparian tree cover is very limited, and large stretches of the riverbanks are unvegetated. This poor riparian cover continues to downstream reaches in the vicinity of the existing A66 and at the

Crossing Point/ Watercourse	Site Observations
	confluence with the Moor Beck. Downstream of the existing A66, the lack of riparian tree cover has led to unchecked livestock poaching of the riverbanks, leading to the condition of the riverbanks to become degraded. **Typical Floodplain Connectivity:** Floodplain connectivity on the Eastfield Sike is mixed. In the Upland reaches of the watercourse on the southern slopes of Middle Fell and in the Warcop Training Grounds floodplain connectivity is naturally poor. The steep upland nature of the Eastfield Sike means that the valley is naturally narrow and the channel gradient is steep, and as such the watercourse is naturally confined in the narrow space within the valley. Downstream of the A66, the steep sided valley observed upstream gives way to a more open floodplain on both banks of the Eastfield Sike. Realignment and straightening of the channel has led to river bed incision as a result of the increased in-channel energy, leaving the floodplain disconnected from the channel.
WCP55 WCP58 (Lowgill Beck) (Low Gill Culvert)	**Wider Catchment Characteristics**: The Lowgill Beck rises at the confluence between the Yosgill Sike and the Woodend Sike, directly upstream of the existing A66 north west of Brough. The Lowgill Beck is immediately culverted beneath the A66 before flowing in a generally western direction towards Warcop, passing through Flitholme and beneath the rail line on the route. The Lowgill Beck discharges into the Crooks Beck in the centre of Warcop. Photographs of the location are shown in Annex A: Site Photograph Locations. **Typical Flow Biotopes:** Downstream of the A66 culvert, the flow velocities within the Lowgill Beck are high, as a result of the steep channel gradient and straightened channel planform. As a result, a continuous riffle feature exists in the vicinity of WCP58. Downstream of the farm access bridge and culvert over the Lowgill Beck, the straightened channel planform gives way to a more sinuous channel, which facilitates the development of a diverse range of flow biotopes, ranging from alternating riffle run sequences and the occasional pool. Dense in-channel vegetation in this reach of the Lowgill Beck generates localised flow complexities, further enhancing the diversity of the flow regime. Further downstream, in the vicinity of the confluence with the Unnamed Tributary of the Lowgill Beck 6.1 to the north, the channel planform of the Lowgill Beck becomes artificially straightened through the agricultural fields. Despite the straightened channel planform, flow diversity increases in this reach, ranging from high flow velocity biotopes such as riffles, to runs and glides. Localised variation in flow is generated by woody material in the channel and informal structures in the channel such as culverts and farm access tracks. Downstream of Low Broomrigg Farm, the channel gradient increases on the approach to WCP55, which increases the flow velocity through this

Crossing Point/ Watercourse	Site Observations
	reach. As such, a continuous riffle feature has developed through this reach. Directly upstream of the road bridge at Flitholme, the flow energy decreases significantly, and a gliding flow biotope replaces the continuous riffle feature observed upstream. Between Flitholme and Warcop flow biotope diversity increases, with the typical biotopes alternating between riffles and runs. Structures in the channel, such as the culvert beneath the rail embankment and farm access tracks impound the flow in some areas, leading to a reduction in flow velocities. **Typical Bed Substrate:** Downstream of the A66 culvert, the typical bed substrate ranges from cobbles to gravels. The high flow in the upper part of this reach conveys finer material such as sands and silts to downstream reaches, leaving behind a river bed composed of coarser material. As such, this reach of the Lowgill Beck can be categorised as a transfer reach. Further downstream of WCP 58 where a diverse range of flow biotopes develops, the typical bed substrate becomes more varied as a result, ranging from coarse cobbles and gravels in high flow biotopes, to sands and silts where flow velocity reduces. Reaches of the Lowgill Beck dominated by dense in-channel vegetation had significant volumes of fine material across the river bed as flow energy was significantly reduced. Further downstream, in the vicinity of the confluence with the Unnamed Tributary of the Lowgill Beck 6.1 to the north, the volume of fine material on the river bed increases significantly. In areas of low flow velocity, the bed is composed almost entirely of fine sandy material, or a layer of fine material covers the existing coarse bed substrate. It is likely that a lower channel gradient, and therefore lower flow energy, combined with input of fine material from the surrounding agricultural land through pathways such as cattle poaching, riverbank erosion and overland flow routes during heavy rainfall events contributes to this increased volume of fine material. As such this reach can be categorised as a sediment storage reach. Downstream of Low Broomrigg Farm, the size of material increases from the finer bed substrate observed upstream to coarse material ranging from cobbles to gravels. The steeper channel gradient in this reach results in higher flow velocities, which are able to mobilise and transport finer bed material such as sands and silts to downstream reaches, leaving coarser bed substrate such as cobbles and gravels in situ. On the approach to the road bridge at WCP55, the structure at the bridge impounds the flow. This significantly reduces the flow velocities immediately upstream, resulting in fine material suspended in the water column depositing on the river bed, and as such the bed substrate in this reach changes from coarse material to fine material. Between Flitholme and Warcop the bed substrate remains mixed. The river bed is composed of coarser material such as cobbles and gravels, but fine sediment input into the river system in this reach is still high, from

Crossing Point/ Watercourse	Site Observations
	pathways such as cattle poaching, riverbank erosion and overland flow routes during heavy rainfall events. The result is fine material choking the river bed substrate in some areas. On the approach to the confluence with the Crooks Beck, the river bed becomes armoured. Finer material is transported to downstream reaches on the Crooks Beck, and the coarser material becomes interlocked as sediment clasts are water worked. **Typical Riparian Composition:** In the upstream reaches of the Lowgill Beck, riparian tree cover is good, with a woodland area covering both the left and right bank of the channel for approximately 1km downstream of the existing A66. This riparian corridor provides the riverbanks with enhanced structural integrity and prevents access to the riverbanks from livestock. Downstream of this woodland area, the dense tree cover gives way to a thin riparian buffer strip of trees and hedgerows on both riverbanks. In areas where riparian cover is lacking, attempts have been made to prevent livestock poaching by installing fences; however, in many instances these have failed to limit cattle poaching, leading to the riverbanks becoming degraded. At the confluence with the Unnamed Tributary of the Lowgill Beck 6.1 to the north and the Lowgill Beck, a well connected wet woodland area exists, which was wetted on the day of the site visit. Further downstream of this wet woodland, riparian vegetation cover on the riverbank decreases significantly. As such, bank stability reduces, and the riverbanks are prone to erosion, undercutting and slumping. The result is an active channel planform that has been controlled with informal bank engineering methods to limit the loss of surrounding agricultural land. In addition, the lack of riparian tree cover has resulted in livestock poaching of the riverbanks, which has led to the degradation of the riverbanks and fine material input into the river system. The lack of riparian tree cover continues further downstream through Flitholme and down to Warcop. The installation of fences along both riverbanks has reduced the risk of livestock poaching, preventing the degradation of the riverbanks. On the approach to the confluence with the Crooks Becks, riparian tree improves significantly. **Typical Floodplain Connectivity:** Across the Lowgill Beck floodplain connectivity is generally poor. The steep narrow valley shape of the Lowgill Beck immediately downstream of the existing A66, combined with the steep channel gradient naturally confines the watercourse to the narrow space. Through the woodland area in the vicinity of WC58, connectivity is improved, with wet woodland areas identified during the site visit suggesting connectivity to some areas of the floodplain for the channel. Further downstream of the woodland area where the narrow valley shape gives way to a wide, open floodplain, bed incision is widespread. It is clear

Crossing Point/ Watercourse	Site Observations
	that the channel planform has been artificially straightened historically, likely by local famers to improve land drainage or delineate field boundaries. The result is an artificial increase to the channel gradient compared to a more natural channel planform, which leads to an increase in flow velocities and bed erosion. Bed incision has also resulted in increased erosion of the riverbank toe, reducing bank stability, encouraging bank slumping and increasing the channel width. This further compounds the issue of floodplain connectivity on the Lowgill Beck, as increased channel width increases the capacity of the channel and reduces the ability of water to spill out onto the floodplain. The exception to this poor floodplain connectivity is the wet woodland area at the confluence with the Unnamed Tributary of the Lowgill Beck 6.1 to the north and the Lowgill Beck. This issue of bed incision and poor floodplain connectivity continues downstream on the Lowgill Beck; in the vicinity of Flitholme wooden toe boards have been installed to prevent the risk of riverbank toe erosion and reduce the likelihood of riverbank slumping and collapse. Floodplain connectivity improves somewhat on the approach to the confluence with the Crooks Beck.
WCP18 (Unnamed Tributary of the Lowgill Beck 6.1)	**Wider Catchment Characteristics:** The Unnamed Tributary of the Lowgill Beck 6.1 Rises on the Warcop Training Grounds. Multiple streams rising from Brough Hill and Bale Hill converge to the south of Musgrave Barn, before flowing in a generally southern direction towards the existing A66. The Unnamed Tributary of the Lowgill Beck 6.1 is subsequently culverted beneath the A66, before continuing towards the Lowgill Beck to the east of Broomrigg End. Photographs of the location are shown in Annex A: Site Photograph Locations. **Typical Flow Biotopes:** The Unnamed Tributary of the Lowgill Beck 6.1 upstream of the A66 can be characterised by a shallow gradient and overgrown channel, resulting in typically low energy flow biotopes. The channel is generally overgrown with thick vegetation, both on the riverbanks and in the channel. The low flow energy within the channel has facilitated the establishment of vegetation on the river bed and banks. This has subsequently slowed the flow down further, leading to additional reductions in flow energy. Glide-type biotopes are dominant throughout this reach. A series of culverts beneath access tracks and field boundaries impound the flow, further reducing flow velocities in the channel. Downstream of the existing A66, the low flow energy of the channel continues. The channel gradient is somewhat improved on the approach to the Lowgill Beck, leading to the development of limited riffle features. The dominant flow biotope continues to be gliding flows. The channel remains overgrown, but improved channel width facilitates observations of the flow biotopes.

Crossing Point/ Watercourse	Site Observations
	Typical Bed Substrate: The Unnamed Tributary of the Lowgill Beck 6.1 upstream of the A66 is dominated by very fine bed material, ranging from sands to silts. The low flow energy within the channel means that larger material such as gravels and cobbles cannot be transported (except potentially in higher flow events). In addition, the low flow energy results in fine material dropping out of suspension and being deposited on the river bed. The surrounding land use is dominated by pastoral farmland. It is likely that during heavy rainfall events the soils and silts from surrounding fields are conveyed into the channel via overland flow routes, further increasing the build-up of fine material on the bed of the channel. Downstream of the existing A66 Culvert, the fine bed substrate continues as a result of the low flow energy. On the approach to the confluence with the Lowgill Beck, the channel gradient increases leading to an increase in flow energy. The result is a change in the typical bed substrate, increasing from fine material such as silts and sands to gravels. The river bed on the approach to the confluence is armoured, as finer material is transported to downstream reaches on the Lowgill Beck, leaving behind a matrix of coarser, interlocked material. **Typical Riparian Composition:** Across the extent of the Unnamed Tributary of the Lowgill Beck 6.1, riparian cover is generally good. In the upstream reach, the channel and riverbanks are overgrown with dense vegetation and the occasional tree. The watercourse enters a forested area directly upstream of the A66 culvert, providing a thick buffer of riparian woodland. Downstream of the A66 culvert, reasonable riparian cover is maintained, with a thin buffer strip of riparian woodland on both the left and right bank of the channel, which continues to the confluence with the Lowgill Beck. In addition, fences have been installed on both the left and right bank of the channel to further prevent livestock poaching of the riverbanks. **Typical Floodplain Connectivity:** Floodplain connectivity on the unnamed watercourse is generally poor. In the upstream reach, the channel has clearly been artificially straightened, most likely to provide enhanced drainage to the surrounding pastoral farmland. As such, the channel has naturally incised downwards over time, leaving the floodplain disconnected from the channel. The connectivity of the floodplain is further degraded in the woodland area directly upstream of the A66 Culvert. Palaeo channels were identified on the right bank of the channel, suggesting that the watercourse previously meandered across the floodplain. However, these palaeo channels are now disconnected from the main channel, with the existing riverbanks approximately 2-3m above the channel. The pattern of bed incision continues downstream of the existing A66 Culvert, with the floodplain remaining disconnected from the channel.

Crossing Point/ Watercourse	Site Observations
	There is further evidence of bed incision in this reach, as the presence of 'J' shaped trees on the riverbank suggests that as bed incision has occurred, the riverbanks have become unstable and collapsed.
WCP59 WCP19 (Woodend Sike)	**Wider Catchment Characteristics:** The Woodend Sike rises in Flascoe Wood to the south of Musgrave Scar, at the point where multiple small streams converge. The Woodend Sike flows in a generally south eastern direction towards the existing A66, where it joins the Yosgill Sike. After the Woodend Sike and Yosgill Sike pass beneath the existing A66, it is named the Lowgill Beck. Photographs of the location are shown in Annex A: Site Photograph Locations. **Typical Flow Biotopes:** The channel gradient of the Woodend Sike is steep from Flascoe Wood down to the existing A66. As a result, the flow energy is high, leading to the development of a diverse range of flow biotopes. Alternating sequences of riffles and runs have developed in the channel. The presence of woody material in the channel has generated local variations in flow energy, with a reduction in flow energy observed directly upstream of woody material in the channel. On the approach to the culvert beneath the A66, the flow diversity reduces, as the channel becomes straightened, and the bed material is replaced by concrete. The result is a continuous riffle / plane-bed feature to the confluence with the Yosgill Beck. **Typical Bed Substrate:** The typical bed substrate within the Yosgill Sike varies between coarse cobbles and gravels. The flow energy on the Woodend Sike is typically high, as a result of the steep channel gradient. As such, finer material such as sands and silts are transported to downstream reaches on the Lowgill Beck. The Woodend Beck can therefore be categorised as a sediment transport reach. **Typical Riparian Composition:** Riparian cover on the Woodend Sike is mixed. In the upstream extent of the watercourse in the vicinity of Flascoe Wood, riparian cover is good, with a dense thicket of tree cover on both the left and right riverbank. As distance downstream increases, riparian tree cover reduces significantly, as the land use changes from woodland to pastoral farmland. Cattle poaching in this reach is widespread due to a lack of riparian cover and fencing on the riverbanks. In the vicinity of the confluence with the Yosgill Sike and the existing A66, riparian tree cover improves significantly, with a riparian buffer strip present on both the left and right riverbanks. This buffer strip serves as a source of woody material for the watercourse, which generates localised diversity in flow and sediment processes, such as erosion and deposition. **Typical Floodplain Connectivity:** Floodplain connectivity on the Woodend Sike is generally poor. The channel has clearly been realigned and straightened historically, most

Crossing Point/ Watercourse	Site Observations
	likely to improve drainage of the surrounding pastoral farmland and to delineate field boundaries. The result is a steeper channel gradient compared to the gradient before the channel management, and with this, increased flow energy. This has led to bed incision along much of the Woodend Sike, which has left the surrounding floodplain disconnected from the channel. There is further evidence of bed incision in this reach, as the presence of 'J' shaped trees on the riverbank suggests that as bed incision has occurred, the riverbanks have become unstable and collapsed.
WCP60 (Yosgill Sike)	**Wider Catchment Characteristics:** The Yosgill Sike rises on Nuts Hill in Helbeck Wood, before flowing in a generally southern direction past Helbeck towards the existing A66. The Moor Beck joins the Yosgill directly upstream of the A66 Culvert. Downstream of the A66 Culvert, the Yosgill is named the Lowgill Beck. Photographs of the location are shown in Annex A: Site Photograph Locations. **Typical Flow Biotopes:** The channel gradient of the Yosgill Sike is steep from Helbeck Wood to the existing A66. As a result, the flow energy is high, leading to the development of high energy flow biotopes such as riffles and rapids. Further downstream at Demesne Farm, the channel gradient begins to level out on the approach to the confluence with the Woodend Sike. As such, flow biotope diversity increases, with alternating riffle and run sequences developing. **Typical Bed Substrate:** The Typical bed substrate within the Yosgill Sike varies between boulders to coarse cobbles and gravels. The flow energy on the Yosgill Sike is typically high, as a result of the steep channel gradient. As such, finer material such as sands and silts are transported to downstream reaches on the Lowgill Beck. The Yosgill Beck can therefore be categorised as a sediment transport reach. Coarse glacial material was identified in the surrounding floodplain of the Yosgill Beck, which likely serves as a source of boulders and coarse cobbles for the watercourse. **Typical Riparian Composition:** Across the Yosgill Beck the riparian cover is generally poor, with a distinct lack of riparian trees. As such, the riverbanks are unstable and are prone to erosion, undercutting and collapse. In addition, there are no measures in place to prevent livestock poaching, leading to heavily degraded riverbanks. **Typical Floodplain Connectivity:** Floodplain connectivity on the Yosgill Sike is generally poor. The steep, active channel has led to natural bed incision and riverbank undercutting. This has left the riverbanks and floodplain at a much higher elevation compared to the river bed. This lack of connectivity is likely to be a result of

Crossing Point/ Watercourse	Site Observations
	post-glaciation readjustment rather than from anthropogenic pressures on the Yosgill. As such, the floodplain is disconnected from the channel in the upper reaches. As the Yosgill Sike approaches to the confluence with the Woodend Sike, the channel gradient decreases, and the scale of bed incision reduces. In this downstream reach bed incision is less significant, and the floodplain connectivity to the channel improves marginally.
WCP62 WCP63 (Unnamed Tributary of Lowgill Beck 6.7) (Bullistone Bridge Culvert)	**Wider Catchment Characteristics:** The Unnamed Tributary of the Lowgill Beck 6.7 rises on Pica Hill to the south of Helbeck and flows in a generally south westerly direction towards Brough, where it is culverted beneath Helbeck Road and the A66 to the north west of Brough. Downstream of the A66, the Unnamed Tributary of the Lowgill Beck 6.7 continues to flow in a westerly direction until it discharges into the Lowgill Beck to the South of Low Broomrigg. Photographs of the location are shown in Annex A: Site Photograph Locations. **Typical Flow Biotopes:** Upstream of the existing A66, the flow within the channel on the day of the site visit was very low. As such, the flow energy was very low despite the steep channel gradient of the watercourse. It is likely that the flow within the channel is frequently low, as the bed of the channel was vegetated with grasses and was overgrown. The straight channel planform further compounds the issue of flow homogeneity, as there is little in channel diversity to generate a complex range of flow biotopes and varying flow energy in the channel. Downstream of the A66 culvert, the channel gradient significantly reduces compared to upstream of the A66 culvert. As observed upstream, the flow within the channel on the day of the site visit was very low. Combined with the low flow energy, the typical flow biotope within the channel can be characterised as a glide or run. The channel is overgrown with grasses and has obviously straightened, which limits the diversity of flow biotopes within the channel and serves to further reduce the flow energy. **Typical Bed Substrate:** The Typical bed substrate within the Unnamed Tributary of the Lowgill Beck 6.7 is very homogeneous both upstream and downstream of the existing A66. Fine material ranging from sands to silts occupy the river bed, as the overgrown nature of the channel reduces flow energy and encourages the deposition of finer material on the bed. The surrounding land use is dominated by pastoral farmland. It is likely that during heavy rainfall events soil and silts occupying fields is conveyed into the channel via overland flow routes, further increasing the build-up of fine material on the bed of the channel. **Typical Riparian Composition:** In the upper reaches of the unnamed Tributary of the Lowgill Beck 6.7, a riparian buffer strip exists on both riverbanks. This provides good riparian tree cover to the watercourse and improves riverbank stability. As distance

Crossing Point/ Watercourse	Site Observations
	downstream decreases, the riparian buffer strip is not continued, and as such riparian cover is non-existent. The result is unstable banks which are more susceptible to bank erosion, undercutting and slumping. The poor condition of the riparian zone continues downstream of the existing A66. This is further compounded by livestock poaching of the riverbanks, which further degrades the condition of the riverbanks. **Typical Floodplain Connectivity:** Floodplain connectivity on the unnamed Tributary of the Lowgill Beck 6.7 is mixed. In the upper limits of the watercourse, where the riparian buffer strip exists, the floodplain is reasonably well connected to the channel, and it is likely this woodland area becomes wetted during high flow events. Further downstream, floodplain connectivity drastically reduces. The channel in this reach has likely been straightened, which increases the channel gradient and leads to accelerated bed incision. The result is the floodplain remaining at a much higher level compared to the river bed. This is further compounded by the trapezoidal geometry of the channel in this location. Downstream of the existing A66, the channel gradient reduces, which limits the extent of bed incision in the channel. As such the floodplain is better connected to the channel in this location compared to upstream reaches.

Stage 1: Hydromorphology screening

14.4.5.22 The screening assessment aims to screen in any works that require WFD assessmentWFD assessment and to identify which WFD water bodies are within and near to the proposed works. Drainage channel outfalls have been screened out of the assessment as their design is secured by the Environmental Management Plan (Application Document 2.7), which is a certified document under DCO. Where hard outfalls currently exist, new drainage channel outfalls will be tied into the existing structure. Drainage channels in areas with natural banks will be designed as a natural outfall (i.e. without hard bank protection).

14.4.5.23 Table 33: Screening of each water bodyindicates which water bodies have been screened in or out of the assessment and the reasons for this decision.

14.4.5.24 The baseline status of the hydromorphology quality elements within the water bodies screened into the assessment are discussed in this section. If there is potential for the proposed works to cause deterioration in the status of a water body or prevent it from achieving its status objectives as defined in the Solway Tweed River Basin Management Plan, the relevant water body and its quality elements have been taken forward and considered further in the scoping assessment at Stage 2.

Table 33: Screening of each water body

Water body/ies	Reason	Screening outcome
Low Gill (Crooks Beck)	The proposed works are located within the waterbody	Screened In

Water body/ies	Reason	Screening outcome
	and therefore, direct impact on this waterbody is possible.	
Eden - Scandal Beck to Lyvennet	The proposed works are located within the waterbody and therefore, direct impact on this waterbody is possible.	Screened In

Baseline status of screened-in water bodies

14.4.5.25 Table 34: Current WFD status of connected water body catchments in Cycle 2 (2019) summarises the water body ID, hydromorphological designation current ecological status / potential and ecological objective for each water body screened into the assessment. This information is provided by the Solway Tweed River Basin Management Plan 2021.

Table 34: Current WFD status of connected water body catchments in Cycle 2 (2019)

Water body ID	Name of water body	Hydromorphological designation	Current Ecological Status/ Potential	Ecological Objective
GB102076070750	Low Gill (Crooks Beck)	Not designated artificial or heavily modified	Poor	Good by 2027
GB102076070880	Eden - Scandal Beck to Lyvennet	Not designated artificial or heavily modified	Good	Good by 2015

14.4.5.26 The tables below outline the current status of the hydromorphological elements and reasons for not achieving good status (RNAGS) according to the most recent WFD cycle.

WFD water body: Low Gill (Crooks Beck)

Table 35: Hydromorphological quality element of Low Gill (Crooks Beck) Cycle 2 (2019)

Hydromorphological Quality Element	Current Status	Objective
Hydrological Regime	High	Supports good by 2015
Morphology	Supports good	Not available

Table 36: RNAGS for Low Gill (Crooks Beck) Cycle 2 (2019)

SWMI*	Activities	Classification Element
Diffuse source	Poor nutrient management	Phosphate
Other pressures	Ecological recovery time - surface waters	Fish

WFD water body: Eden - Scandal Beck to Lyvennet

Table 37: Hydromorphological quality element of Eden - Scandal Beck to Lyvennet Cycle 2 (2019)

Hydromorphological Quality Element	Current Status	Objective
Hydrological Regime	Supports good	High by 2015

Morphology	Supports good	Not available

Table 38: RNAGS for Eden - Scandal Beck to Lyvennet Cycle 2 (2019)

SWMI*	Activities	Classification Element
Not Available	Not Available	Not Available

*Significant water management issue

Stage 2: Hydromorphology scoping

14.4.5.27 The scoping assessment identifies whether the water body's quality elements, identified during the screening assessment, are at risk from the proposed works. The proposed development works are being appraised in terms of their impact on WFD status and objectives. If any quality elements are found to be at risk of detrimental impact, further assessment and/ or mitigation may be required.

Hydromorphological quality elements of the Eden - Scandal Beck to Lyvennet water body

14.4.5.28 The following Watercourse Crossing Point was identified as falling within the Eden-Scandal Beck to Lyvennet water body catchment:

- Watercourse Crossing Point 11 (Dike Culvert).

14.4.5.29 As such, the potential impacts of the proposed works at each identified crossing point will have on Eden - Scandal Beck to Lyvennet water body have been assessed. Where there is the potential for the proposed works to impact the geomorphological condition of watercourses within the Eden - Scandal Beck to Lyvennet water body.

Watercourse Crossing Point 11 (Dike Culvert)

14.4.5.30 The proposed works at this location include the extension of the existing culvert 8m upstream and 32m downstream. The culvert barrel dimensions of the proposed culvert extension are to be the same as the existing culvert. The Unnamed Tributary of the Mire Sike 6.12 downstream of the proposed culvert outfall is to be realigned to accommodate the culvert extension.

14.4.5.31 Table 39: Assessment of works at Watercourse Crossing Point 11 (Dike Culvert) on the Unnamed Tributary of the Mire Sike 6.12, against the hydromorphological quality elements for the Eden - Scandal Beck to Lyvennet water body catchment, assesses the potential impacts arising from proposed works at Watercourse Crossing Point 11 (Dike Culvert) on the Unnamed Tributary of the Mire Sike 6.12 within the Eden - Scandal Beck to Lyvennet WFD water body catchment.

Table 39: Assessment of works at Watercourse Crossing Point 11 (Dike Culvert) on the Unnamed Tributary of the Mire Sike 6.12, against the hydromorphological quality elements for the Eden - Scandal Beck to Lyvennet water body catchment

WFD Quality Element	Current Status	Potential Impact/Mitigation Measures	Further assessment and/or mitigation required?
Hydrology: Quantity and Dynamics of flow	Not Assessed	Areas of the Unnamed Tributary of the Mire Sike 6.12 that are currently open channel will be culverted following the completion of the works, which will alter the dynamics of flow (e.g., flow velocity, water depth, wetted area etc.) on a local scale at the unnamed Watercourse. However, the existing flow dynamics on the Unnamed Tributary of the Mire Sike 6.12 are homogeneous and lack geomorphological diversity and can be described as already degraded as a result of anthropogenic and agricultural pressures. As such, the proposed works are unlikely to lead to a further degradation of the quantity and dynamics of flow. Therefore, this quality element will not be considered as part of the impact assessment for the Eden- Scandal Beck to Lyvennet water body.	No
Hydrology: Connection to ground water bodies	Not Assessed	The extension of impermeable surface as a result of the culvert extension along the watercourse accounts for just 2% of the total length of the Unnamed Tributary of the Mire Sike 6.12, and 0.09% proportion of the entire WFD waterbody. As such, this reduction in connectivity between the watercourse and ground water bodies is not considered to be significant enough to impact ground water connectivity. Therefore, this quality element will be considered as part of the impact assessment for the Eden -Scandal Beck to Lyvennet water body.	No
River Continuity	Not Assessed	The existing Dike Culvert on the Unnamed Tributary of the Mire Sike 6.12 already limits the conveyance of flow and sediment from upstream of the culvert to downstream reaches. Extending the length of this control on flow and sediment conveyance will not further restrict flow and sediment conveyance; the internal clear span and height of the proposed culvert extension to the north and south will match that of the existing Dike Culvert. As such, the existing river continuity will be maintained following the completion of the works and there will be no degradation of the existing condition of River Continuity. Therefore, this quality element will not be considered as part of the	No

WFD Quality Element	Current Status	Potential Impact/Mitigation Measures	Further assessment and/or mitigation required?
		impact assessment for the Eden - Scandal Beck to Lyvennet water body.	
Morphology: River width and depth	Not Assessed	The width and depth of the channel will be dictated by the geometry of the culvert barrel once the works are complete. However, the existing river width and depth on the Unnamed Tributary of the Mire Sike 6.12 is homogeneous with a trapezoidal channel geometry and lacks geomorphological diversity. Modifications to the river width and depth as a result of agricultural and infrastructure influences has resulted in the degraded geometry of the Unnamed Tributary of the Mire Sike 6.12. As such, the proposed works are unlikely to lead to further degradation of the river width and depth. Therefore, this quality element will not be considered as part of the impact assessment for the Eden - Scandal Beck to Lyvennet water body.	No
Morphology: Structure and substrate of the river bed	Not Assessed	The extension of the culvert will result in loss of a short length of river bed. However, the existing condition of the river bed is already degraded and lacks geomorphological diversity and character. As such, the proposed works are unlikely to lead to further degradation of the river structure and substrate of the river bed. Therefore, this quality element will not be considered as part of the impact assessment for the Eden - Scandal Beck to Lyvennet water body.	No
Morphology: Structure of the riparian zone	Not Assessed	The extension of the Dike Culvert will involve the replacement of the existing riparian zone with an embankment to support the existing A66. In addition, the replacement of a section of open channel with a culvert barrel will reduce the connectivity of the watercourse to the riparian zone and surrounding floodplain. The existing condition of the riparian zone is already degraded. Riparian tree cover is sparse or non-existent in some reaches of the Unnamed Tributary of the Mire Sike 6.12, and modifications to the planform and geometry of the river channel has resulted in a reduction in natural floodplain connectivity. In addition, the surrounding agricultural land use has led to a further degradation to the condition of the riparian zone. As such, the proposed works are unlikely to lead to further degradation of the	No

WFD Quality Element	Current Status	Potential Impact/Mitigation Measures	Further assessment and/or mitigation required?
		structure of the riparian zone. Therefore, this quality element will not be considered as part of the impact assessment for the Eden - Scandal Beck to Lyvennet water body.	

Hydromorphological quality elements of the Low Gill (Crooks Beck) water body

14.4.5.32 The following Watercourse Crossing Points were identified as falling within the Low Gill (Crooks Beck) water body catchment:

- Watercourse Crossing Points 12 and 13 (Cringle Beck River Crossing)
- Watercourse Crossing Points 50 and 15 (Moor Beck Viaduct)
- Watercourse Crossing Point 19 (Low Gill Culvert)
- Watercourse Crossing Point 63 (Bullistone Bridge Culvert).

14.4.5.33 As such, the potential impacts of the proposed works at each identified Watercourse Crossing Point will have on the Low Gill (Crooks Beck) water body have been assessed. Where there is the potential for the proposed works to impact the geomorphological condition of watercourses within the Low Gill (Crooks Beck) water body, the requirement for a further assessment within paragraph 14.4.5.56 to 14.4.5.610 has been stipulated.

Watercourse Crossing Points 12 and 13 (Cringle Beck River Crossing)

14.4.5.34 The proposed works at this location include the installation of a bridge structure spanning 108m. A bridge width of 31m and a height of 13.456m across both the Unnamed Watercourse and the Cringle Beck. A total of 5 bridge piers will be installed on the floodplain to support the bridge. The bridge deck width will be 43.3m.

14.4.5.35 Table 40: Assessment of works at Watercourse Crossing Points 12 and 13 (Cringle Beck River Crossing) on the Unnamed Tributary of the Cringle Beck 6.1 and the Cringle Beck, against the hydromorphological quality elements for the Low Gill (Crooks Beck) water body catchment assesses the potential impacts arising from proposed works at Watercourse Crossing Points 12 and 13 (Cringle Beck River Crossing) on the Unnamed Tributary of the Cringle Beck 6.1 and Crooks Beck within the Low Gill (Crooks Beck) WFD water body catchment.

Table 40: Assessment of works at Watercourse Crossing Points 12 and 13 (Cringle Beck River Crossing) on the Unnamed Tributary of the Cringle Beck 6.1 and the Cringle Beck, against the hydromorphological quality elements for the Low Gill (Crooks Beck) water body catchment

WFD Quality Element	Current Status	Potential Impact	Further assessment and/or mitigation required?
Hydrology: Quantity and Dynamics of flow	Not Assessed	During low flow and in-channel flow events (i.e. up to bankfull), the proposed works will not disrupt flow dynamics within the channel, as there are no proposed modifications to the Cringle Beck channel or Unnamed Tributary of the Cringle Beck 6.1 channel. During out of bank flood flows, the embankments supporting the carriageway on the left and right bank floodplain have the potential to disrupt existing overland flow routes on the left and right bank floodplain as well as lateral connectivity of the river with its floodplain. As a consequence, flows would be confined to the channel and a narrower floodplain area. As such, there is likely to be a detrimental impact on the dynamics of flow. Therefore, this quality element will be considered as part of the impact assessment for the Low Gill (Crooks Beck) water body.	Yes
Hydrology: Connection to ground water bodies	Not Assessed	The proposed works do not involve modifications in the channel of either the Unnamed Tributary of the Cringle Beck 6.1 or the Cringle Beck. As such, the existing connectivity between the fluvial environment and ground water bodies will remain as existing. In addition, there is to be minor modification to the floodplain of both watercourses; the addition of piers on the functional floodplain represents the only addition of impermeable surfaces. The road embankment will be set back from the riverbanks and occupy the floodplain. As such, there is unlikely to be a detrimental influence on the connectivity between surface water flows on the floodplain and ground water bodies. Therefore, this quality element will not be considered as part of the impact assessment for the Low Gill (Crooks Beck) water body.	No
River Continuity	Not Assessed	The proposed works have the potential to impact the continuity of the Moor Beck. During low flow and in-channel flow events (i.e. up to bank full), the proposed works will not disrupt in-channel flow conveyance and sediment transport dynamics, as there are no proposed modifications to the Moor Beck channel. During out of bank flood flows, the embankments supporting the carriageway on the left and right bank floodplain have the potential to seriously disrupt existing longitudinal sediment transport	Yes

WFD Quality Element	Current Status	Potential Impact	Further assessment and/or mitigation required?
		and flow conveyance characteristics in the channel as well as lateral connectivity of the river with its floodplain. Overland flow routes on the left and right bank floodplain will be blocked and disconnected, disrupting existing sediment and flow conveyance routes on the floodplain confined to the channel and a narrower floodplain area, resulting in an increase in flow velocities and shear stress in the channel. This has the potential to increase riverbank and bed scour, which is likely to ultimately lead to a variation in existing sediment transport dynamics. As such, there is likely to be a detrimental impact on the continuity of both the Unnamed Tributary of the Cringle Beck 6.1 or the Cringle Beck. Therefore, this quality element will be considered as part of the impact assessment for the Low Gill (Crooks Beck) water body.	
Morphology: River width and depth	Not Assessed	The proposed structure has a span of 31m, which is wider than the existing width of the Cringle Beck and Unnamed Tributary of the Cringle Beck 6.1 at this location. As such, there will not be a direct impact on the existing channel width or depth as a result of the proposed works. However, during out of bank flood flows, the embankments supporting the carriageway on the left and right bank floodplain blocks overland flow routes and confines flows through the structure. This has the potential to increase in-channel velocities and shear stress, which is likely to result in bed incision and bank scour, ultimately leading to changes in river width and depth. Therefore, this quality element will be considered as part of the impact assessment for the Low Gill (Crooks Beck) water body	Yes
Morphology: Structure and substrate of the river bed	Not Assessed	During out of bank flood flows, the embankments supporting the carriageway on the left and right bank floodplain blocks overland flow routes and confines flows through the structure. This has the potential to increase in-channel velocities and shear stress, which is likely to lead to river bed scour, removing the existing river bed substrate and bed forms. A loss of in channel river bed features will negatively impact the condition of the river bed	Yes

WFD Quality Element	Current Status	Potential Impact	Further assessment and/or mitigation required?
		substrate. Therefore, this quality element will need to be considered as part of the impact assessment for the Low Gill (Crooks Beck) water body.	
Morphology: Structure of the riparian zone	Not Assessed	The proposed works do not involve modification to the riparian zone of either the Unnamed Tributary of the Cringle Beck 6.1 or the Cringle Beck. On the Cringle Beck, the bridge span width is 31m, and the channel is positioned in the centre of the bridge span. This allows for sufficient space on both the left and right bank floodplain of the Cringle Beck between the proposed bridge piers and the riverbanks. On the Unnamed Tributary of the Cringle Beck 6.1, the bridge span width is 31m and the channel is positioned off centre to the right of the bridge span. Despite this, an 8m buffer strip between the pier positioned on the right bank floodplain and the right bank of the Unnamed Tributary of the Cringle Beck 6.1 exists. This allows for sufficient space between on both the left and right bank floodplain of the Unnamed Tributary of the Cringle Beck 6.1 between the proposed bridge piers and the riverbanks. As such, there will be no detrimental impact to the structure of the riparian zone. Therefore, this quality element will not be considered as part of the impact assessment for the Low Gill (Crooks Beck) water body.	No

Watercourse Crossing Points 50 and 15 (Moor Beck Viaduct)

14.4.5.36 The proposed works at this location include the installation of a viaduct bridge structure spanning 259.75m. Four bridge openings will occupy the floodplain, with a bridge opening width of 63m on the Moor Beck and a bridge opening width of 49.25m on the Moor Beck (Offtake). Two additional bridge openings of 49m and 49.25m will occupy areas of the floodplain without watercourses. Six pier locations will be installed to support the bridge, with five plinths installed across the width of the bridge deck to support the viaduct. These will be spaced at 32.5m intervals across the bridge soffit. The viaduct deck width will be 32.69m.

14.4.5.37 Table 41: Assessment of works at Watercourse Crossing Points 50 and 15 (Moor Beck Viaduct) on the Moor Beck and Moor Beck (Offtake) against the hydromorphological quality elements for the Low Gill (Crooks Beck) water body catchment the potential impacts arising from proposed works at Watercourse Crossing Points 50 and 15 (Moor Beck

Viaduct) on the Moor Beck and Moor Beck (Offtake) within the Low Gill (Crooks Beck) WFD water body catchment.

Table 41: Assessment of works at Watercourse Crossing Points 50 and 15 (Moor Beck Viaduct) on the Moor Beck and Moor Beck (Offtake) against the hydromorphological quality elements for the Low Gill (Crooks Beck) water body catchment

WFD Quality Element	Current Status	Potential Impact	Further assessment and/or mitigation required?
Hydrology: Quantity and Dynamics of flow	Not Assessed	During low flow and in-channel flow events (i.e. up to bankfull), the proposed works will not disrupt flow dynamics within the channel, as there are no proposed modifications to the Moor Beck channel or Moor Beck (Offtake) channel. During out of bank flood flows, the embankments supporting the viaduct structure have the potential to disrupt existing overland flow routes on the left and right bank floodplain as well as lateral connectivity of the river with its floodplain. As a consequence, flows would be confined through the channel and narrower floodplain. As such, there is likely to be a detrimental impact on the dynamics of flow. Therefore, this quality element will be considered as part of the impact assessment for the Low Gill (Crooks Beck) water body.	Yes
Hydrology: Connection to ground water bodies	Not Assessed	The proposed works do not involve modifications in the channel of either the Moor Beck or the Moor Beck (Offtake). As such, the existing connectivity between the fluvial environment and ground water bodies will remain the same as existing conditions. In addition, there is to be minimal modifications to the floodplain of both watercourses; the addition of piers on the functional floodplain represent the only addition of impermeable surfaces. The road embankment will be set back a significant distance from the watercourse and will be out of the functional floodplain. As such, there is unlikely to be a detrimental influence on the connectivity between surface water flows on the floodplain and ground water bodies. Therefore, this quality element will not be considered as part of the impact assessment for the Low Gill (Crooks Beck) water body.	No
River Continuity	Not Assessed	The proposed works have the potential to impact the continuity of the Moor Beck and Moor Beck (Offtake). During low flow and in-channel flow events (i.e. up to bank full), the proposed works will not disrupt in-channel flow conveyance and sediment transport dynamics,	Yes

WFD Quality Element	Current Status	Potential Impact	Further assessment and/or mitigation required?
		as there are no proposed modifications to the Moor Beck channel or the Moor Beck (Offtake) channel. During out of bank flood flows, the embankments supporting the viaduct structure have the potential to seriously disrupt existing longitudinal sediment transport and flow conveyance characteristics in the channel as well as lateral connectivity of the river with its floodplain. Overland flow routes on the left and right bank floodplain will be blocked and disconnected, disrupting existing sediment and flow conveyance routes on the floodplain. As a consequence, flows would be confined to the channel and a narrower floodplain, resulting in an increase in flow velocities and shear stress in the channel. This has the potential to increase riverbank and bed scour, which is likely to ultimately lead to a variation in existing sediment transport dynamics. As such, there is likely to be a detrimental impact on river continuity. Therefore, this quality element will be considered as part of the impact assessment for the Low Gill (Crooks Beck) water body.	
Morphology: River width and depth	Not Assessed	The proposed viaduct structure has a span of 49.25m to convey the Moor Beck and Moor Beck (Offtake) channels through both channel at this location. As such, there will not be a direct impact increase on the existing channel width or depth as a result of the proposed works. However, during out of bank flood flows, the embankments supporting the viaduct structure block overland flow routes and confine flows through the viaduct openings. This has the potential to increase in-channel velocities and shear stress, which is likely to result in bed incision and / bank scour, ultimately leading to changes in river width and depth. Therefore, this quality element will need to be considered as part of the impact assessment for the Low Gill (Crooks Beck) water body.	Yes
Morphology: Structure and substrate of the river bed	Not Assessed	During out of bank flood flows, the embankments supporting the viaduct structure blocks overland flow routes and confines flows through the viaduct openings. This has the potential to increase in-channel velocities and shear stress, which is likely to lead to river bed	Yes

WFD Quality Element	Current Status	Potential Impact	Further assessment and/or mitigation required?
		scour, removing the existing river bed substrate and bed forms. A diverse range of river bed formations, including bar features, riffles, runs and pools were identified on the Moor Beck at this location. A loss of these features will negatively impact the condition of the river bed substrate. Therefore, this quality element will need to be considered as part of the impact assessment for the Low Gill (Crooks Beck) water body.	
Morphology: Structure of the riparian zone	Not Assessed	The proposed works do not involve modification to the riparian zone of either the Moor Beck or Moor Beck (Offtake). On the Moor Beck, the bridge span width is 63m, and the channel is positioned off centre to the left of the bridge span. Despite this, there is a 10.85m buffer strip between the left bank of the Moor Beck and the pier occupying the left bank floodplain exists, and an approximate 50m distance between the right bank and the pier occupying the right bank floodplain. On the Moor Beck (Offtake), the bridge span width is 49.25m, and the channel is positioned in the centre of the bridge opening. There is a 23.5m distance between the left and right riverbanks and the piers occupying the left and right bank floodplains respectively. As such, the proposed works will not have an impact on the existing condition of the riparian zone. Therefore, this quality element will not be considered as part of the impact assessment for the Low Gill (Crooks Beck) water body.	No

Watercourse Crossing Point 51 (Warcop Junction West)

14.4.5.38 The proposed structure involves the installation of an underbridge structure spanning 25m across the width of the Moor Beck for a total length of 25m, to convey the A66 junction carriageway across the Moor Beck. Road embankments will be constructed on the left and right of the bridge as part of the Warcop Junction layout. The existing road bridge over the Moor Beck will remain in situ. A flood compensation structure will be added on the floodplain area between the left bank of the Moor Beck and the right bank of the Moor Beck Offtake, and on the left bank floodplain of the Moor Beck. An embankment will be installed on the eastern extent of the flood compensation structure to improve retention of flood waters. The existing banks of the Moor Beck will not be modified to facilitate the installation of the flood compensation structure.

14.4.5.39 Table 42: Assessment of works at Watercourse Crossing Point 51 (Warcop Junction West) on the Moor Beck, against the hydromorphological quality elements for the Low Gill (Crooks Beck) water body catchment assesses the potential impacts arising from proposed works at Watercourse Crossing Point 51 (Warcop Junction West) on the Moor Beck, which is within the Low Gill (Crooks Beck) WFD water body catchment.

Table 42: Assessment of works at Watercourse Crossing Point 51 (Warcop Junction West) on the Moor Beck, against the hydromorphological quality elements for the Low Gill (Crooks Beck) water body catchment

WFD Quality Element	Current Status	Potential Impact	Further assessment and/or mitigation required?
Hydrology: Quantity and Dynamics of flow	Not Assessed	During low flow and in-channel flow events (i.e. up to bankfull), the proposed works will not disrupt flow dynamics within the channel, as there are no proposed modifications to the Moor Beck channel. During moderate flood flows, the flood compensation structure captures and stores water on the floodplain, which limits the conveyance of flood water on the left bank floodplain of the Moor Beck. As a consequence, the embankments on the floodplain associated with Warcop Junction West are less likely to interact with overland flow routes on the left bank of the Moor Beck during moderate flood flows, and therefore less likely to disrupt flow dynamics in the channel. Losses in the overland flow route on the left bank floodplain of the Moor Beck will ultimately change the dynamics of flow within the overland flow route. During significant flood flows, the Warcop Junction embankment and the embankment associated with the flood compensation structure have the potential to seriously disrupt existing overland flow routes on the left and right bank floodplain as well as lateral connectivity of the river with its floodplain. Combined with the additional storage of water on the floodplain within the flood compensation structure, there is potential to disrupt the flow dynamics within the channel of the Moor Beck. Therefore, this quality element will be considered as part of the impact assessment for the Low Gill (Crooks Beck) water body	Yes
Hydrology: Connection to ground water bodies	Not Assessed	All proposed embankments will be set back from the riverbanks and occupy the floodplain. As such, there is not expected to be a significant reduction in connectivity between the	No

WFD Quality Element	Current Status	Potential Impact	Further assessment and/or mitigation required?
		watercourse and ground water bodies. Therefore, this quality element will not be considered as part of the impact assessment of the Low Gill (Crooks Beck) water body.	
River Continuity	Not Assessed	The proposed works have the potential to impact the continuity of the Moor Beck. During low flow and in-channel flow events (i.e. up to bank full), the proposed works will not disrupt in-channel flow conveyance and sediment transport dynamics, as there are no proposed modifications to the Moor Beck channel. During moderate flood flows, the flood compensation structure contains and stores water on the floodplain, which limits the conveyance of flood water on the left bank floodplain of the Moor Beck. The embankments on the floodplain associated with Warcop Junction West are less likely to interact with overland flow routes during moderate flood flows, and therefore less likely to disrupt the conveyance of flow and sediment both on the floodplain and in the channel. The loss of the overland flow route on the left bank of the Moor Beck has the potential to disrupt the connectivity between the channel and the floodplain, which is likely to lead to a disruption of the lateral continuity of the watercourse. During significant flood flows, the Warcop Junction embankment and the embankment associated with the flood compensation structure has the potential to seriously disrupt existing overland flow routes on the left and right bank floodplain as well as lateral connectivity of the river with its floodplain. Combined with the additional storage of water on the floodplain within the flood compensation structure, there is the potential for the conveyance of flow and sediment across the Moor Beck channel to be disrupted. In addition, the increased conveyance of flow from the flood compensation structure back into the Moor Beck has the potential to increase flow velocities on the right bank floodplain, and as a consequence increase the risk of riverbank and bed scour. The addition of fine material into the river system is likely to ultimately lead to a	Yes

WFD Quality Element	Current Status	Potential Impact	Further assessment and/or mitigation required?
		variation in existing sediment transport dynamics. Therefore, this quality element will be considered as part of the impact assessment for the Low Gill (Crooks Beck) water body.	
Morphology: River width and depth	Not Assessed	The proposed underbridge structure has a span of 25m, which is wider than the existing width of the Moor Beck at this location. As such, there will be no direct impact on the existing channel width or depth as a result of the proposed works. During moderate flood flows, the flood compensation structure contains and stores water on the floodplain, which limits the conveyance of flood water on the left bank floodplain of the Moor Beck. As a consequence, the embankments on the floodplain associated with Warcop Junction West are less likely to interact with overland flow routes on the left bank of the Moor Beck during moderate flood flows. This reduces the risk of increased flow velocities on the floodplain and in the channel and as a consequence the risk of riverbank and bed scour. Therefore, it is unlikely that the width and depth of the channel during moderate flood events will be degraded. However, during significant flood flows, the increased conveyance of flow from the flood compensation structure back into the Moor Beck has the potential to increase flow velocities on the right bank floodplain, which is likely to lead to riverbank scour and changes in river width. Therefore, this will be considered as part of the impact assessment on the Low Gill (Crooks Beck) water body.	Yes
Morphology: Structure and substrate of the river bed	Not Assessed	During moderate flood flows, the flood compensation structure contains and stores water on the floodplain, which limits the conveyance of flood water on the left bank floodplain of the Moor Beck. As a consequence, the embankments on the floodplain associated with Warcop Junction West are less likely to interact with overland flow routes on the left bank of the Moor Beck during moderate flood flows. This reduces the risk of increased flow velocities in the channel and therefore the risk	Yes

WFD Quality Element	Current Status	Potential Impact	Further assessment and/or mitigation required?
		of river bed scour. Consequently, it is unlikely that the existing bed substrate and bed features within the Moor Beck will be disrupted during moderate flood events. During significant flood flows, the Warcop Junction embankment and the embankment associated with the flood compensation structure have the potential to disrupt existing overland flow routes on the left and right bank floodplain as well as lateral connectivity of the river with its floodplain. This has the potential to ultimately change in-channel flow velocities and shear stresses, which is likely to lead to a degradation of the existing river bed substrate and river bed forms within the Moor Beck. A diverse range of river bed formations, including bar features, riffles, runs and pools were identified on the Moor Beck. A loss of these features will negatively impact the condition of the river bed substrate. Therefore, this will be considered as part of the impact assessment on the Lowgill (Crooks Beck) water body.	
Morphology: Structure of the riparian zone	Not Assessed	The proposed works are unlikely to have an impact on the existing structure of the riparian zone. The span of the proposed underbridge structure is 25m, which is much wider than the existing Moor Beck channel width. This will provide a buffer strip on both the left and right bank of the channel for a riparian corridor. The riverbanks in the vicinity of the proposed flood compensation structure will be maintained, and as such there will be no degradation of the existing riparian zone in this reach. The length of the proposed underbridge structure is 25m, which accounts for just 0.4% of the total length of the Hayber Gill/Moor Beck/Crooks Beck watercourse. Therefore, any potential impacts on the riparian zone of the Moor Beck resulting from this proposal will be insignificant. Moreover, the existing condition of the riparian zone is poor in this reach; there is poor coverage of riparian vegetation on both banks of the Moor Beck. As such, the proposed underbridge structure is unlikely to have a negative impact on the existing condition of the riparian zone. Therefore, this will not be	No

WFD Quality Element	Current Status	Potential Impact	Further assessment and/or mitigation required?
		considered as part of the impact assessment on the Low Gill (Crooks Beck) water body.	

Watercourse Crossing Point 52 (Warcop Junction East)

14.4.5.40 The proposed structure involves the installation of an underbridge structure spanning 25m across the width of the Moor Beck for a total length of 25m, to convey the A66 junction carriageway across the Moor Beck. Road embankments will be constructed on the left and right of the bridge as part of the Warcop Junction layout. The existing road bridge over the Moor Beck will remain in situ.

14.4.5.41 Table 43: Assessment of works at Watercourse Crossing Point 52 (Warcop Junction East) on the Moor Beck, against the hydromorphological quality elements for the Low Gill (Crooks Beck) water body catchment. assesses the potential impacts arising from proposed works at Watercourse Crossing Point 51 (Warcop Junction East) on the Moor Beck, which is within the Low Gill (Crooks Beck) WFD water body catchment.

Table 43: Assessment of works at Watercourse Crossing Point 52 (Warcop Junction East) on the Moor Beck, against the hydromorphological quality elements for the Low Gill (Crooks Beck) water body catchment.

WFD Quality Element	Current Status	Potential Impact	Further assessment and/or mitigation required?
Hydrology: Quantity and Dynamics of flow	Not Assessed	During low flow and in-channel flow events (i.e. up to bankfull), the proposed works will not disrupt flow dynamics within the channel, as there are no proposed modifications to the Moor Beck channel. During moderate flood flows, the flood compensation structure captures and stores water on the floodplain, which limits the conveyance of flood water on the left bank floodplain of the Moor Beck. As a consequence, the embankments on the floodplain associated with Warcop Junction East are less likely to interact with overland flow routes on the left bank of the Moor Beck during moderate flood flows, and therefore less likely to disrupt flow dynamics in the channel. Losses in the overland flow route on the left bank floodplain of the Moor Beck will ultimately change the dynamics of flow within the overland flow route. During significant flood flows, the Warcop Junction embankment and the embankment associated with the flood compensation	Yes

WFD Quality Element	Current Status	Potential Impact	Further assessment and/or mitigation required?
		structure have the potential to seriously disrupt existing overland flow routes on the left and right bank floodplain as well as lateral connectivity of the river with its floodplain. Combined with the additional storage of water on the floodplain within the flood compensation structure, there is potential to disrupt the flow dynamics within the channel of the Moor Beck. Therefore, this quality element will be considered as part of the impact assessment for the Low Gill (Crooks Beck) water body	
Hydrology: Connection to ground water bodies	Not Assessed	All proposed embankments will be set back from the riverbanks and occupy the floodplain. As such, there is not expected to be a significant reduction in connectivity between the watercourse and ground water bodies. Therefore, this quality element will not be considered as part of the impact assessment of the Low Gill (Crooks Beck) water body.	No
River Continuity	Not Assessed	The proposed works have the potential to impact the continuity of the Moor Beck. During low flow and in-channel flow events (i.e. up to bank full), the proposed works will not disrupt in-channel flow conveyance and sediment transport dynamics, as there are no proposed modifications to the Moor Beck channel. During moderate flood flows, the flood compensation structure contains and stores water on the floodplain, which limits the conveyance of flood water on the left bank floodplain of the Moor Beck. The embankments on the floodplain associated with Warcop Junction East are less likely to interact with overland flow routes during moderate flood flows, and therefore less likely to disrupt the conveyance of flow and sediment both on the floodplain and in the channel. The loss of the overland flow route on the left bank of the Moor Beck has the potential to disrupt the connectivity between the channel and the floodplain, which is likely to lead to a disruption of the lateral continuity of the watercourse. During significant flood flows, the Warcop Junction embankment and the embankment associated with the flood compensation structure has the potential to seriously disrupt existing overland flow routes on the left and right	Yes

WFD Quality Element	Current Status	Potential Impact	Further assessment and/or mitigation required?
		bank floodplain as well as lateral connectivity of the river with its floodplain. Combined with the additional storage of water on the floodplain within the flood compensation structure, there is the potential for the conveyance of flow and sediment across the Moor Beck channel to be disrupted. In addition, the increased conveyance of flow from the flood compensation structure back into the Moor Beck has the potential to increase flow velocities on the right bank floodplain, and as a consequence increase the risk of riverbank and bed scour. The addition of fine material into the river system is likely to ultimately lead to a variation in existing sediment transport dynamics. Therefore, this quality element will be considered as part of the impact assessment for the Low Gill (Crooks Beck) water body.	
Morphology: River width and depth	Not Assessed	The proposed underbridge structure has a span of 25m, which is wider than the existing width of the Moor Beck at this location. As such, there will not be a direct impact increase on the existing channel width or depth as a result of the proposed works. During moderate flood flows, the flood compensation structure contains and stores water on the floodplain, which limits the conveyance of flood water on the left bank floodplain of the Moor Beck. As a consequence, the embankments on the floodplain associated with Warcop Junction East are less likely to interact with overland flow routes on the left bank of the Moor Beck during moderate flood flows. This reduces the risk of increased flow velocities on the floodplain and in the channel and as a consequence the risk of riverbank and bed scour. Therefore, it is unlikely that the width and depth of the channel during moderate flood events will be degraded. However, during significant flood flows, the increased conveyance of flow from the flood compensation structure back into the Moor Beck has the potential to increase flow velocities on the right bank floodplain, which is likely to lead to riverbank scour and changes in river width.	Yes

WFD Quality Element	Current Status	Potential Impact	Further assessment and/or mitigation required?
		Therefore, this will be considered as part of the impact assessment on the Low Gill (Crooks Beck) water body.	
Morphology: Structure and substrate of the river bed	Not Assessed	During moderate flood flows, the flood compensation structure captures and stores additional water on the floodplain, which limits the conveyance of flood water on the left bank floodplain of the Moor Beck. As a consequence, the embankments on the floodplain associated with Warcop Junction East are less likely to interact with overland flow routes on the left bank of the Moor Beck during moderate flood flows. This reduces the risk of increased flow velocities in the channel and as a consequence the risk of river bed scour. Therefore, it is unlikely that the existing bed substrate and bed features within the Moor Beck will be disrupted during moderate flood events. During significant flood flows, the Warcop Junction embankment and the embankment associated with the flood compensation structure has the potential to seriously disrupt existing overland flow routes on the left and right bank floodplain as well as lateral connectivity of the river with its floodplain. This has the potential to ultimately change in channel flow velocities and shear stresses, which is likely to lead to a degradation of the existing river bed substrate and river bed forms within the Moor Beck. A diverse range of river bed formations, including bar features, riffles, runs and pools were identified on the Moor Beck. A loss of these features will negatively impact the condition of the river bed substrate. Therefore, this will be considered as part of the impact assessment on the Lowgill (Crooks Beck) water body.	Yes
Morphology: Structure of the riparian zone	Not Assessed	The proposed works are unlikely to have an impact on the existing structure of the riparian zone. The span of the proposed underbridge structure is 25m, which is much wider than the existing Moor Beck channel width. This will provide a buffer strip on both the left and right bank of the channel for a riparian corridor. The length of the proposed underbridge structure is 19.6m, which accounts for just 0.32% of the total	No

WFD Quality Element	Current Status	Potential Impact	Further assessment and/or mitigation required?
		length of the Hayber Gill/Moor Beck/Crooks Beck watercourse. Therefore, any potential impacts on the riparian zone of the Moor Beck resulting from this proposal will be insignificant. Moreover, the existing condition of the riparian zone is poor in this reach; there is poor coverage of riparian vegetation on both banks of the Moor Beck. As such, the proposed underbridge structure is unlikely to have a negative impact on the existing condition of the riparian zone. Therefore, this will not be considered as part of the impact assessment on the Low Gill (Crooks Beck) water body.	

Watercourse Crossing Point 17 (Eastfield Sike Underbridge)

14.4.5.42 The proposed structure involves the replacement of the existing double barred circular culvert structure beneath the A66 with an underbridge structure spanning 19m across the width of the Eastfield Sike for a total length of 50.6m to convey the A66 carriageway across the Eastfield Sike. The existing culvert upstream of the A66 will be retained, and the culvert located downstream of the A66 will be removed.

14.4.5.43 Table 44: Assessment of works at Watercourse Crossing Point 17 (Eastfield Sike Underbridge) on the Eastfield Sike, against the hydromorphological quality elements for the Low Gill (Crooks Beck) water body catchment. assesses the potential impacts arising from proposed works at Watercourse Crossing Point 17 (Eastfield Sike Underbridge) on the Eastfield Sike, which is within the Low Gill (Crooks Beck) WFD water body catchment.

Table 44: Assessment of works at Watercourse Crossing Point 17 (Eastfield Sike Underbridge) on the Eastfield Sike, against the hydromorphological quality elements for the Low Gill (Crooks Beck) water body catchment.

WFD Quality Element	Current Status	Potential Impact	Further assessment and/or mitigation required?
Hydrology: Quantity and Dynamics of flow	Not Assessed	The replacement of a culvert structure with an underbridge structure will lead to an improvement in the existing flow dynamics on the Eastfield Sike. The existing culvert conveying the watercourse beneath the existing A66 carriageway is constricting flows during bankfull and out of bank flow conditions. It is likely that this constriction impounds flows upstream of the existing structure, reducing flow diversity. The replacement of this culvert with a wider underbridge structure will lead to an	No

WFD Quality Element	Current Status	Potential Impact	Further assessment and/or mitigation required?
		improvement in flow diversity, as the impoundment on the flow will be removed. Furthermore, the existing culvert structure located downstream of the existing A66 culvert will also be removed. This will remove another constriction on the flow, and lead to additional improvements to the dynamics of flow. As such, the proposed works will not detrimentally impact the existing quantity and dynamics of flow and has the potential to improve conditions. Therefore, this quality element will not be considered as part of the impact assessment on the Low Gill (Crooks Beck) water body.	
Hydrology: Connection to ground water bodies	Not Assessed	There are no proposed impermeable surfaces on the floodplain or in the river channel as part of the proposed works. Furthermore, the replacement of the existing A66 culvert structure with an underbridge structure, and the removal of the culvert downstream of the A66 will reduce the overall impermeable surface on the river bed of the Eastfield Sike. As such, there is not expected to be a significant reduction in connectivity between the watercourse and ground water bodies. Therefore, this quality element will not be considered as part of the impact assessment of the Low Gill (Crooks Beck) water body.	No
River Continuity	Not Assessed	The replacement of a culvert structure with an underbridge structure will lead to an improvement in the existing flow dynamics on the Eastfield Sike. The existing culvert conveying the watercourse beneath the existing A66 carriageway is disrupting the longitudinal connectivity of the watercourse, by constricting the conveyance of flow and the transfer of sediment from upstream reaches to downstream. This is further compounded by the culvert located upstream and downstream of the A66 carriageway. The proposed replacement of the A66 culvert with an underbridge structure will reduce the constriction on flow and sediment transfer from upstream reaches to downstream that currently exists. Furthermore, the removal of the culvert located downstream of the A66 carriageway culvert will provide further improvements to the longitudinal conveyance of flow and sediment. As such, there is not	No

WFD Quality Element	Current Status	Potential Impact	Further assessment and/or mitigation required?
		expected to be a reduction in the continuity of the Eastfield Sike. Therefore, this quality element will not be considered as part of the impact assessment of the Low Gill (Crooks Beck) water body.	
Morphology: River width and depth	Not Assessed	The proposed works are unlikely to lead to a change in the width or depth of the Eastfield Sike. The replacement of the existing A66 carriageway with an underbridge structure will remove a control on the existing width of the Eastfield Sike. The 19m width of the proposed underbridge structure provides sufficient space for the watercourse compared to the existing culvert structure. Furthermore, the removal of the culvert provides an opportunity to establish a suitable width and depth to the channel and encourage natural geomorphological processes to be maintained and improved. It is required that a geomorphologist is included within the design team to ensure that the channel is designed to encourage and promote geomorphological processes. As such, there is not expected to be a degradation of the existing river width or depth. Therefore, this quality element will not be considered as part of the impact assessment of the Low Gill (Crooks Beck) water body.	No
Morphology: Structure and substrate of the river bed	Not Assessed	The replacement of the existing A66 carriageway culvert with an underbridge structure will lead to improvements to the structure and substrate of the river bed. The concrete invert of the culvert is the current bed of the channel, an unnatural substrate compared to other reaches of the Eastfield Sike. The installation of an underbridge structure in place of this culvert will provide an opportunity to establish a natural river bed, which will improve river bed diversity in terms of bedforms, habitats and sediments. Moreover, the existing culvert is disrupting the conveyance of sediment from upstream reaches to downstream. Removing this constriction of sediment transfer will improve the ability of the watercourse to replenish the river bed substrate and naturally improve the condition of the river bed substrate once the culvert has been removed. A hydraulic modelling study must be carried out to ensure	No

WFD Quality Element	Current Status	Potential Impact	Further assessment and/or mitigation required?
		that the bed material introduced into the channel is suitably sized to encourage development of bedforms and encourage natural geomorphic processes through the reach. In summary, there is not expected to be a degradation of the existing structure and substrate of the river bed. Therefore, this quality element will not be considered as part of the impact assessment of the Low Gill (Crooks Beck) water body.	
Morphology: Structure of the riparian zone	Not Assessed	The proposed installation of an underbridge structure will involve the replacement of the 32m of existing riparian buffer strip with embankments associated with the proposed A66 carriageway and underbridge structure. The existing culvert length is 18m, whereas the proposed underbridge structure length is 50.6m, resulting in a loss of riparian zone to the north of the A66. The condition of the riparian zone in this region is poor, with a lack of riparian vegetation. Moreover, the loss of riparian zone accounts for approximately 0.4% of the Eastfield Sike, which is an insignificant loss. As such, there is not expected to be a degradation of the existing structure of the riparian zone. Therefore, this quality elementquality element will not be considered as part of the impact assessment of the Low Gill (Crooks Beck) water body.	No

Watercourse Crossing Point 55 and 58 (Flitholme Underbridge)

14.4.5.44 There are no proposals to modify or replace this bridge structure as part of the proposed works and therefore no further assessment will be required at the hydromorphology scoping (Stage 2) or impact assessment (Stage 3) stages.

Watercourse Crossing Point 18 (Broomrigg Culvert)

14.4.5.45 The proposed structure involves the replacement of the existing culvert conveying the watercourse beneath the exiting A66 carriageway with a portal culvert (a culvert without an artificial bed to facilitate natural bed substrate), spanning 6m across the width of the Unnamed Tributary of the Lowgill Beck 6.1 with a height of 2m. The total length of the portal culvert is 41.7m. The Unnamed Tributary of the Lowgill Beck 6.1 will need to be realigned to align with the position and direction of the proposed portal culvert.

14.4.5.46 Table 45: Assessment of works at Watercourse Crossing Point 18 (Broomrigg Culvert) on the Unnamed Tributary of the Lowgill Beck 6.1, against the hydromorphological quality elements for the Low Gill (Crooks Beck) water body catchment. assesses the potential impacts arising from proposed works at Watercourse Crossing Point 18 (Broomrigg Culvert) on the Unnamed Tributary of the Lowgill Beck 6.1, which is within the Low Gill (Crooks Beck) WFD water body catchment.

Table 45: Assessment of works at Watercourse Crossing Point 18 (Broomrigg Culvert) on the Unnamed Tributary of the Lowgill Beck 6.1, against the hydromorphological quality elements for the Low Gill (Crooks Beck) water body catchment.

WFD Quality Element	Current Status	Potential Impact	Further assessment and/or mitigation required?
Hydrology: Quantity and Dynamics of flow	Not Assessed	The proposed works have the potential to impact the existing quantity and dynamics of flow within the Unnamed Tributary of the Lowgill Beck 6.1. The installation of the portal culvert itself will not have an impact on the quantity and dynamics of flow. During low flow and in-channel flow events (i.e. up to bankfull), the proposed works will not disrupt flow dynamics in the channel, as the installation of the culvert only requires modification to the riparian zone, and not modification within the channel or to the river bed. To accommodate the installation of the portal culvert, the channel will need to be realigned, and the channel planform will be straightened, leading to a reduction in overall channel length. This will result in an increase in channel gradient and subsequently an increase in flow velocities. The total loss of channel length as a result of the realignment is approximately 40m. This is likely to have an impact on the existing flow biotopes observed within the channel, as well as the flow dynamics within the channel and in the vicinity of the Lowgill confluence. As such, there is the potential for disruption of flow dynamics on both the Unnamed Tributary of the Lowgill Beck 6.1 and the Lowgill Beck. Assessing the impact that the proposed works will have on the quantity and dynamics of flow is further complicated by the proposed removal of the existing culvert conveying the Unnamed Tributary of the Lowgill Beck 6.1 beneath the existing A66 carriageway. It is likely that this existing structure impounds flow upstream during out of bank flood flows, therefore controlling flow dynamics and the quantity of flow within the watercourse downstream of the structure. Removing this existing control will lead to a change in the	Yes

WFD Quality Element	Current Status	Potential Impact	Further assessment and/or mitigation required?
		existing flow dynamics. As such, the proposed works have the potential to impact the existing quantity and dynamics of flow and has the potential to improve conditions. Overall, this quality element will be considered as part of the impact assessment on the Low Gill (Crooks Beck) water body.	
Hydrology: Connection to ground water bodies	Not Assessed	There are no proposed impermeable surfaces to be installed in the river channel as part of the proposed works. The proposed portal culvert will retain a natural bed substrate rather than a concrete bed, ensuring that connectivity between fluvial and groundwater systems remains uninterrupted. Furthermore, the existing piped culvert conveying the watercourse beneath the existing A66 carriageway will be replaced with this new structure, and as such the concrete bed through the existing culvert will be replaced with natural river bed substrate, leading to a reduction in overall impermeable surfaces on the river bed. As such, there is not expected to be a significant reduction in connectivity between the watercourse and ground water bodies. Therefore, this quality element will not be considered as part of the impact assessment of the Low Gill (Crooks Beck) water body.	No
River Continuity	Not Assessed	The continuity of the watercourse is not expected to be impacted by the proposed works. The existing culvert conveying the Unnamed Tributary of the Lowgill Beck 6.2 beneath the existing A66 carriageway restricts the conveyance of sediment and flow from upstream reaches to downstream. The proposed works involve the replacement of this existing structure with a larger culvert. The proposed portal culvert has an opening width of 6m and height of 2m which provides sufficient space for the small tributary and will reduce the existing constriction on the conveyance of sediment and flow from upstream reaches to downstream. As such, there is not expected to be a reduction in the continuity of the Unnamed Tributary of the Lowgill 6.2. Therefore, this quality element will not be considered as part of the impact assessment of the Low Gill (Crooks Beck) water body.	No

WFD Quality Element	Current Status	Potential Impact	Further assessment and/or mitigation required?
Morphology: River width and depth	Not Assessed	The proposed works involves the realignment of the Unnamed Tributary of the Lowgill Beck 6.2 to accommodate the installation of a portal culvert. The decrease in channel length caused by the realignment will result in a corresponding increase in channel gradient. This has the potential to increase in-channel flow velocities and shear stress, which is likely to lead to bed erosion and channel incision processes and result in an increase in channel depth over time. As such, there is the potential for degradation of the existing river depth. Therefore, this quality element will be considered as part of the impact assessment of the Low Gill (Crooks Beck) water body.	Yes
Morphology: Structure and substrate of the river bed	Not Assessed	The proposed works involve the realignment of the Unnamed Tributary of the Lowgill Beck 6.2 to accommodate the installation of a portal culvert. There is the risk that the condition of the bed substrate within the realigned channel may be degraded as part of these works. As such, there is the potential for degradation of the existing structure and substrate of the river bed. Therefore, this quality elementwill be considered as part of the impact assessment of the Low Gill (Crooks Beck) water body.	Yes
Morphology: Structure of the riparian zone	Not Assessed	The proposed installation of the portal culvert on the Unnamed Tributary of the Lowgill Beck 6.2 is unlikely to impact the structure of the riparian zone. The portal culvert will be installed on the riverbanks of the realigned channel, resulting in a 41m length of degraded riparian zone. Despite this, the existing structure of the riparian zone in the vicinity of the proposed culvert installation is poor; there is a lack of riparian vegetation and the riverbanks have been poached by livestock. Moreover, the wet woodland identified further downstream adjacent to the confluence with the Lowgill Beck will remain untouched. Therefore, the proposed installation of the culvert is unlikely to lead to further deterioration of the riparian zone. As such, there is not expected to be a degradation of the existing structure of the riparian zone. Therefore, this quality element will not be considered as part of the impact assessment of the Low Gill (Crooks Beck) water body.	No

Watercourse Crossing Point 59 and 19 (Low Gill Culvert)

14.4.5.47 The proposed works at this location include the extension of the existing culvert by 16m upstream. A precast concrete headwall is to be installed at the inlet of the culvert extension, with erosion protection measures considered. The width and depth of the of the proposed culvert extension are to be the same as the existing culvert. The Yosgill Sike and Woodend Sike upstream of the existing culvert inlet are to be realigned to accommodate the proposed culvert extension.

14.4.5.48 Table 46: Assessment of works at Watercourse Crossing Point 59 and 19 (Low Gill Culvert) on the Low Gill, against the hydromorphological quality elements for the Low Gill (Crooks Beck) water body catchment. assesses the potential impacts arising from proposed works at Watercourse Crossing Point 59 and 19 (Low Gill Culvert) on the Low Gill in the vicinity of the Low Gill (Crooks Beck), which is within the Low Gill (Crooks Beck) WFD water body catchment.

Table 46: Assessment of works at Watercourse Crossing Point 59 and 19 (Low Gill Culvert) on the Low Gill, against the hydromorphological quality elements for the Low Gill (Crooks Beck) water body catchment.

WFD Quality Element	Current Status	Potential Impact	Further assessment and/or mitigation required?
Hydrology: Quantity and Dynamics of flow	Not Assessed	The realignment of the Yosgill Sike and Woodend Sike channels will reduce channel sinuosity, and therefore reduce the existing flow complexity existing on both channels. This is likely to result in homogenous flow dynamics on the approach to the Low Gill Culvert, a degradation compared to the existing diversity in flow dynamics. In addition, areas of the Low Gill that are currently open channel will be culverted following the completion of the works, which will alter the dynamics of flow (e.g., flow velocity, water depth, wetted area etc.). The realignment of the channel to accommodate the installation of the culvert has the potential to reduce the overall length of the Yosgill Sike and Woodend Sike, which will in turn lead to an increase in channel gradient and is likely to subsequently result in an increase in in-channel flow velocities and shear stress. This is likely to have an impact on the existing flow biotopes observed within the channel, as well as the dynamics of flow through the proposed culvert. As such, there is the potential for impacts on the flow dynamics of the Yosgill Sike, Woodend Sike and Lowgill Beck. Therefore, this quality element will be considered as part of the impact	Yes

WFD Quality Element	Current Status	Potential Impact	Further assessment and/or mitigation required?
		assessment for the Low Gill (Crooks Beck) water body.	
Hydrology: Connection to ground water bodies	Not Assessed	The extension of impermeable surface along the watercourse as a result of the culvert extension accounts for just 0.4% of the total length of the Low Gill Beck. As such, this reduction in connectivity between the watercourse and ground water bodies is not significant enough to impact the ground water connectivity. Therefore, this quality element will not be considered as part of the impact assessment of the Low Gill (Crooks Beck) water body.	No
River Continuity	Not Assessed	The existing culvert on the Low Gill Beck already limits the conveyance of flow and sediment from upstream of the culvert to downstream reaches. Extending the length of this control on flow and sediment conveyance will not further restrict flow and sediment conveyance; the internal clear span and height of the proposed culvert extension upstream will match that of the existing Low Gill Culvert. As such, the proposed works will not impact the existing river continuity. Therefore, this quality element will not be considered as part of the impact assessment on the Low Gill (Crooks Beck) water body.	No
Morphology: River width and depth	Not Assessed	The replacement of a section of open channel with a culvert will result in a change to the existing width and depth of the Low Gill Beck. Following the completion of the culvert extension, the width and depth of the channel will be dictated by the geometry of the culvert barrel. In addition, the realignment of the Yosgill Sike and Woodend Sike is likely to lead to a modification of the river width on these two watercourses directly upstream of the proposed culvert extension. As a result, this has the potential to degrade the existing river geometry, compared to the current geomorphological diversity exhibited under current conditions. The existing geomorphological condition in the watercourse is good, and this modification is likely to lead to a loss of the existing morphological diversity in the channel. Therefore, this will be considered as part of the impact assessment on the Low Gill (Crooks Beck) water body.	Yes

WFD Quality Element	Current Status	Potential Impact	Further assessment and/or mitigation required?
Morphology: Structure and substrate of the river bed	Not Assessed	The replacement of natural river bed substrate with the proposed culvert extension upstream will result in a loss of natural river bed substrate. In addition, natural river bed substrate will be disrupted following the proposed realignment of the Yosgill Sike and Woodend Sike, which is likely to further degrade the condition of the river bed substrate. In addition, the shortened channel length of the Yosgill Sike and Woodend Sike will result in an increased channel gradient, potentially leading to increased in-channel flow velocities and shear stress, which may result in river bed scour. A diverse range of river bed formations, including bar features, riffles, runs and pools were identified on the Yosgill Sike. A loss of these features will negatively impact the condition of the river bed substrate. The existing geomorphological conditions in the river bed are good, with a diverse range of river bed forms and sediment sizes. This modification would lead to a loss of the existing morphological diversity in the channel. This has the potential to negatively impact the structure and substrate of the river bed at the water body catchment scale. Therefore, this will be considered as part of the impact assessment on the Lowgill (Crooks Beck) water body.	Yes
Morphology: Structure of the riparian zone	Not Assessed	The extension of the Low Gill Culvert will involve the replacement of the existing riparian zone with an embankment to support the Existing A66. In addition, the replacement of a section of open channel with a culvert barrel will significantly reduce the connectivity of the watercourse to the riparian zone and surrounding floodplain. The existing condition of the riparian zone is good, and the culvert extension would lead to a loss of riparian diversity. The proposed realignment of the Yosgill and Woodend Sike has the potential to reduce the existing floodplain connectivity and further reduce the condition of the riparian zone. In particular on the Woodend Sike, which has a notable riparian buffer strip spanning 200 meters upstream of the confluence with the Yosgill Sike. This combined loss of riparian zone and	Yes

WFD Quality Element	Current Status	Potential Impact	Further assessment and/or mitigation required?
		floodplain connectivity will lead to a degradation of the riparian zone on the Low Gill Beck. As such, this will be considered as part of the impact assessment on the Low Gill (Crooks Beck) water body.	

Watercourse Crossing Point 62 and 63 (Bullistone Bridge Culvert)

14.4.5.49 The proposed works at this location include an extension of the existing culvert by 23m upstream. The culvert barrel diameter of the proposed culvert extension is the same as the existing culvert barrel.

14.4.5.50 Table 47: Assessment of works at Watercourse Crossing Point 62 and 63 (Bullistone Bridge Culvert) on the Unnamed Watercourse against the hydromorphological quality elements of the Low Gill (Crooks Beck) water body catchment assesses the potential impacts arising from proposed works at Watercourse Crossing Point 62 and 63 (Bullistone Bridge Culvert) on the Unnamed Tributary of the Lowgill Beck 6.7, which is within the Low Gill (Crooks Beck) WFD water body catchment.

Table 47: Assessment of works at Watercourse Crossing Point 62 and 63 (Bullistone Bridge Culvert) on the Unnamed Watercourse against the hydromorphological quality elements of the Low Gill (Crooks Beck) water body catchment

WFD Quality Element	Current Status	Potential Impact	Further assessment and/or mitigation required?
Hydrology: Quantity and Dynamics of flow	Not Assessed	Areas of the Unnamed Tributary of the Lowgill Beck 6.7 that are currently open channel will be culverted following the completion of the works, which will alter the dynamics of flow (e.g., flow velocity, water depth, wetted area etc.) on a local scale at the unnamed Watercourse. Despite this, the existing flow dynamics on the unnamed Watercourse are homogeneous and lack geomorphological diversity and can be described as already degraded, as a result of anthropogenic and agricultural pressures. The small size of the watercourse (approximate channel width is 2m) further limits flow dynamics. As such, the proposed works are unlikely to lead to further degradation of the quantity and dynamics of flow. Therefore, this quality element will not be considered as part of the impact assessment on the Low Gill (Crooks Beck) water body.	No
Hydrology: Connection to	Not Assessed	The extension of impermeable surface along the watercourse accounts for just 0.5% of the total length of the Unnamed Tributary of the Lowgill	No

WFD Quality Element	Current Status	Potential Impact	Further assessment and/or mitigation required?
ground water bodies		Beck 6.7, and an even smaller proportion of the entire WFD waterbody. As such, this reduction in connectivity between the watercourse and ground water bodies is not significant enough to impact ground water connectivity. Therefore, this quality element will not be considered as part of the impact assessment on the Low Gill (Crooks Beck) water body.	
River Continuity	Not Assessed	The existing Bullistone Bridge Culvert on the Unnamed Tributary of the Lowgill Beck 6.7 already limits the conveyance of flow and sediment from upstream of the culvert to downstream reaches. Extending the length of this control on flow and sediment conveyance will not further restrict flow and sediment conveyance; the internal clear span and height of the proposed culvert extension to the north and south will match that of the existing Bullistone Bridge Culvert. As such, the existing river continuity will be maintained following the completion of the works and there will be no degradation of the existing condition of river continuity. Therefore, this quality element will not be considered as part of the impact assessment of the Low Gill (Crooks Beck) water body.	No
Morphology: River width and depth	Not Assessed	Following the completion of the culvert extension, the width and depth of the channel will be dictated by the geometry of the culvert barrel. Despite this, the existing river width and depth on the Unnamed Tributary of the Lowgill Beck 6.7 upstream of the structure is significantly degraded; the channel is trapezoidal and lacks geomorphological diversity. Modifications to the river width and depth as a result of agricultural and infrastructure influences has resulted in the degraded nature of the river width and depth in the vicinity of Bullistone Bridge Culvert on the Unnamed Tributary of the Lowgill Beck 6.7. The small size of the watercourse further limits flow dynamics. As such, the proposed works are unlikely to lead to further degradation of the river width and depth. Therefore, this quality element will not be considered as part of the impact assessment on the Low Gill (Crooks Beck) water body.	No

WFD Quality Element	Current Status	Potential Impact	Further assessment and/or mitigation required?
Morphology: Structure and substrate of the river bed	Not Assessed	Despite the loss of river bed substrate in the immediate vicinity of the Bullistone Bridge Culvert, the existing condition of the river bed is already degraded and lacks geomorphological diversity and character. As such, the proposed works are unlikely to lead to a further degradation of the river structure and substrate of the river bed. Therefore, this quality element will not be considered as part of the impact assessment on the Low Gill (Crooks Beck) water body.	No
Morphology: Structure of the riparian zone	Not Assessed	The extension of the Bullistone Bridge Culvert will involve the replacement of the existing riparian zone with an embankment to support the existing A66 to the north. In addition, the replacement of a section of open channel with a culvert barrel will reduce the connectivity of the watercourse to the riparian zone and surrounding floodplain. Despite the loss of riparian zone in the immediate vicinity of the Bullistone Bridge Culvert, the existing condition of the riparian zone is already degraded. Riparian tree cover is non-existent upstream of the existing structure, and the trapezoidal geometry of the channel has led to poor interaction between the floodplain and the modified channel. In addition, the surrounding agricultural land use has led to a further degradation to the condition of the riparian zone, with evidence of poached riverbanks and unstable, unvegetated riverbanks found upstream of the existing structure. It is clear that the existing structure of the riparian zone is already degraded and lacks geomorphological diversity and character. As such, the proposed works are unlikely to lead to further degradation of the structure of the riparian zone. Therefore, this quality element will not be considered as part of the impact assessment on the Low Gill (Crooks Beck) water body.	No

Impact assessment

14.4.5.51 The Impact Assessment needs to consider if there is a pathway linking the pressure to the quality element. If there is no pathway there can be no impact on the quality element and there is no need for any further assessment of that quality element to be carried out. If there is a potential pathway the assessment must consider if the activity, and the pressure it creates, may cause deterioration of the quality element.

14.4.5.52 In order to effectively assess the potential impacts of the proposed works and decide upon suitable mitigation measures, a good understanding of the proposed scheme and design is required. Should any revisions be made to the proposed works that could impact any of the WFD quality elements, this section must be revised.

14.4.5.53 The mitigation measures stipulated within the impact assessment are secured by the Project Design Principles (Application Document 5.11) and the Environmental Management Plan (Application Document 2.7), which are certified documents under DCO.

14.4.5.54 Provided the mitigation measures stipulated within the impact assessment and in section 14.4.9 are implemented at the detailed design stage, cumulative impacts from the proposed works to the hydromorphology quality elements of the Low Gill (Crooks Beck) water body will be mitigated sufficiently.

Impact assessment of the Low Gill (Crooks Beck) water body

14.4.5.55 Table 48: Impacts and mitigation measures of Watercourse Crossing Point 12 and 13 (Cringle Beck Crossing) to Table 53: Impacts and mitigation measures of Watercourse Crossing Point 59 and 19 (Low Gill Culvert) discuss each of the quality elements identified as being potentially at risk in the scoping assessment each structure assessed in the Low Gill (Crooks Beck) WFD water body. Mitigation measures are required to mitigate the effects of the proposed works. It should be noted that these mitigation measures differ to the Mitigation Measures identified for any Heavily Modified water body.

Watercourse Crossing Point 12 and 13 (Cringle Beck Crossing)

14.4.5.56 Table 48: Impacts and mitigation measures of Watercourse Crossing Point 12 and 13 (Cringle Beck Crossing) stipulatesthe mitigation measures required to offset the impacts arising from the proposed works at Watercourse Crossing Point 12 and 13 (Cringle Beck Crossing).

Table 48: Impacts and mitigation measures of Watercourse Crossing Point 12 and 13 (Cringle Beck Crossing)

WFD Quality Element	Pathway (direct / indirect/ none)	Potential Impact/ Mitigation measures
Hydrology: Quantity and Dynamics of Flow	Direct	**Permanent Impact:** During out of bank flood flows, the embankments supporting the carriageway on the left and right bank floodplain have the potential to disrupt existing overland flow routes on the left and right bank floodplain as well as lateral connectivity of the river with its floodplain. As a consequence, flows would be confined to the channel and a narrower floodplain area.

WFD Quality Element	Pathway (direct / indirect/ none)	Potential Impact/ Mitigation measures
		Mitigation: The watercourse confinement during out of bank flows and the resulting impact on flow dynamics will be compensated by the development of an option to remeander the reach of the Cringle Beck and the Unnamed Tributary of the Cringle Beck 6.1 in the vicinity of the Cringle Beck Crossing. Feasibility and design development of this option will be undertaken during detailed design. Increasing the sinuosity of the channel planform will help to re-naturalise the connection between the channel and the floodplain, helping to offset the alteration of flow pathways on the floodplain and improve flow dynamics.
Morphology: River Continuity	Direct	**Permanent Impact:** During out of bank flows and flood flows, the embankments supporting the carriageway on the left and right bank floodplain have the potential to disrupt existing longitudinal sediment transport and flow conveyance characteristics in the channel as well as lateral connectivity of the river with its floodplain. Overland flow routes on the left and right bank floodplain will be blocked and disconnected, disrupting existing sediment and flow conveyance routes on the floodplain. As a consequence, flows would be confined through the narrow structure, resulting in an increase in flow velocities and shear stress within the channel. This has the potential to increase riverbank and bed scour, which is likely to ultimately lead to a variation in existing sediment transport dynamics. **Mitigation:** The watercourse confinement during out of bank flows and the resulting impact on river continuity will be compensated by the development of an option to remeander the reach of the Cringle Beck and the Unnamed Tributary of the Cringle Beck 6.1 in the vicinity of the Cringle Beck Crossing. Feasibility and design development of this option will be undertaken during detailed design. Increasing the sinuosity of the channel planform will help to re-naturalise the longitudinal connection of upstream reaches of both channels to downstream reaches, and the lateral connection between the channel and the floodplain, helping to offset the alteration of both longitudinal and lateral continuity.
Morphology: River width and depth	Direct	**Permanent Impact:** During out of bank flows and flood flows, the embankments supporting the carriageway on the left and right bank floodplain have the potential to block overland flow routes and confine flows through the structure. This has the potential to increase in-channel velocities and shear stress, which is likely to lead to bed incision and / or bank scour and initiate changes to river width and depth.

WFD Quality Element	Pathway (direct / indirect/ none)	Potential Impact/ Mitigation measures
		Mitigation: The watercourse confinement during out of bank flows and the resulting potential impact on river width and depth will be compensated by the development of an option to remeander the reach of the Cringle Beck and the Unnamed Tributary of the Cringle Beck 6.1 in the vicinity of the Cringle Beck Crossing. Feasibility and design development of this option will be undertaken during detailed design. Increasing the sinuosity of the channel planform will help to re-naturalise the longitudinal connection of upstream reaches of both channels to downstream reaches, and the lateral connection between the channel and the floodplain, helping to encourage natural processes.
Morphology: Structure and substrate of the river bed	Direct	**Permanent Impact:** During out of bank flows and flood flows, the embankments supporting the carriageway on the left and right bank floodplain have the potential to block overland flow routes and confine flows through the structure. This has the potential to increase in-channel velocities and shear stress, which is likely to result in bed incision and / or bank scour and the removal the existing river bed substrate and bed forms. **Mitigation:** The watercourse confinement during out of bank flows and the resulting potential impact on the structure and substrate of the river bed will be compensated by the development of an option to remeander the reach ofthe Cringle Beck and the Unnamed Tributary of the Cringle Beck 6.1 in the vicinity of the Cringle Beck Crossing. Feasibility and design development of this option will be undertaken during detailed design. Increasing the sinuosity of the channel planform will help to mitigate increases in flow velocities in the channel associated with the limited overland flow route on the left bank floodplain, helping to offset potential increases to river bed scour and river bed composition change.

Watercourse Crossing Point 50 and 15 (Moor Beck Viaduct)

14.4.5.57 Table 49: Impacts and mitigation measures of Watercourse Crossing Point 50 and 15 (Moor Beck Viaduct) explores the mitigation measures required to offset the impacts arising from the proposed works at Watercourse Crossing Point 50 and 15 (Moor Beck Viaduct).

Table 49: Impacts and mitigation measures of Watercourse Crossing Point 50 and 15 (Moor Beck Viaduct)

WFD Quality Element	Pathway (direct / indirect/ none)	Potential Impact/ Mitigation measures
Hydrology: Quantity and	Direct	**Permanent Impact:** To support the assessment of impacts arising from the installation of the Moor Beck Viaduct structure, modelling results presented in

WFD Quality Element	Pathway (direct / indirect/ none)	Potential Impact/ Mitigation measures
Dynamics of Flow		ES Appendix 14.9: Detailed Geomorphological Modelling (Application Document 3.4) have been analysed to provide an improved understanding of potential changes to the quantity and dynamics of flow. During out of bank flood flows, the embankments supporting the viaduct structure have the potential to seriously disrupt existing overland flow routes on the left and right bank floodplain as well as lateral connectivity of the river with its floodplain. The close proximity to the viaduct embankment to the left bank of the Moor Beck results in an acceleration to both in channel and floodplain velocities and shear stresses. Flow is confined through the channel and a narrower floodplain area, which results in the increases in flow velocities and shear stresses. **Mitigation:** At detailed design, the exact site-specific mitigation necessary to compensate for disrupted flood flow route, flow confinement and increased flow velocities and flow energy in the vicinity of the embankment associated with the Moor Beck viaduct will be determined and will include: • Realignment of the channel to increase sinuosity • Creation of a multi-threaded channel • Green bank protection measures Feasibility and design development of these options will be undertaken during detailed design. Any future plans will be developed to ensure there is no change to the conclusions set out within the Habitats Regulations Assessment Stage 1: Likely Significant Effects Habitats (Application Document 3.5) and Regulation Assessment Stage 2: Statement to Inform Appropriate Assessment (Application Document 3.6). Additional geomorphological modelling may be required on an iterative basis to inform detailed design of mitigation. It will be used to demonstrate that the detailed design achieves the outcomes relied upon within the HRA LSE and HRA SIAA and appropriate mitigation is developed to mitigate any potential adverse effects on hydromorphology. The realignment of the channel, or the creation of a multi-threaded system / increased sinuosity in this reach will help to slow the flow down and reduce flow velocities. This will also encourage the redirection of flow energy away from the embankment to reduce the risk of scour in the vicinity of the embankment in close proximity to the left bank of the Moor Beck, mitigating the increases to flow velocities and shear stresses in this location. This will ensure that the existing dynamics of flow within the Moor Beck are maintained. Improving the sinuosity of the channel as part of

WFD Quality Element	Pathway (direct / indirect/ none)	Potential Impact/ Mitigation measures
		this proposed realignment would also provide additional benefits to the existing dynamics of flow.
Morphology: River Continuity	Direct	**Permanent Impact:** To support the assessment of impacts arising from the installation of the Moor Beck Viaduct structure, hydraulic modelling results have been analysed to provide an improved understanding of potential changes to the river continuity (ES Appendix 14.2: Flood Risk Assessment and Outline Drainage Strategy (Application Document 3.2) and ES Appendix 14.9: Detailed Geomorphological Modelling (Application Document 3.4)). During out of bank flood flows, the embankments supporting the viaduct structure have the potential to seriously disrupt existing longitudinal sediment transport and flow conveyance characteristics in the channel as well as lateral connectivity of the river with its floodplain. Overland flow routes on the left and right bank floodplain will be blocked and disconnected, disrupting existing sediment and flow conveyance routes on the floodplain. As a consequence, flows would be confined through the narrow structure, resulting in an increase in flow velocities and shear stress within the channel. This has the potential to increase riverbank and bed scour, which is likely to ultimately lead to a variation in existing sediment transport dynamics. An assessment of hydraulic model results provided further justification for the risk of disruption to the river continuity. Shear stress values in the immediate vicinity of the Moor Beck Viaduct increased significantly, which will result in the increased scour of river bed substrate and scour of the riverbanks and floodplain, resulting in an increase in the fine material in the river system, disrupting existing longitudinal sediment transport dynamics. **Mitigation:** At detailed design, the exact site-specific mitigation necessary to compensate for disrupted flood flow route, flow confinement and increased flow velocities and flow energy in the vicinity of the embankment associated with the Moor Beck viaduct will be determined and will include: • Realignment of the channel to increase sinuosity • Creation of a multi-threaded channel • Green bank protection measures Feasibility and design development of these options will be undertaken during detailed design. Any future plans will be developed to ensure there is no change to the conclusions set out within the Habitats Regulations Assessment Stage 1: Likely Significant Effects Habitats (Application Document 3.5) and Regulation Assessment Stage 2: Statement to Inform Appropriate Assessment (Application Document 3.6). Additional geomorphological modelling may be required on an iterative basis

WFD Quality Element	Pathway (direct / indirect/ none)	Potential Impact/ Mitigation measures
		to inform detailed design of mitigation. It will be used to demonstrate that the detailed design achieves the outcomes relied upon within the HRA LSE and HRA SIAA and appropriate mitigation is developed to mitigate any potential adverse effects on hydromorphology. The realignment of the channel, or the creation of a multi-threaded system / increased sinuosity in this reach will help to slow the flow down and reduce flow velocities. This will also encourage the redirection of flow energy away from the embankment to reduce the risk of scour in the vicinity of the embankment in close proximity to the left bank of the Moor Beck, mitigating the increases to flow velocities and shear stresses in this location. Improving the sinuosity of the channel as part of this proposed realignment would also provide additional benefits to the existing continuity of the watercourse, as lateral continuity and connectivity between the channel and the floodplain will be improved.
Morphology: River Width and Depth	Direct	**Permanent Impact:** To support the assessment of impacts arising from the installation of the Moor Beck Viaduct structure, hydraulic modelling results have been analysed to provide an improved understanding of potential changes to the river width and depth (ES Appendix 14.2: Flood Risk Assessment and Outline Drainage Strategy (Application Document 3.2) and Appendix 14.9: Detailed Geomorphological Modelling (Application Document 3.4)). During out of bank flood flows, the embankments supporting the viaduct structure have the potential to seriously disrupt overland flow routes and confine flows through the structure. This has the potential to increase in-channel velocities and shear stress, which is likely to lead to bed incision and / or bank scour. An assessment of hydraulic model results provided further justification for the risk of disruption to the river width and depth. Shear stress values in the immediate vicinity of the Moor Beck Viaduct increased significantly, which will result in the increased scour of river bed substrate and scour of the riverbanks and floodplain. Consequently, it is likely that the accelerated rates of river bed and riverbank erosion will lead to a modification to the existing width and depth of the channel. **Mitigation:** At detailed design, the exact site-specific mitigation necessary to compensate for disrupted flood flow route, flow confinement and increased flow velocities and flow energy in the vicinity of the embankment associated with the Moor Beck viaduct will be determined and will include: • Realignment of the channel to increase sinuosity • Creation of a multi-threaded channel

WFD Quality Element	Pathway (direct / indirect/ none)	Potential Impact/ Mitigation measures
		• Green bank protection measures Feasibility and design development of these options will be undertaken during detailed design. Any future plans will be developed to ensure there is no change to the conclusions set out within the Habitats Regulations Assessment Stage 1: Likely Significant Effects Habitats (Application Document 3.5) and Regulation Assessment Stage 2: Statement to Inform Appropriate Assessment (Application Document 3.6). Additional geomorphological modelling may be required on an iterative basis to inform detailed design of mitigation. It will be used to demonstrate that the detailed design achieves the outcomes relied upon within the HRA LSE and HRA SIAA and appropriate mitigation is developed to mitigate any potential adverse effects on hydromorphology. The realignment of the channel, or the creation of a multi-threaded system / increased sinuosity in this reach will help to slow the flow down and reduce flow velocities. This will also encourage the redirection of flow energy away from the embankment to reduce the risk of scour in the vicinity of the embankment in close proximity to the left bank of the Moor Beck, mitigating the increases to flow velocities and shear stresses in this location. This will ensure that the existing width and depth of the Moor Beck are maintained.
Morphology: Structure and substrate of the river bed	Direct	**Permanent Impact:** To support the assessment of impacts arising from the installation of the Moor Beck Viaduct structure, modelling results presented in ES Appendix 14.9: Detailed Geomorphological Modelling (Application Document 3.4) have been analysed to provide an improved understanding of potential changes to the structure and substrate of the river bed. During out of bank flood flows, the embankments supporting the viaduct structure have the potential to seriously disrupt overland flow routes and confine flows through the structure. This has the potential to increase in-channel velocities and shear stress, which is likely to result in bed incision and / or bank scour and the removal the existing river bed substrate and bed forms. An assessment of hydraulic model results provided further justification for the risk of disruption to the river width and depth. Shear stress values in the immediate vicinity of the Moor Beck Viaduct increased significantly, which will result in the increased scour of river bed substrate and scour of the riverbanks and floodplain. Consequently, it is likely that the accelerated rates of river bed and riverbank erosion will lead to a modification to the modification of the existing structure and substrate of the river bed. **Mitigation:** At detailed design, the exact site-specific mitigation necessary to compensate for disrupted flood flow route, flow confinement and

WFD Quality Element	Pathway (direct / indirect/ none)	Potential Impact/ Mitigation measures
		increased flow velocities and flow energy in the vicinity of the embankment associated with the Moor Beck viaduct will be determined and will include: • Realignment of the channel to increase sinuosity • Creation of a multi-threaded channel • Green bank protection measures Feasibility and design development of these options will be undertaken during detailed design. Any future plans will be developed to ensure there is no change to the conclusions set out within the Habitats Regulations Assessment Stage 1: Likely Significant Effects Habitats (Application Document 3.5) and Regulation Assessment Stage 2: Statement to Inform Appropriate Assessment (Application Document 3.6). Additional geomorphological modelling may be required on an iterative basis to inform detailed design of mitigation. It will be used to demonstrate that the detailed design achieves the outcomes relied upon within the HRA LSE and HRA SIAA and appropriate mitigation is developed to mitigate any potential adverse effects on hydromorphology. The realignment of the channel, or the creation of a multi-threaded system / increased sinuosity in this reach will help to slow the flow down and reduce flow velocities. This will also encourage the redirection of flow energy away from the embankment to reduce the risk of scour in the vicinity of the embankment in close proximity to the left bank of the Moor Beck, mitigating the increases to flow velocities and shear stresses in this location. This will ensure that the existing structure and substrate of the river bed are maintained.

Watercourse Crossing Point 51 (Warcop Junction West)

14.4.5.58 Table 50: Impacts and mitigation measures of Watercourse Crossing Point 51 (Warcop Junction West) explores the mitigation measures required to offset the impacts arising from the proposed works at Watercourse Crossing Point 51 (Warcop Junction West).

Table 50: Impacts and mitigation measures of Watercourse Crossing Point 51 (Warcop Junction West)

WFD Quality Element	Pathway (direct / indirect/ none)	Potential Impact/ Mitigation measures
Hydrology: Quantity and Dynamics of Flow	Direct	**Permanent Impact:** To support the assessment of impacts arising from the installation of the Warcop Junction structure, modelling results presented in Appendix 14.9: Detailed Geomorphological Modelling (Application Document 3.4) have been analysed to provide an improved understanding of potential changes to the quantity and dynamics of flow.

WFD Quality Element	Pathway (direct / indirect/ none)	Potential Impact/ Mitigation measures
		During moderate flood flows, the flood compensation structure contains and stores additional water on the floodplain, which limits the conveyance of flood water on the left bank floodplain of the Moor Beck. Losses in the overland flow route on the left bank floodplain of the Moor Beck will ultimately change the dynamics of flow within the overland flow route. During significant flood flows, the Warcop Junction embankment and the embankment associated with the flood compensation structure have the potential to disrupt existing overland flow routes on the left and right bank floodplain as well as lateral connectivity of the river with its floodplain. The Warcop Junction embankments cause flood water to back up on the left bank floodplain, which result in significant reductions in flow velocities. Within the flood compensation structure, flow velocities reduce significantly as water is captured and stored on the floodplain, and conveyance of flow on the right bank floodplain is slowed down. On the right bank of the Moor Beck where overland flow is redirected back into the channel from the flood compensation structure, flow velocities increase significantly as the embankment associated with the flood compensation structure reduces the conveyance of flow further downstream and encourages flow to re-enter the channel. In summary, the overland flow route on the left bank of the Moor Beck is disrupted by the Warcop Junction West structure in both moderate and significant flood events. This represents a degradation of the existing flow dynamics on the floodplain of the Moor Beck. **Mitigation:** At detailed design, the exact site-specific mitigation necessary to compensate for the disrupted flood flow route will be determined and will include realignment of the channel to increase sinuosity. Increasing the sinuosity of the channel planform and channel restoration will help to re-naturalise the connection between the channel and the floodplain, helping to offset the alteration of flow pathways. Feasibility and design development of this option will be undertaken during detailed design. Any future plans will be developed to ensure there is no change to the conclusions set out within the Habitats Regulations Assessment Stage 1: Likely Significant Effects Habitats (Application Document 3.5) and Regulation Assessment Stage 2: Statement to Inform Appropriate Assessment (Application Document 3.6). Additional geomorphological modelling may be required on an iterative basis to inform detailed design of mitigation. It will be used to demonstrate that the detailed design achieves the outcomes relied upon within the HRA LSE and HRA SIAA and appropriate mitigation is developed to mitigate any potential adverse effects on hydromorphology.

WFD Quality Element	Pathway (direct / indirect/ none)	Potential Impact/ Mitigation measures
Morphology: River Continuity	Direct	**Permanent Impact:** To support the assessment of impacts arising from the installation of the Warcop Junction structure, modelling results presented in Appendix 14.9: Detailed Geomorphological Modelling (Application Document 3.4) have been analysed to provide an improved understanding of potential changes to the quantity and dynamics of flow. During moderate flood flows, the flood compensation structure contains and stores additional water on the floodplain, which limits the conveyance of flood water on the left bank floodplain of the Moor Beck. The loss of the overland flow route on the left bank of the Moor Beck has the potential to disrupt the connectivity between the channel and the floodplain, which is likely to lead to a disruption of the lateral continuity of the watercourse. During significant flood flows, the Warcop Junction embankment and the embankment associated with the flood compensation structure has the potential to disrupt existing overland flow routes on the left and right bank floodplain as well as lateral connectivity of the river with its floodplain. Combined with the additional storage of water on the floodplain within the flood compensation structure, there is the potential for the conveyance of flow and sediment across the Moor Beck channel to be disrupted. In addition, the increased conveyance of flow from the flood compensation structure back into the Moor Beck has the potential to increase flow velocities on the right bank floodplain. Increases in flow velocities on the right bank floodplain are significant enough to cause scour of the right bank of the channel. The addition of fine material into the river system is likely to ultimately lead to a variation in existing sediment transport dynamics. **Mitigation:** The flood compensation structure improves the storage of water on the floodplain upstream of Warcop Junction, which provides improvements to the lateral connectivity between the channel and the floodplain. At detailed design, the exact site-specific mitigation necessary to offset the potential degradation to river continuity associated with the overland flow route on the left bank of the Moor Beck will be determined and will include: • Increasing the roughness of the flood compensation structure through vegetation planting. This would improve the storage of fine material and water during flood events, and therefore improving the lateral continuity of the channel and the floodplain. In addition, this has the potential to provide additional habitat benefits.

WFD Quality Element	Pathway (direct / indirect/ none)	Potential Impact/ Mitigation measures
		• Realignment of the reach of the Moor Beck between the Moor Beck viaduct structure upstream and the Warcop Junction structure downstream. Increasing the sinuosity of the channel planform will encourage more water onto the floodplain during flood events and the subsequent deposition of material onto the floodplain. This will ultimately lead to an improvement in the lateral continuity of the channel and the floodplain. At detailed design, the exact site-specific mitigation measures necessary to mitigate against the potential increased risk of scour to the right bank riverbank of the Moor Beck will be determined and will include: • Riparian planting on the floodplain in the vicinity of the flood compensation structure. This would improve the roughness of the floodplain, and consequently reduce the flow velocities on the floodplain as water is conveyed from the flood compensation structure back into the Moor Beck. • Green scour protection measures on the floodplain where flow is conveyed from the flood compensation structure back into the Moor Beck. Overall, feasibility and design development of these options will be undertaken during detailed design. Any future plans will be developed to ensure there is no change to the conclusions set out within the Habitats Regulations Assessment Stage 1: Likely Significant Effects Habitats (Application Document 3.5) and Regulation Assessment Stage 2: Statement to Inform Appropriate Assessment (Application Document 3.6). Additional geomorphological modelling may be required on an iterative basis to inform detailed design of mitigation. It will be used to demonstrate that the detailed design achieves the outcomes relied upon within the HRA LSE and HRA SIAA and appropriate mitigation is developed to mitigate any potential adverse effects on hydromorphology.
Morphology: River width and depth	Direct	**Permanent Impact:** To support the assessment of impacts arising from the installation of the Warcop Junction structure, modelling results presented in ES Appendix 14.9: Detailed Geomorphological Modelling (Application Document 3.4) have been analysed to provide an improved understanding of potential changes to the quantity and dynamics of flow. During moderate flood flows, the flood compensation structure contains and stores additional water on the floodplain, which limits the conveyance of flood water on the left bank floodplain of the Moor Beck. As a consequence, the embankments on the floodplain

WFD Quality Element	Pathway (direct / indirect/ none)	Potential Impact/ Mitigation measures
		associated with Warcop Junction West are less likely to interact with overland flow routes on the left bank of the Moor Beck during moderate flood flows. This reduces the risk of increased flow velocities on the floodplain and in the channel and therefore the risk of riverbank and bed scour. The additional storage of flood water within the flood compensation structure further reduces any potential increases to in channel flow velocities or shear stresses arising from changes to overland flow routes. Flow velocities and shear stresses within the channel remain unchanged in the baseline and post development scenario in the hydraulic model analysis, and the risk of the channel width or depth changing as a result of increased bed or bank scour is limited. During significant flood flows, increased conveyance of flow from the flood compensation structure back into the Moor Beck has the potential to increase flow velocities on the right bank floodplain. Increases in flow velocities on the right bank floodplain are significant enough to cause scour of the right bank of the channel. However, the additional storage of flood water on the floodplain within the flood compensation structure limits the changes to in channel flow velocities and shear stresses. Shear stress values directly upstream of the Warcop Junction reduce slightly, as the retention of more water on the floodplain reduces the flow velocities within the channel. As such, there is unlikely to be accelerated rates of bed scour in the vicinity of Warcop Junction, only accelerated rates of bank erosion on the right bank of the channel. **Mitigation:** At detailed design, the exact site-specific mitigation measures necessary to mitigate against the potential increased risk of scour to the right bank riverbank of the Moor Beck will be determined and will include: • Riparian planting on the floodplain in the vicinity of the flood compensation structure. This would improve the roughness of the floodplain, and consequently reduce the flow velocities on the floodplain as water is conveyed from the flood compensation structure back into the Moor Beck. • Green scour protection measures on the floodplain where flow is conveyed from the flood compensation structure back into the Moor Beck.
Morphology: Structure and substrate of the river bed	Direct	**Permanent Impact:** To support the assessment of impacts arising from the installation of the Warcop Junction structure, modelling results presented in ES Appendix 14.9: Detailed Geomorphological Modelling (Application Document 3.4) have been analysed to provide an improved understanding of potential changes to the structure and substrate of the river bed.

WFD Quality Element	Pathway (direct / indirect/ none)	Potential Impact/ Mitigation measures
		During moderate flood flows, the flood compensation structure captures and stores additional water on the floodplain, which limits the conveyance of flood water on the left bank floodplain of the Moor Beck. As a consequence, the embankments on the floodplain associated with Warcop Junction West are less likely to interact with overland flow routes on the left bank of the Moor Beck during moderate flood flows. This reduces the risk of increased flow velocities on the floodplain and in the channel and as a consequence the risk of bed scour. The additional storage of flood water within the flood compensation structure further reduces any potential increases to in channel flow velocities or shear stresses arising from changes to overland flow routes. Flow velocities and shear stresses within the channel remain unchanged in the baseline and post development scenario in the hydraulic model analysis. The additional storage of flood water on the floodplain within the flood compensation structure limits the changes to in channel flow velocities and shear stresses. Shear stress values directly upstream of the Warcop Junction reduce slightly, as the retention of more water on the floodplain reduces the flow velocities within the channel. As such, there is unlikely to be accelerated rates of bed scour in the vicinity of Warcop Junction, and therefore the composition of the river bed substrate and the river bed forms are unlikely to change. In addition, the presence of the flood compensation structure provides additional space on the floodplain to store and retain fine sediment within the river system. Additional storage will reduce the conveyance of fine material to downstream reaches, where it has the potential to disrupt the composition of the river bed. The hydraulic model results indicate the storage of material ranging from sands to silts across a range of flood events within the flood compensation structure. **Mitigation:** At detailed design, the exact site-specific mitigation necessary to ensure the retention of existing river bed structure and substrate will be determined and will include: • Realignment of the channel to increase sinuosity. Increasing the sinuosity of the channel planform will ensure the existing diverse range of river bed forms and range of river bed substrate will be maintained. A more sinuous channel planform compared to the exiting planform will increase flow diversity across the realigned reach, encouraging the deposition and transportation of a range of sediment sizes.

WFD Quality Element	Pathway (direct / indirect/ none)	Potential Impact/ Mitigation measures
		• Increasing the roughness of the flood compensation structure through vegetation planting. This would improve the storage of fine material. In addition, this has the potential to provide additional habitat benefits. Feasibility and design development of these options will be undertaken during detailed design. Any future plans will be developed to ensure there is no change to the conclusions set out within the Habitats Regulations Assessment Stage 1: Likely Significant Effects Habitats (Application Document 3.5) and Regulation Assessment Stage 2: Statement to Inform Appropriate Assessment (Application Document 3.6). Additional geomorphological modelling may be required on an iterative basis to inform detailed design of mitigation. It will be used to demonstrate that the detailed design achieves the outcomes relied upon within the HRA LSE and HRA SIAA and appropriate mitigation is developed to mitigate any potential adverse effects on hydromorphology.

Watercourse Crossing Point 52 (Warcop Junction East)

14.4.5.59 Table 51: Impacts and mitigation measures of Watercourse Crossing Point 52 (Warcop Junction East) explores the mitigation measures required to offset the impacts arising from the proposed works at Watercourse Crossing Point 52 (Warcop Junction East).

Table 51: Impacts and mitigation measures of Watercourse Crossing Point 52 (Warcop Junction East)

WFD Quality Element	Pathway (direct / indirect/ none)	Potential Impact/ Mitigation measures
Hydrology: Quantity and Dynamics of Flow	Direct	**Permanent Impact:** To support the assessment of impacts arising from the installation of the Warcop Junction structure, modelling results presented in Appendix 14.9: Detailed Geomorphological Modelling (Application Document 3.4) have been analysed to provide an improved understanding of potential changes to the quantity and dynamics of flow. During moderate flood flows, the flood compensation structure contains and stores additional water on the floodplain, which limits the conveyance of flood water on the left bank floodplain of the Moor Beck. Losses in the overland flow route on the left bank floodplain of the Moor Beck will ultimately change the dynamics of flow within the overland flow route. During significant flood flows, the Warcop Junction embankment and the embankment associated with the flood compensation structure has the potential to disrupt existing overland flow routes on the left and right bank floodplain as well as lateral connectivity

WFD Quality Element	Pathway (direct / indirect/ none)	Potential Impact/ Mitigation measures
		of the river with its floodplain. The Warcop Junction embankments cause flood water to back up on the left bank floodplain, which result in significant reductions in flow velocities. Within the flood compensation structure, flow velocities reduce significantly as water is captured and stored on the floodplain, and conveyance of flow on the right bank floodplain is slowed down. On the right bank of the Moor Beck where overland flow is redirected back into the channel from the flood compensation structure, flow velocities increase significantly as the embankment associated with the flood compensation structure reduces the conveyance of flow further downstream and encourages flow to re-enter the channel. In summary, the overland flow route on the left bank of the Moor Beck is disrupted by the Warcop Junction East structure in both moderate and significant flood events. This represents a degradation of the existing flow dynamics on the floodplain of the Moor Beck. **Mitigation:** At detailed design, the exact site-specific mitigation necessary to compensate for the disrupted flood flow route will be determined and will include realignment of the channel to increase sinuosity. Increasing the sinuosity of the channel planform will help to re-naturalise the connection between the channel and the floodplain, helping to offset the alteration of flow pathways. Feasibility and design development of this option will be undertaken during detailed design. Any future plans will be developed to ensure there is no change to the conclusions set out within the Habitats Regulations Assessment Stage 1: Likely Significant Effects Habitats (Application Document 3.5) and Regulation Assessment Stage 2: Statement to Inform Appropriate Assessment (Application Document 3.6). Additional geomorphological modelling may be required on an iterative basis to inform detailed design of mitigation. It will be used to demonstrate that the detailed design achieves the outcomes relied upon within the HRA LSE and HRA SIAA and appropriate mitigation is developed to mitigate any potential adverse effects on hydromorphology.
Morphology: River Continuity	Direct	**Permanent Impact:** To support the assessment of impacts arising from the installation of the Warcop Junction structure, modelling results presented in ES Appendix 14.9: Detailed Geomorphological Modelling (Application Document 3.4) have been analysed to provide an improved understanding of potential changes to the quantity and dynamics of flow.

WFD Quality Element	Pathway (direct / indirect/ none)	Potential Impact/ Mitigation measures
		During moderate flood flows, the flood compensation structure contains and stores additional water on the floodplain, which limits the conveyance of flood water on the left bank floodplain of the Moor Beck. The loss of the overland flow route on the left bank of the Moor Beck has the potential to disrupt the connectivity between the channel and the floodplain, which is likely to lead to a disruption of the lateral continuity of the watercourse. During significant flood flows, the Warcop Junction embankment and the embankment associated with the flood compensation structure has the potential to disrupt existing overland flow routes on the left and right bank floodplain as well as lateral connectivity of the river with its floodplain. Combined with the additional storage of water on the floodplain within the flood compensation structure, there is the potential for the conveyance of flow and sediment across the Moor Beck channel to be disrupted. In addition, the increased conveyance of flow from the flood compensation structure back into the Moor Beck has the potential to increase flow velocities on the right bank floodplain. Increases in flow velocities on the right bank floodplain are significant enough to cause scour of the right bank of the channel. The addition of fine material into the river system is likely to ultimately lead to a variation in existing sediment transport dynamics. **b** The flood compensation structure improves the storage of water on the floodplain upstream of Warcop Junction, which provides improvements to the lateral connectivity between the channel and the floodplain. At detailed design, the exact site-specific mitigation necessary to offset the potential degradation to river continuity associated with the overland flow route on the left bank of the Moor Beck will be determined and will include: • Increasing the roughness of the flood compensation structure through vegetation planting. This would improve the storage of fine material and water during flood events, and therefore improving the lateral continuity of the channel and the floodplain. In addition, this has the potential to provide additional habitat benefits. • Realignment of the reach of the Moor Beck between the Moor Beck viaduct structure upstream and the Warcop Junction structure downstream. Increasing the sinuosity of the channel planform will encourage more water onto the floodplain during flood events and the subsequent deposition of material onto the floodplain. This will ultimately lead to an improvement in the lateral continuity of the channel and the floodplain.

WFD Quality Element	Pathway (direct / indirect/ none)	Potential Impact/ Mitigation measures
		At detailed design, the exact site-specific mitigation measures necessary to mitigate against the potential increased risk of scour to the right bank riverbank of the Moor Beck will be determined and will include: • Riparian planting on the floodplain in the vicinity of the flood compensation structure. This would improve the roughness of the floodplain, and consequently reduce the flow velocities on the floodplain as water is conveyed from the flood compensation structure back into the Moor Beck. • Green scour protection measures on the floodplain where flow is conveyed from the flood compensation structure back into the Moor Beck. Overall, feasibility and design development of these options will be undertaken during detailed design. Any future plans will be developed to ensure there is no change to the conclusions set out within the Habitats Regulations Assessment Stage 1: Likely Significant Effects Habitats (Application Document 3.5) and Regulation Assessment Stage 2: Statement to Inform Appropriate Assessment (Application Document 3.6). Additional geomorphological modelling may be required on an iterative basis to inform detailed design of mitigation. It will be used to demonstrate that the detailed design achieves the outcomes relied upon within the HRA LSE and HRA SIAA and appropriate mitigation is developed to mitigate any potential adverse effects on hydromorphology.
Morphology: River width and depth	Direct	**Permanent Impact:** To support the assessment of impacts arising from the installation of the Warcop Junction structure, modelling results presented in ES Appendix 14.9: Detailed Geomorphological Modelling (Application Document 3.4) have been analysed to provide an improved understanding of potential changes to the quantity and dynamics of flow. During moderate flood flows, the flood compensation structure contains and stores additional water on the floodplain, which limits the conveyance of flood water on the left bank floodplain of the Moor Beck. As a consequence, the embankments on the floodplain associated with Warcop Junction East are less likely to interact with overland flow routes on the left bank of the Moor Beck during moderate flood flows. This reduces the risk of increased flow velocities on the floodplain and in the channel and therefore the risk of riverbank and bed scour. The additional storage of flood water within the flood compensation structure further reduces any potential increases to in channel flow velocities or shear stresses arising from changes to overland flow routes. Flow velocities and

WFD Quality Element	Pathway (direct / indirect/ none)	Potential Impact/ Mitigation measures
		shear stresses within the channel remain unchanged in the baseline and post development scenario in the hydraulic model analysis, and the risk of the channel width or depth changing as a result of increased bed or bank scour is limited. During significant flood flows, increased conveyance of flow from the flood compensation structure back into the Moor Beck has the potential to increase flow velocities on the right bank floodplain. Increases in flow velocities on the right bank floodplain are significant enough to cause scour of the right bank of the channel. However, the additional storage of flood water on the floodplain within the flood compensation structure limits the changes to in channel flow velocities and shear stresses. Shear stress values directly upstream of the Warcop Junction reduce slightly, as the retention of more water on the floodplain reduces the flow velocities within the channel. As such, there is unlikely to be accelerated rates of bed scour in the vicinity of Warcop Junction, only accelerated rates of bank erosion on the right bank of the channel. **Mitigation:** At detailed design, the exact site-specific mitigation measures necessary to mitigate against the potential increased risk of scour to the right bank riverbank of the Moor Beck will be determined and will include: • Riparian planting on the floodplain in the vicinity of the flood compensation structure. This would improve the roughness of the floodplain, and consequently reduce the flow velocities on the floodplain as water is conveyed from the flood compensation structure back into the Moor Beck. • Green scour protection measures on the floodplain where flow is conveyed from the flood compensation structure back into the Moor Beck.
Morphology: Structure and substrate of the river bed	Direct	**Permanent Impact:** To support the assessment of impacts arising from the installation of the Warcop Junction structure, modelling results presented in ES Appendix 14.9: Detailed Geomorphological Modelling (Application Document 3.4) have been analysed to provide an improved understanding of potential changes to the structure and substrate of the river bed. During moderate flood flows, the flood compensation structure captures and stores additional water on the floodplain, which limits the conveyance of flood water on the left bank floodplain of the Moor Beck. As a consequence, the embankments on the floodplain associated with Warcop Junction East are less likely to interact with overland flow routes on the left bank of the Moor Beck during

WFD Quality Element	Pathway (direct / indirect/ none)	Potential Impact/ Mitigation measures
		moderate flood flows. This reduces the risk of increased flow velocities on the floodplain and in the channel and as a consequence the risk of bed scour. The additional storage of flood water within the flood compensation structure further reduces any potential increases to in channel flow velocities or shear stresses arising from changes to overland flow routes. Flow velocities and shear stresses within the channel remain unchanged in the baseline and post development scenario in the hydraulic model analysis. The additional storage of flood water on the floodplain within the flood compensation structure limits the changes to in channel flow velocities and shear stresses. Shear stress values directly upstream of the Warcop Junction reduce slightly, as the retention of more water on the floodplain reduces the flow velocities within the channel. As such, there is unlikely to be accelerated rates of bed scour in the vicinity of Warcop Junction, and therefore the composition of the river bed substrate and the river bed forms are unlikely to change. In addition, the presence of the flood compensation structure provides additional space on the floodplain to store and retain fine sediment within the river system. Additional storage will reduce the conveyance of fine material to downstream reaches, where it has the potential to disrupt the composition of the river bed. The hydraulic model results indicate the storage of material ranging from sands to silts across a range of flood events within the flood compensation structure. **Mitigation:** At detailed design, the exact site-specific mitigation necessary to ensure the retention of existing river bed structure and substrate will be determined and will include: Realignment of the channel to increase sinuosity. Increasing the sinuosity of the channel planform will ensure the existing diverse range of river bed forms and range of river bed substrate will be maintained. A more sinuous channel planform compared to the exiting planform will increase flow diversity across the realigned reach, encouraging the deposition and transportation of a range of sediment sizes. • Increasing the roughness of the flood compensation structure through vegetation planting. This would improve the storage of fine material. In addition, this has the potential to provide additional habitat benefits. Feasibility and design development of these options will be undertaken during detailed design. Any future plans will be

WFD Quality Element	Pathway (direct / indirect/ none)	Potential Impact/ Mitigation measures
		developed to ensure there is no change to the conclusions set out within the Habitats Regulations Assessment Stage 1: Likely Significant Effects Habitats (Application Document 3.5) and Regulation Assessment Stage 2: Statement to Inform Appropriate Assessment (Application Document 3.6). Additional geomorphological modelling may be required on an iterative basis to inform detailed design of mitigation. It will be used to demonstrate that the detailed design achieves the outcomes relied upon within the HRA LSE and HRA SIAA and appropriate mitigation is developed to mitigate any potential adverse effects on hydromorphology.

Watercourse Crossing Point 18 (Broomrigg Culvert)

14.4.5.60 Table 52: Impacts and mitigation measures of Watercourse Crossing Point 51 (Broomrigg Culvert) explores the mitigation measures required to offset the impacts arising from the proposed works at Watercourse Crossing Point 18 (Broomrigg Culvert).

Table 52: Impacts and mitigation measures of Watercourse Crossing Point 51 (Broomrigg Culvert)

WFD Quality Element	Pathway (direct / indirect/ none)	Potential Impact/ Mitigation measures
Hydrology: Quantity and Dynamics of Flow	Direct	**Permanent Impact:** To accommodate the installation of the portal culvert, the channel will need to be realigned, and the channel planform will be straightened, leading to a reduction in overall channel length. This will result in an increase in channel gradient and is likely to lead to an increase in in-channel flow velocities and shear stress. The total loss of channel length as a result of the realignment is approximately 40m. This is likely to have an impact on the existing flow biotopes observed within the channel, as well flow dynamics within the channel and in the vicinity of the Lowgill confluence. As such, there is the potential for flow dynamic disruption on both the Unnamed Tributary of the Lowgill Beck 6.1 and the Lowgill Beck. **Mitigation:** To understand the impact of the culvert and channel realignment on the quantity and dynamics of flow, additional hydraulic modelling analysis using both low flows and flood flows will be conducted. Using shear stress, velocity and water level analysis, the implications of increasing the channel gradient and removing the existing culvert conveying the Unnamed Tributary of the Lowgill Beck 6.1 beneath the existing A66 carriageway can be fully understood. Modifications to the realigned channel geometry, including the width and depth of the channel, and channel gradient can then be investigated during detailed design to encourage natural geomorphological processes to be maintained and

WFD Quality Element	Pathway (direct / indirect/ none)	Potential Impact/ Mitigation measures
		improved. It is required that a geomorphologist is included within the design team to ensure that the channel is designed to encourage and promote geomorphological processes.
Morphology: River width and depth	Direct	**Permanent Impact:** The decrease in channel length caused by the realignment will result in a corresponding increase in channel gradient. This has the potential to increase in-channel flow velocities and shear stress, which is likely to lead to bed erosion and channel incision processes and result in an increase in channel depth over time. **Mitigation:** To understand the impact of the culvert and channel realignment on the width and depth of the channel, additional hydraulic modelling analysis using both low flows and flood flows will be conducted. Using shear stress, velocity and water level analysis, the implications of increasing the channel gradient and removing the existing culvert conveying the Unnamed Tributary of the Lowgill Beck 6.1 beneath the existing A66 carriageway can be fully understood. Modifications to the realigned channel geometry, including the width and depth of the channel, and channel gradient can then be investigated during detailed design to encourage natural geomorphological processes to be maintained and improved. It is required that a geomorphologist is included within the design team to ensure that the channel is designed to encourage and promote geomorphological processes.
Morphology: Structure and substrate of the river bed	Direct	**Permanent Impact:** There is the risk that the condition of the bed substrate within the realigned channel may be degraded as part of these works. Following the excavation of the realigned channel, appropriate river bed substrate will need to be placed on the river bed to ensure that the existing structure and substrate of the river bed is maintained, and that the risk of bed scour is not exacerbated. **Mitigation:** Appropriate river bed substrate will need to be placed on the bed of the realigned channel through the portal culvert to reduce the risk of degradation to the structure and substrate of the river bed. The river bed material in the section of channel that will be offline following the completion of the channel realignment should be redistributed in the realigned channel, to maintain the existing substrate of the river bed as much as possible. Following the potential for increased flow velocities and bed scour identified in Table 45: Assessment of works at Watercourse Crossing Point 18 (Broomrigg Culvert) on the Unnamed Tributary of the Lowgill Beck 6.1, against the hydromorphological quality elements for the Low Gill (Crooks Beck) water body catchment. Comparisons of existing and post development shear stresses and flow velocities within the

WFD Quality Element	Pathway (direct / indirect/ none)	Potential Impact/ Mitigation measures
		realigned and de-culverted channel through a range of flows from low flows to flood flows will be necessary to ensure that the relocated, site-won material is suitable for re-use within the channel. The sediment size distribution may need to be adjusted, depending on the findings of the hydraulic modelling study to ensure that natural geomorphological processes are be maintained and improved, where possible.

Watercourse Crossing Point 59 and 19 (Low Gill Culvert)

14.4.5.61 Table 53: Impacts and mitigation measures of Watercourse Crossing Point 59 and 19 (Low Gill Culvert) explores the mitigation measures required to offset the impacts arising from the proposed works at Watercourse Crossing Point 59 and 19 (Low Gill Culvert).

Table 53: Impacts and mitigation measures of Watercourse Crossing Point 59 and 19 (Low Gill Culvert)

WFD Quality Element	Pathway (direct / indirect/ none)	Potential Impact/ Mitigation measures
Hydrology: Quantity and Dynamics of Flow	Direct	**Permanent Impact:** The proposed works will lead to a loss of open channel on the Low Gill. The subsequent extension of the Low Gill culvert will alter the dynamics of flow (e.g., flow velocity, water depth, wetted area etc.). The Yosgill Sike and Woodend Sike will be realigned to accommodate this culvert extension, which will reduce the existing channel sinuosity, and result in a loss in flow heterogeneity. In addition, the channel planform will be shortened as a result of the channel realignment, leading an increase in channel gradient and potentially an increase in in-channel flow velocities and shear stress. This is likely to have an impact on the existing flow biotopes observed within the channel, as well as the dynamics of flow within the channel. **Mitigation:** To offset the loss of natural flow dynamics and diversity on the Low Gill Beck, Yosgill Sike and Woodend Sike, riparian planting of tree cover is to be undertaken and a riparian buffer strip will be created on the Yosgill Sike and Woodend Sike. The introduction of a dense riparian buffer strip along the river banks of both watercourses upstream of the structure will provide a natural source of woody material to the watercourse. Naturally occurring woody material in the channel increases flow and sediment diversity, which encourages localised variation in flow velocities. This develops a natural pattern of river width and depth diversity over time, which contributes to naturally sinuous flow mechanics developing across

WFD Quality Element	Pathway (direct / indirect/ none)	Potential Impact/ Mitigation measures
		a river reach. The natural introduction of woody material into the channel can be assisted by installing root wads or securing large wood at strategic locations along the Yosgill or Woodend Sike. This would restore the potential loss of flow diversity as a result of the proposed culvert extension and channel realignment. In addition, the channel realignment design for the Yosgill Sike and Woodend Sike will be steered by input from a geomorphologist and ecologist. This would facilitate a more natural, sinuous channel planform to be incorporated into the design, with the opportunity to include enhanced riparian and fluvial habitat. This would provide significant geomorphological benefits to the Low Gill Beck, Yosgill Sike and Woodend Sike. To understand the impact on the quantity and dynamics of flow, additional hydraulic modelling analysis using both low flows and flood flows is required. Using shear stress, velocity and water level analysis, the implications of increasing the channel gradient can be fully understood. Modifications to the realigned channel geometry, including the width and depth of the channel, and channel gradient will be investigated to encourage natural geomorphological processes to be maintained and improved.
Morphology: River width and depth	Direct	**Permanent Impact:** The replacement of open channel with the proposed culvert extension will result in a change to the existing width and depth of the Low Gill Beck. Following the completion of the culvert extension, the width and depth of the channel will be dictated by the geometry of the culvert barrel. The Yosgill Sike and Woodend Sike will be realigned to accommodate this culvert extension, which will result in a homogenous channel width and depth. **Mitigation:** To offset the loss of natural diversity in channel width and depth on the Low Gill Beck, Yosgill Sike and Woodend Sike, riparian planting of tree cover is to be undertaken on the Yosgill Sike and Woodend Sike. The introduction of a dense riparian buffer strip along the river banks of both watercourses upstream of the structure will provide a natural source of woody material to the watercourse. Naturally occurring woody material in the channel increases flow diversity and encourages localised scour of riverbanks and deposition of sediment in the channel margins. This develops a natural pattern of river width and depth diversity over time. The natural introduction of woody material into the channel can be assisted by installing root wads or securing large wood at strategic locations along the Yosgill or Woodend Sike.

WFD Quality Element	Pathway (direct / indirect/ none)	Potential Impact/ Mitigation measures
		In addition, the channel realignment design for the Yosgill Sike and Woodend Sike will be steered by input from a geomorphologist and ecologist. Comparisons of existing and post development shear stresses, flow velocities and water levels within the realigned channels through a range of flows from low flows to flood flows will be necessary to investigate the implementation of a suitable bed material grain size distribution. This will facilitate and encourage natural geomorphological processes to be maintained and improved. This would facilitate a more natural, sinuous channel planform to be incorporated into the design, with the opportunity to incorporate enhanced riparian and fluvial habitat. This would provide significant geomorphological benefits to the Low Gill Beck, Yosgill Sike and Woodend Sike.
Morphology: Structure and substrate of the river bed	Direct	**Permanent Impact:** The extension of the Low Gill Culvert upstream will result in the loss of the natural river bed substrate, which will be replaced with a concrete culvert barrel. In addition, natural river bed substrate on the Yosgill Sike and Woodend Sike, including geomorphological river bed structures, will be lost when both watercourses are realigned to accommodate the culvert extension. This combined loss of the existing structure and substrate of the river bed reflects a degradation of the river bed compared with current conditions. There is the risk that the condition of the bed substrate within the realigned channels of the Yosgill Sike and Woodend Sike may be degraded as part of these works. Following the excavation of the realigned channel, appropriate river bed substrate will need to be placed on the river bed to ensure that the existing structure and substrate of the river bed is maintained, and that the risk of bed scour is not exacerbated. **Mitigation:** To offset the loss and degradation of the natural river bed substrate on the Low Gill Beck, Yosgill Sike and Woodend Sike, riparian planting of tree cover is to be undertaken and a riparian buffer strip will be created on the Yosgill Sike and Woodend Sike. The introduction of a dense riparian buffer strip along the river banks of both watercourses upstream of the structure will provide a natural source of woody material to the watercourse. Naturally occurring woody material in the channel increases the localised diversity in sediment transport mechanics, encouraging localised pockets of sediment deposition and erosion, generating a heterogeneous river bed structure. The natural introduction of woody material into the channel can be assisted by installing root wads or securing large wood at strategic locations along the Yosgill or Woodend Sike.

WFD Quality Element	Pathway (direct / indirect/ none)	Potential Impact/ Mitigation measures
		Following the potential for increased flow velocities and bed scour identified in Table 46: Assessment of works at Watercourse Crossing Point 59 and 19 (Low Gill Culvert) on the Low Gill, against the hydromorphological quality elements for the Low Gill (Crooks Beck) water body catchment., comparisons of existing and post development shear stresses and flow velocities within the realigned channel through a range of flows from low flows to flood flows will be necessary to investigate the implementation of a suitable bed material grain size distribution. This will facilitate and encourage natural geomorphological processes to be maintained and improved. In addition, locally sourced, natural river gravels will be introduced into the proposed realigned channels of the Yosgill Sike and Woodend Sike. The material introduced to the realigned channel should be similar to the naturally occurring river bed material in adjacent reaches. A mix of sediment sizes and clasts will be used, to introduce diversity in the range of sediment clasts in the river bed structure.
Morphology: Structure of the riparian zone	Direct	**Permanent Impact:** The extension of the Low Gill Culvert will involve the replacement of the existing riparian zone with an embankment to support the existing A66. The replacement of a section of open channel with a culvert barrel will significantly reduce the connectivity of the watercourse to the riparian zone and surrounding floodplain. The realignment of the Yosgill Sike and Woodend Sike will result in the loss of existing riparian habitats on both these watercourses, particularly the riparian buffer strip on the Woodend Sike. This combined loss of riparian zone and floodplain connectivity will lead to a degradation of the riparian zone on the Low Gill. **Mitigation:** To offset the loss of riparian habitat and structure, riparian planting of tree cover along the riverbanks of the Yosgill Sike and Woodend Sike will be undertaken and a riparian buffer strip will be created. Planting riparian woodland in this reach will mitigate against the risk of riparian habitat degradation associated with the extension of the Low Gill Culvert and the realignment of the Yosgill Sike and Woodend Sike. Moreover, riparian planting will provide additional geomorphological benefits such as improved floodplain connectivity, improved riverbank integrity and resistance to scour, and improved habitat space for the watercourses.

Water body mitigation measures

14.4.5.62 Both the Eden - Scandal to Lyvennet water body and Low Gill (Crooks Beck) water body are not designated as heavily modified or artificial. Therefore, there are no hydromorphology mitigation measures assigned to the water body identified in the Solway Tweed River Basin Management Plan 2021.

WFD hydromorphology assessment objectives

Table 54: Hydromorphology assessment of proposed works against WFD objectives for the Solway Tweed River Basin Management Plan 2021

WFD Hydromorphology Assessment Objectives	Assessment of works
Objective 1: The proposed works do not cause deterioration in the Status of the Hydromorphology Elements of the water body	Adherence to the stipulated mitigation measures detailed in Table 48: Impacts and mitigation measures of Watercourse Crossing Point 12 and 13 (Cringle Beck Crossing) to Table 53 and section 14.4.9 will ensure the proposed works will not cause a deterioration ton the status of the hydromorphology quality elements of the Eden - Scandal to Lyvennet water body and Low Gill (Crooks Beck) water body.
Objective 2: The proposed works do not compromise the ability of the water body to achieve its WFD status objectives	The proposed works do not compromise the ability of the Eden - Scandal to Lyvennet water body and Low Gill (Crooks Beck) water body. to achieve Good hydromorphological status, provided the mitigation measures detailed in Table 48: Impacts and mitigation measures of Watercourse Crossing Point 12 and 13 (Cringle Beck Crossing) to Table 53 and section 14.4.9 are adhered to.
Objective 3: The proposed works do not cause a permanent exclusion or compromised achievement of the WFD objectives in other bodies of water within the same RBD	Impacts arising from the proposals at the scheme will be direct and local to the fluvial environment on site. The impacts arising from the proposed works will not impact on areas elsewhere in the catchment and will not impact other WFD waterbodies within the RBMP.
Objective 4: The proposed works contribute to the delivery of the WFD objectives	The proposed works will contribute to the delivery of the WFD objectives by ensuring no detrimental impact to the water body at the water body scale for both the Eden - Scandal to Lyvennet water body and Low Gill (Crooks Beck) water body, and by providing localised hydromorphological enhancements, provided the mitigation measures detailed in Table 48: Impacts and mitigation measures of Watercourse Crossing Point 12 and 13 (Cringle Beck Crossing) to Table 53 and Section 14.4.9 are adhered to.

Appleby to Brough key considerations

14.4.5.63 The impact assessment determines whether the proposed works have the potential to significantly impact any of the hydromorphology quality elements screened into the assessment. Specific mitigation measures required to prevent the deterioration of specific quality elements are considered in Table 53: Impacts and mitigation measures of Watercourse Crossing Point 59 and 19 (Low Gill Culvert). Additional mitigation measures to be considered at each of the proposed structures screened into the assessment are listed in section 14.4.9.

14.4.5.64 The mitigation measures stipulated within the impact assessment are secured by the Project Design Principles (Application Document 5.11) and the Environmental Management Plan (Application Document 2.7), which are certified documents under DCO.

14.4.5.65 As part of National Highway's maintenance, inspections of potential scour on the Moor Beck Viaduct and Warcop Junction will be conducted. Should any adverse changes be reported, appropriate mitigation plans to address this will be developed and implemented by National Highways, The enviornment Agency and Natural England will be consulted on impacts to geomorphology.

Summary

14.4.5.66 The WFD scoping stage (Stage 2) identified that the proposed works at the following watercourse crossing points assessed will have a detrimental impact to the Low Gill (Crooks Beck) WFD water body without appropriate **mitigation:**

- WCP 12 and 13 (Cringle Beck Crossing)
- WCP 50 and 15 (Moor Beck Viaduct)
- WCP 51 (Warcop Junction West)
- WCP 52 (Warcop Junction East)
- WCP 18 (Broomgrigg Culvert)
- WCP 59 and 19 (Low Gill Culvert).

14.4.5.67 The works proposed at Appleby to Brough are likely to directly impact the following hydromorphology quality elements for the Low Gill (Crooks Beck) water body without appropriate **mitigation:**

- Hydrology: Quantity and Dynamics of flow
- Morphology: Structure and substrate of the river bed
- Morphology: River continuity
- Morphology: River width and depth
- Morphology: Structure of the riparian zone.

14.4.5.68 The mitigation and compensation measures required to achieve the WFD objectives required include:

- Green scour protection measures
- Realignment of the Cringle Beck to increase sinuosity
- Realignment of the Moor Beck to increase sinuosity and reduce scour risk
- Riparian planting on the floodplain in the vicinity of the flood compensation structure associated with Warcop Junction and Moor Beck Viaduct to increase roughness
- Hydraulic Modelling to understand the impact on quantity and dynamics of flow and structure and substrate of the river bed
- Continued monitoring of the Moor Beck Viaduct, Warcop Junction West and Warcop junction East embankments will be required to assess the rate of bank erosion, retreat and channel planform migration
- Further hydraulic modelling of the Moor Beck Viaduct, Warcop Junction West and Warcop junction East embankments and

refinement of design during detailed design to ensure no change in potential effect on geomorphology.

14.4.5.69 The assessment reported in this assessment is based on a precautionary worst case scenario. As such, the mitigation identified in this assessment as being required to mitigate the likely significant effects reported are based on this worst case scenario. It may be the case that as detailed design of the Project evolves, it becomes apparent that a lesser form of mitigation is required to achieve the same outcome. As such, the EMP secures the 'maximum' extent of mitigation required (as identified in this assessment) but also, where appropriate, includes mechanisms (e.g. by way of further surveys or modelling) to establish, pre-construction and during detailed design, whether the identified mitigation can be refined such that a lesser extent is required to achieve the outcome reported in this assessment. The fundamental point is that the mitigation identified in this assessment is secured by the EMP, where required to achieve the outcome reported in this assessment.

14.4.6 Bowes Bypass

Scheme Overview and proposed works

Scheme location

14.4.6.1 The scheme location for Bowes Bypass, and the proposed watercourse crossing points, are shown in Plate 15: Scheme location for Bowes Bypass and proposed watercourse crossing points.

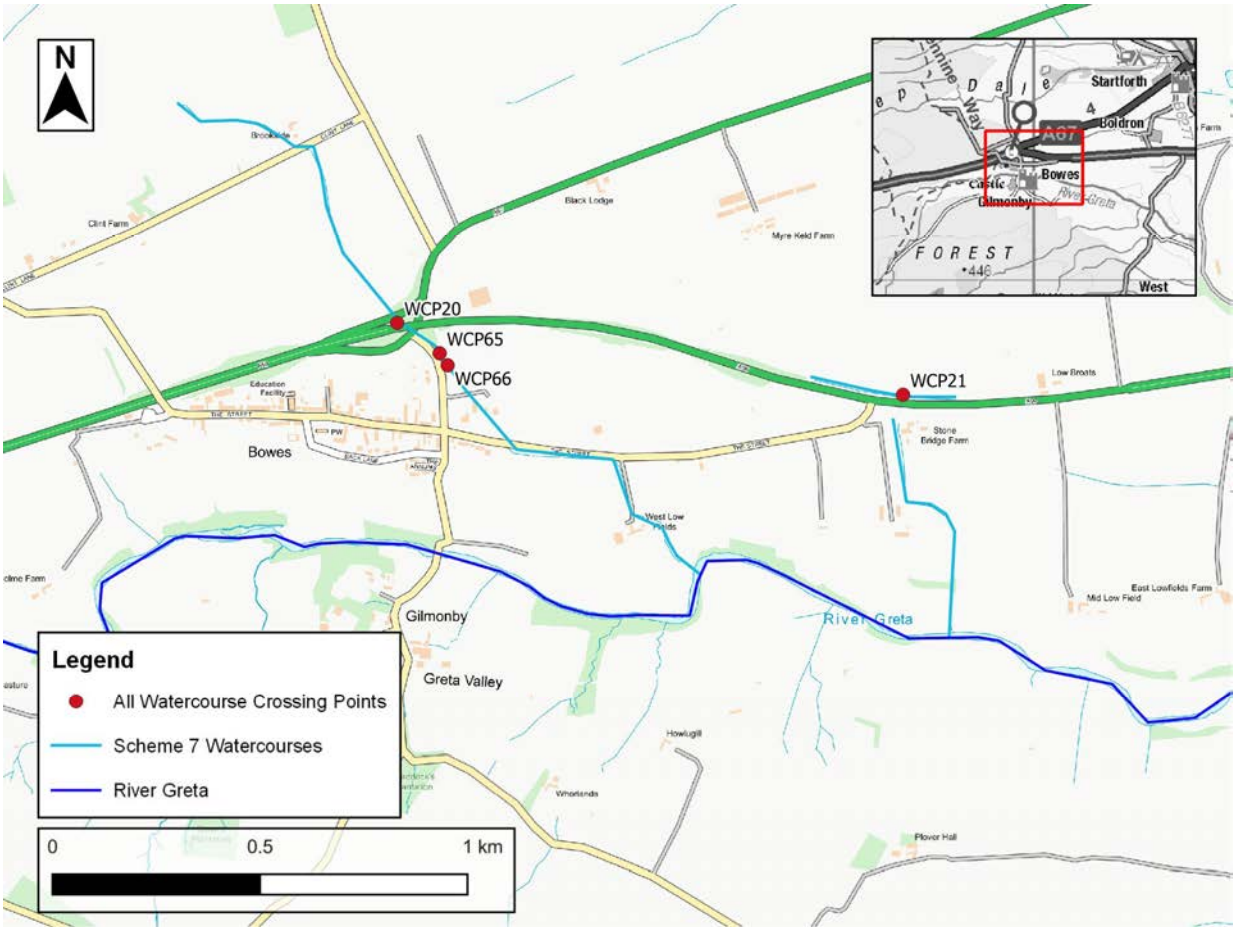

Plate 15: Scheme location for Bowes Bypass and proposed watercourse crossing points

Proposed works

14.4.6.2 The proposed works at each identified watercourse crossing point in Plate 15: Scheme location for Bowes Bypass and proposed watercourse crossing points are summarised in the following sections.

Watercourse Crossing Points 20, 65 and 66 (Culvert S07-C01)

- An existing pipe culvert to be extended by 37.94m upstream at WCP 20 with varying diameters.
- At WCP 20 the diameter will be 0.45m.
- At WCP 65 the diameter will be 0.525m.
- At WCP 66 the diameter will be 0.675m.

Watercourse Crossing Point 21 (Culvert S07-C04)

- An existing pipe culvert to be extended by 17.92m with a diameter matching the existing culvert, which is 0.66m.

Baseline hydromorphology desktop study

Survey scope

14.4.6.3 The Scheme 7 Watercourse Crossing Points are located within the Greta from Sleightholme Beck to Eller Beck water body catchment (ES Figure 14.3: WFD Surface Water Bodies (Application Document 3.3)). The following section provides a summary of the geomorphological characteristics of this catchment.

Catchment and character

14.4.6.4 The source of the River Greta lies in the North Pennines AONB, approximately 10km west of the village of Bowes. The River Greta rises at an elevation of approximately 407mAOD and flows downstream in an easterly direction. The Greta from Sleightholme Beck to Eller Beck water body drains an area of 17.81 km^2. The water body begins in East Bowes and flows downstream in an easterly direction through Bowes for approximately 7km.

14.4.6.5 The water body catchment Greta from Sleightholme Beck to Eller Beck is in the Pennine hills and is primarily rural with areas of grassland, woodland, and farmland. Stainmore Forest lies south of the water body.

14.4.6.6 The geology within the Greta from Sleightholme Beck to Eller Beck water body catchment is mixed. The geology in the north of the catchment is Stainmore Formation, characterised by Mudstone, Siltstone and Sandstone. In the south of the catchment, the geology is Alston Formation, characterised by Limestone, Sandstone, Siltstone and Mudstone.

Historic trend analysis

14.4.6.7 There has been very little change to the river system in the c. 130 years since the earliest mapping available online. There has not been significant change to the River Greta planform, which can be attributed to the topography within the catchment as the River Greta is confined by the Pennine hills. Bowes is situated in the Greta Valley with steep valleys and narrow floodplains preventing channel migration. In addition to steep valleys, urbanisation can be attributed to the channel confinement of the Bowes Bypass watercourses. Since before 1888, the watercourses have been managed and restricted to prevent flooding of the urban settlement of Bowes. The eastern watercourse previously flowed through Bowes Railway station which operated between 1861 and 1962.

Assessment of LiDAR Data

14.4.6.8 The palaeo channels identified in Areas 1, 2 and 3 (Plate 16: Assessment of palaeo channels in the vicinity of Bowes Bypass) indicate that the River Greta has migrated slightly but not to a large extent. Historic mapping does not indicate any channel migration. This suggests that any changes in the channel form of the River Greta occurred prior to 1897. This can be attributed to the topography of the water body catchment. The River Greta has been confined by a steep valley and narrow floodplain.

14.4.6.9 LiDAR data suggests that the Bowes Bypass watercourses have reduced in sinuosity. To the north of Bowes, in Area 4, palaeo channels indicate a more active, meandering channel on the left-hand floodplain (Plate 16: Assessment of palaeo channels in the vicinity of Bowes Bypass). It is probable that the channel has been straightened and moved to increase the availability of agricultural land.

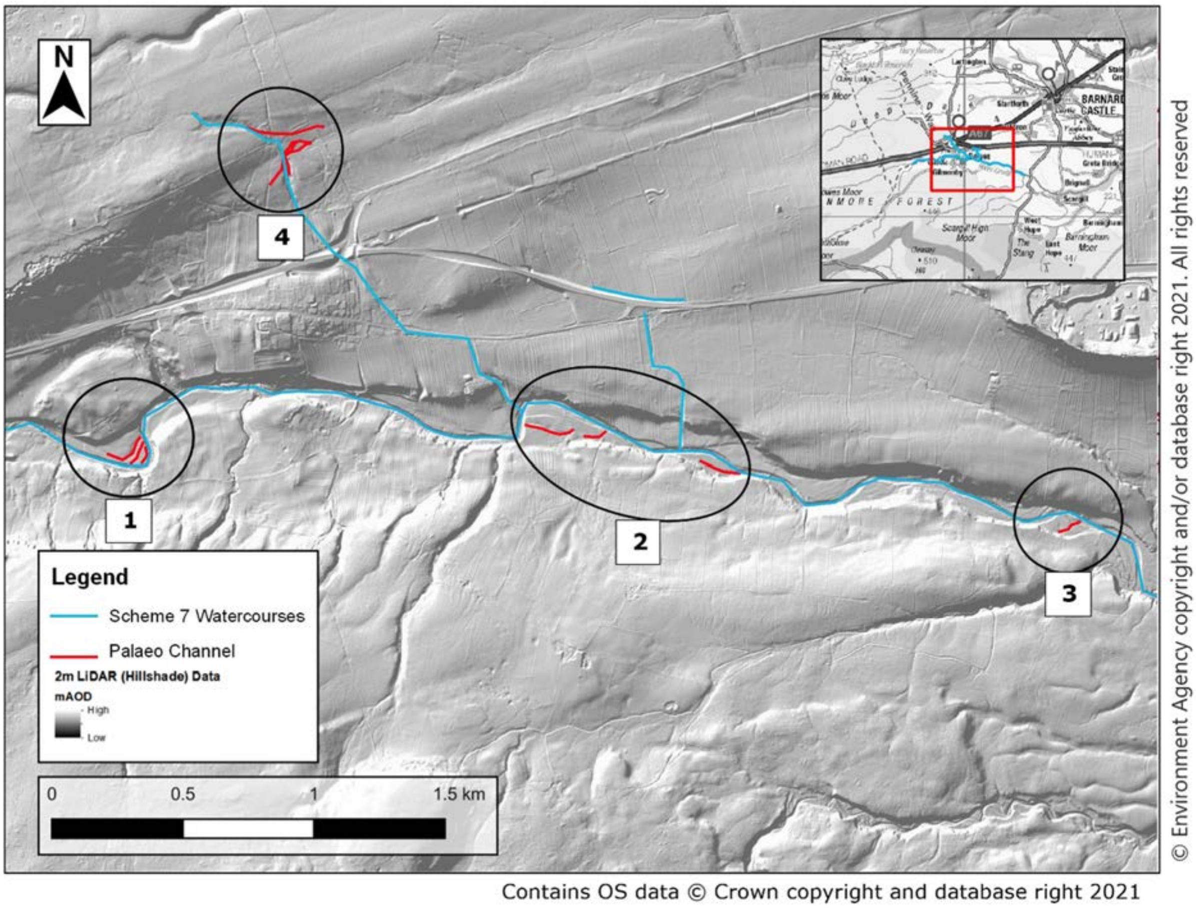

Plate 16: Assessment of palaeo channels in the vicinity of Bowes Bypass

Baseline hydromorphology site observations

Table 55: Baseline hydromorphology for each water body

Crossing Point/ Watercourse	Site Observations
WCP20 - Unnamed Tributary of River Greta 7.3	**Wider Catchment Characteristics:** The Unnamed Tributary rises in Bowes, to the east of Tallentire J K Farm and to the south of the Bessy Sike. The watercourse flows in a south easterly direction for approximately 305m before it is culverted beneath Clint Lane. The watercourse continues to flow for approximately 280m in a south easterly direction towards a second culvert at the Old Armoury Campsite. Past the second culvert, the watercourse continues to flow in a

Crossing Point/ Watercourse	Site Observations
	south easterly direction for a further 180m, towards the existing A66. At the existing A66, the watercourse is culverted. The watercourse remains culverted as it flows through the village of Bowes for approximately 450m, until it passes beneath The Street in Gilmonby. At Gilmonby, the watercourse flows through the West Low Fields in a south easterly direction and is discharged into the River Greta. Photographs of the location are shown in Annex A: Site Photograph Locations. **Observed In-Channel Modifications:** • Culvert at Clint Lane • Informal bridge structure immediately downstream of the culvert at Clint Lane • Outfall in the channel at the Old Armoury Campsite • Culvert further downstream at the field boundary at the Old Armoury Campsite **Typical Flow Biotopes:** Immediately downstream of the culvert at Clint Lane the flow velocities within the Unnamed Tributary channel are low and the watercourse is ponded. Construction of an informal bridge structure immediately downstream of the culvert has resulted in an overwide channel cross section. The result is a shallow gradient and low flow velocity. In this location, deposition of sediment and debris has impounded the flow. Downstream of the bridge structure, the channel is overgrown with vegetation and gliding flows are the typical flow biotope within the channel in this reach. Flow and channel sinuosity increases slightly further downstream. On approach to the second culvert at the Old Armoury Campsite field boundary, flow energy reduces. It is likely that the shallower channel gradient, combined with an increase in vegetation along the riparian zone causes a reduction in flow energy. Flow dynamics downstream at the A66 were not observable as the channel is culverted through the village of Bowes until it reaches Gilmonby. **Typical Bed Substrate:** Along the Unnamed Tributary, the typical bed substrate comprises of fine sediment including sands and silts. Upstream, a lack of flow velocity has caused the deposition of fine sediment in the vicinity of the culvert and bridge structure. Further downstream, bank erosion of the channel margins at more sinuous sections of the watercourse has inputted sediment into the river system. A decline in channel gradient and increased vegetation along the watercourse has resulted in a reduction in flow velocity. As a result, fine sediment is not transported from the reach and settles within the watercourse.

Crossing Point/ Watercourse	Site Observations
	Typical Riparian Composition: Low lying grass characterises the riparian zone. Riparian tree cover is sparse and the surrounding agricultural land is arable farmland. In more sinuous areas of the watercourse, bank erosion has removed vegetation which becomes sparse along the riparian zone. Prior to the field boundary at the Old Armoury Campsite, vegetation cover increases slightly and the riverbank is covered by long grasses and rushes. Downstream of the second culvert, there has been poaching of the riverbanks by the livestock occupying the field. **Typical Floodplain Connectivity:** At Clint Lane, the watercourse is well connected to the floodplain. Floodplain connectivity reduces downstream. Remnants of an historic gravel river bed visible in the riverbank and river terraces in the floodplain indicate that the channel is deeply incised and the bed is at a lower elevation than historically. Over time, the channel has incised downwards into the river bed, which has left the floodplain disconnected from the watercourse. Downstream, towards the second culvert, floodplain connectivity is improved as the gradient of the channel reduces and the channel becomes less incised. The channel has not undergone bed incision, and the presence of rushes on the floodplain suggests that the floodplain becomes regularly wetted during heavy rainfall events.
WCP21 - Unnamed Tributary of River Greta 7.4/ 7.5	**Wider Catchment Characteristics:** The Unnamed Tributary, to the east of Bowes and north of the A66, flows parallel to the A66. The watercourse is culverted beneath the A66 and continues to flow through Stone Bridge Farm for approximately 600m in a southerly direction before draining into the River Greta. Photographs of the location are shown in Annex A: Site Photograph Locations. **Observed In-Channel Modifications:** • Culvert at the existing A66 • Culvert at Stone Bridge Farm **Typical Flow Biotopes:** To the north of the existing A66, there were no distinguishable flow biotopes in the channel. There was very little flow in the channel in this reach, and the overgrown nature of the channel significantly slowed down any flow observed. South of the A66, in the vicinity of the Stone Bridge Farm culvert, flow conditions are poor. Downstream of the Stone Bridge Farm culvert, flow velocity and depth increase. The channel remains to be overgrown with vegetation and gliding flows are the typical flow biotope within the channel in this area of the reach.

Crossing Point/ Watercourse	Site Observations
	Typical Bed Substrate: North of the A66, the bed substrate is difficult to discern due to the overgrown nature of the channel. At Stone Bridge Farm, in areas where the bed is exposed, the bed substrate consists of fine sediment with some small gravels. A fine sediment layer coats the gravel bed. This is likely to be derived locally from the channel banks or is likely to be sourced from surrounding agricultural field via overland flow routes during rainfall events. The low flow conditions mean that the fine sediment settles on the bed rather than being transported to downstream reaches. **Typical Riparian Composition:** Upstream and downstream of the existing A66, the riparian strip is overgrown, and comprises of long grasses. North of the A66, the surrounding agricultural land is arable farmland. There are thickets of riparian tree cover along the watercourse downstream of Stone Bridge Farm. **Typical Floodplain Connectivity:** The connectivity of the floodplain to the channel is moderate. Despite the straightened channel planform, the channel has not undergone excessive bed incision. Evidence of wetted areas of the floodplain suggest that the water is able to spill out of bank and onto the floodplain.

Stage 1: Hydromorphology screening

14.4.6.10 The screening assessment aims to screen in any works that require WFD assessment and to identify which WFD water bodies are within and near to the proposed works.

14.4.6.11 Drainage channel outfalls have been screened out of the assessment as their design is secured by the Environmental Management Plan (Application Document 2.7), which is a certified document under DCO. Where hard outfalls currently exist, new drainage channel outfalls will be tied into the existing structure. Drainage channels in areas with natural banks will be designed as a natural outfall (i.e. without hard bank protection).

14.4.6.12 Table 56: Screening of each water body indicates which water bodies have been screened in or out of the assessment and the reasons for this decision.

14.4.6.13 The baseline status of the hydromorphology quality elements within the water bodies screened into the assessment are discussed in this section. If there is potential for the proposed works to cause deterioration in the status of a water body or prevent it from achieving its status objectives as defined in the Solway Tweed River Basin Management Plan, the relevant water body and its quality elements associated with hydromorphological function have been taken forward and considered further in the scoping assessment at Stage 2.

Table 56: Screening of each water body

Water body/ies	Reason	Screening outcome
Greta from Sleightholme Beck to Eller Beck	The proposed works for Bowes Bypass are located within the waterbody and therefore, direct impact on this waterbody is possible.	Screened In
Greta from Eller Beck to Gill Beck	The waterbody is located approximately 3.4 km downstream of the easternmost point of Bowes Bypass (WCP21). A survey of WCP21 revealed a dry ditch watercourse. Any mechanisms for downstream impact are very limited. As such the waterbody is not likely to be impacted by the works.	Screened Out

Baseline status of screened-in water bodies

14.4.6.14 Table 57: Current WFD status of connected water body catchments in Cycle 2 (2019) summarises the water body ID, hydromorphological designation, current ecological status / potential and ecological objective for each water body screened into the assessment. This information is provided by the Solway Tweed River Basin Management Plan 2021.

Table 57: Current WFD status of connected water body catchments in Cycle 2 (2019)

Water body ID	Name of water body	Hydromorphological designation	Current Ecological Status/ Potential	Ecological Objective
GB103025072110	Greta from Eller Beck to Gill Beck Water Body	Not designated artificial or heavily modified	Good ecological status	Supports good by 2015

14.4.6.15 The tables below outline the current status of the hydromorphological quality elements and reasons for not achieving good status (RNAGS) according to the most recent WFD cycle.

Table 58: Hydromorphological Quality Element of Greta from Sleightholme Beck to Eller Beck in Cycle 2 (2019)

Hydromorphological Quality Element	Current Status	Objective
Hydrological Regime	High	Supports good by 2015
Morphology	Supports good	Not available

Table 59: RNAGS for Greta from Sleightholme Beck to Eller Beck in Cycle 2 (2019)

SWMI*	Activities	Classification Element
Natural	Barriers - ecological discontinuity	Fish
Physical modification	Barriers - ecological discontinuity	Fish
Other pressures	Ecological recovery time - surface waters	Fish

*Significant Water Management Issues

Stage 2: Hydromorphology Scoping

14.4.6.16 The scoping assessment identifies whether the water body's quality elements, identified during the screening assessment, are at risk from the proposed works. The proposed development works are being appraised in terms of their impact on WFD status and objectives. If any quality elements are found to be at risk of detrimental impact, further assessment and/ or mitigation may be required.

Hydromorphological quality elements of the Greta from Sleightholme Beck to Eller Beck Water Body

14.4.6.17 The following Watercourse Crossing Points were identified as falling within the Greta from Sleightholme Beck to Eller Beck water body catchment:

- Watercourse Crossing Point 21 (Culvert S07-C04)
- Watercourse Crossing Point 20, 65 and 66 (Culvert S07-C01)

14.4.6.18 As such, the potential impacts of the proposed works at each identified crossing point will have on the Greta from Sleightholme Beck to Eller Beck water body have been assessed. Where there is the potential for the proposed works to impact on geomorphological condition of watercourses within the Greta from Sleightholme Beck to Eller Beck water body

Watercourse Crossing Point 21 (Culvert S07-C04)

14.4.6.19 The proposed works at this location includes the extension of an existing pipe culvert by 17.92m in length with a diameter matching the existing culvert, which is 0.66m.

14.4.6.20 Table 60: Assessment of works at Watercourse Crossing Point 21 (Culvert S07-C04) on the Unnamed Watercourse at The Old Armoury Campsite, Bowes, which is within the Greta from Sleightholme Beck to Eller Beck Water Body catchment. assesses the potential impacts arising from proposed works at Watercourse Crossing Point 21 (Culvert S07-C04) on the Unnamed Tributary of River Greta 7.4/ 7.5, which is within the Greta from Sleightholme Beck to Eller Beck Water Body catchment.

Table 60: Assessment of works at Watercourse Crossing Point 21 (Culvert S07-C04) on the Unnamed Watercourse at The Old Armoury Campsite, Bowes, which is within the Greta from Sleightholme Beck to Eller Beck Water Body catchment.

WFD Quality Element	Current Status	Potential Impact	Further assessment and/or mitigation required?
Hydrology: Quantity and Dynamics of flow	Not Assessed	The extension of an existing pipe culvert by 17.92m in length with a diameter matching the existing culvert (0.66m) is unlikely to alter the dynamics of flow (e.g., flow velocity, water depth, wetted area etc.) at the Unnamed Tributary of River Greta 7.4/7.5.	No

WFD Quality Element	Current Status	Potential Impact	Further assessment and/or mitigation required?
		This location is currently culverted; upstream of the structure the watercourse lacked geomorphological diversity and the watercourse can be described as already degraded as a result of anthropogenic and agricultural pressures. As such, the proposed works are unlikely to lead to further degradation of the quantity and dynamics of flow. Therefore, this quality element will not be considered as part of the impact assessment for the Greta from Sleightholme Beck to Eller Beck water body.	
Hydrology: Connection to ground water bodies	Not Assessed	The extension of an existing pipe culvert by 17.92m in length with a diameter matching the existing culvert (0.66m) is unlikely to impact the existing connectivity of the watercourse to ground water bodies. This watercourse is currently significantly culverted and is not a significant contributor to ground water. As such, this reduction in connectivity between the drain and ground water bodies is not significant enough to impact ground water connectivity. Therefore, this quality element will not be considered as part of the impact assessment for the Greta from Sleightholme Beck to Eller Beck water body as part of the impact assessment.	No
River Continuity	Not Assessed	This watercourse is currently significantly culverted and degraded as a result of anthropogenic and agricultural pressures. As such, there will be no impact to river continuity. Therefore, this quality element will not be considered as part of the impact assessment for the Greta from Sleightholme Beck to Eller Beck water body as part of the impact assessment.	No
Morphology: River width and depth	Not Assessed	This watercourse is currently significantly culverted and degraded as a result of anthropogenic and agricultural pressures. As such, there will be no impact to river width and depth. Therefore, this quality element will not be considered as part of the impact assessment for the Greta from Sleightholme Beck to Eller Beck water body as part of the impact assessment.	No
Morphology: Structure and	Not Assessed	This watercourse is currently significantly culverted and degraded as a result of	No

WFD Quality Element	Current Status	Potential Impact	Further assessment and/or mitigation required?
substrate of the river bed		anthropogenic and agricultural pressures. As such, there will be no impact to the structure and substrate of the river bed. Therefore, this quality element will not be considered as part of the impact assessment for the Greta from Sleightholme Beck to Eller Beck water body as part of the impact assessment.	
Morphology: Structure of the riparian zone	Not Assessed	This watercourse is currently significantly culverted and degraded as a result of anthropogenic and agricultural pressures. As such, there will be no impact to the structure of the riparian zone. Therefore, this quality element will not be considered as part of the impact assessment for the Greta from Sleightholme Beck to Eller Beck water body as part of the impact assessment.	No

Watercourse Crossing Point 20, 65 and 66 (Culvert S07-C01)

14.4.6.21 The proposed works at this location includes the extension of an existing pipe culvert by 37.94m upstream at WCP 20 with varying diameters.

14.4.6.22 Table 61: Assessment of works at Watercourse Crossing Point 20, 65 and 66 (Culvert S07-C01) on the Unnamed Watercourse at The Old Armoury Campsite, Bowes, which is within the Greta from Sleightholme Beck to Eller Beck Water Body catchment. assesses the potential impacts arising from proposed works at Watercourse Crossing Point 20, 65 and 66 (Culvert S07-C01) on the Unnamed Tributary of River Greta 7.3, culverted beneath the A66 to Stone Bridge Farm, which is within the Greta from Sleightholme Beck to Eller Beck Water Body catchment.

Table 61: Assessment of works at Watercourse Crossing Point 20, 65 and 66 (Culvert S07-C01) on the Unnamed Watercourse at The Old Armoury Campsite, Bowes, which is within the Greta from Sleightholme Beck to Eller Beck Water Body catchment.

WFD Quality Element	Current Status	Potential Impact	Further assessment and/or mitigation required?
Hydrology: Quantity and Dynamics of flow	Not Assessed	The extension of an existing pipe culvert by 37.94m in length with varying diameters is unlikely to alter the dynamics of flow (e.g., flow velocity, water depth, wetted area etc.) at the Unnamed Tributary of River Greta 7.3, culverted beneath the A66 to Stone Bridge Farm. This location is currently culverted; upstream of the structure the watercourse lacked geomorphological diversity and the watercourse can be described as already degraded as a result of anthropogenic and	No

WFD Quality Element	Current Status	Potential Impact	Further assessment and/or mitigation required?
		agricultural pressures. As such, the proposed works are unlikely to lead to further degradation of the quantity and dynamics of flow. Therefore, this quality element will not be considered as part of the impact assessment for the Greta from Sleightholme Beck to Eller Beck water body.	
Hydrology: Connection to ground water bodies	Not Assessed	The extension of an existing pipe culvert by 37.94m in length with varying diameters is unlikely to impact the existing connectivity of the watercourse to ground water bodies. This watercourse is currently significantly culverted and is not a significant contributor to ground water. As such, this reduction in connectivity between the drain and ground water bodies is not significant enough to impact ground water connectivity. Therefore, this quality element will not be considered as part of the impact assessment for the Greta from Sleightholme Beck to Eller Beck water body as part of the impact assessment.	No
River Continuity	Not Assessed	This watercourse is currently significantly culverted and degraded as a result of anthropogenic and agricultural pressures. As such, there will be no impact to river continuity. Therefore, this quality element will not be considered as part of the impact assessment for the Greta from Sleightholme Beck to Eller Beck water body as part of the impact assessment.	No
Morphology: River width and depth	Not Assessed	This watercourse is currently significantly culverted and degraded as a result of anthropogenic and agricultural pressures. As such, there will be no impact to river width and depth. Therefore, this quality element will not be considered as part of the impact assessment for the Greta from Sleightholme Beck to Eller Beck water body as part of the impact assessment.	No
Morphology: Structure and substrate of the river bed	Not Assessed	This watercourse is currently significantly culverted and degraded as a result of anthropogenic and agricultural pressures. As such, there will be no impact to the structure and substrate of the river bed. Therefore, this quality element will not be considered as part of the impact assessment for the Greta from	No

WFD Quality Element	Current Status	Potential Impact	Further assessment and/or mitigation required?
		Sleightholme Beck to Eller Beck water body as part of the impact assessment.	
Morphology: Structure of the riparian zone	Not Assessed	This watercourse is currently significantly culverted and degraded as a result of anthropogenic and agricultural pressures. As such, there will be no impact to the structure of the riparian zone. Therefore, this quality element will not be considered as part of the impact assessment for the Greta from Sleightholme Beck to Eller Beck water body as part of the impact assessment.	No

Impact assessment

14.4.6.23 The impact assessment needs to consider if there is a pathway linking the pressure to the quality elements. If there is no pathway there can be no impact on the quality element and there is no need for any further assessment of that quality elements to be carried out. If there is a potential pathway the assessment must consider if the activity, and the pressure it creates, may cause deterioration of the quality element.

14.4.6.24 In order to effectively assess the potential impacts of the proposed works and decide upon suitable mitigation measures, a good understanding of the proposed scheme and design is required. Should any revisions be made to the proposed works that could impact any of the WFD quality elements, this section should be revised.

14.4.6.25 No potential impacts were identified in the scoping assessment, as outlined in Stage 2: Hydromorphology Scoping.

Water body mitigation measures

14.4.6.26 The Greta from Sleightholme Beck to Eller Beck water body is not classified as heavily modified or artificial. Therefore, there are no hydromorphology mitigation measures assigned to this water body identified in the Solway Tweed River Basin Management Plan 2021.

WFD hydromorphology assessment objectives

Table 62: Hydromorphology Assessment of proposed works against WFD objectives for the Solway Tweed River Basin Management Plan 2021

WFD Hydromorphology Assessment Objectives	Assessment of works
Objective 1: The proposed works do not cause deterioration in the Status of the Ecological Elements of the water body	The proposed works will not cause a deterioration in the status of the Greta from Sleightholme Beck to Eller Beck water bodies

WFD Hydromorphology Assessment Objectives	Assessment of works
Objective 2: The proposed works do not compromise the ability of the water body to achieve its WFD status objectives	The proposed works do not compromise the ability of the Greta from Sleightholme Beck to Eller Beck water bodies
Objective 3: The proposed works do not cause a permanent exclusion or compromised achievement of the WFD objectives in other bodies of water within the same RBD	The impacts arising from the proposed works will not impact on areas elsewhere in the catchment and will not impact other WFD waterbodies within the RBMP.
Objective 4: The proposed works contribute to the delivery of the WFD objectives	The proposed works will contribute to the delivery of the WFD objectives by ensuring no detrimental impact to the water body at the water body scale.

Bowes Bypass Bank key considerations

14.4.6.27 Additional mitigation measures that are to be considered at each of the proposed structures screened into the assessment are listed in section 14.4.9.

Summary

14.4.6.28 The impact assessment determines whether the proposed works have the potential to significantly impact any of the hydromorphology quality elements screened into the assessment. The proposals will not cause a deterioration in the status of specific quality elements, therefore no specific mitigation measures have been required in this assessment.

14.4.7 Cross Lanes to Rokeby

Scheme overview and proposed works

Scheme location

14.4.7.1 The scheme location for Cross Lanes to Rokeby, and the proposed watercourse crossing points, are shown in Plate 17: Scheme location for Cross Lanes to Rokeby and proposed watercourse crossing points.

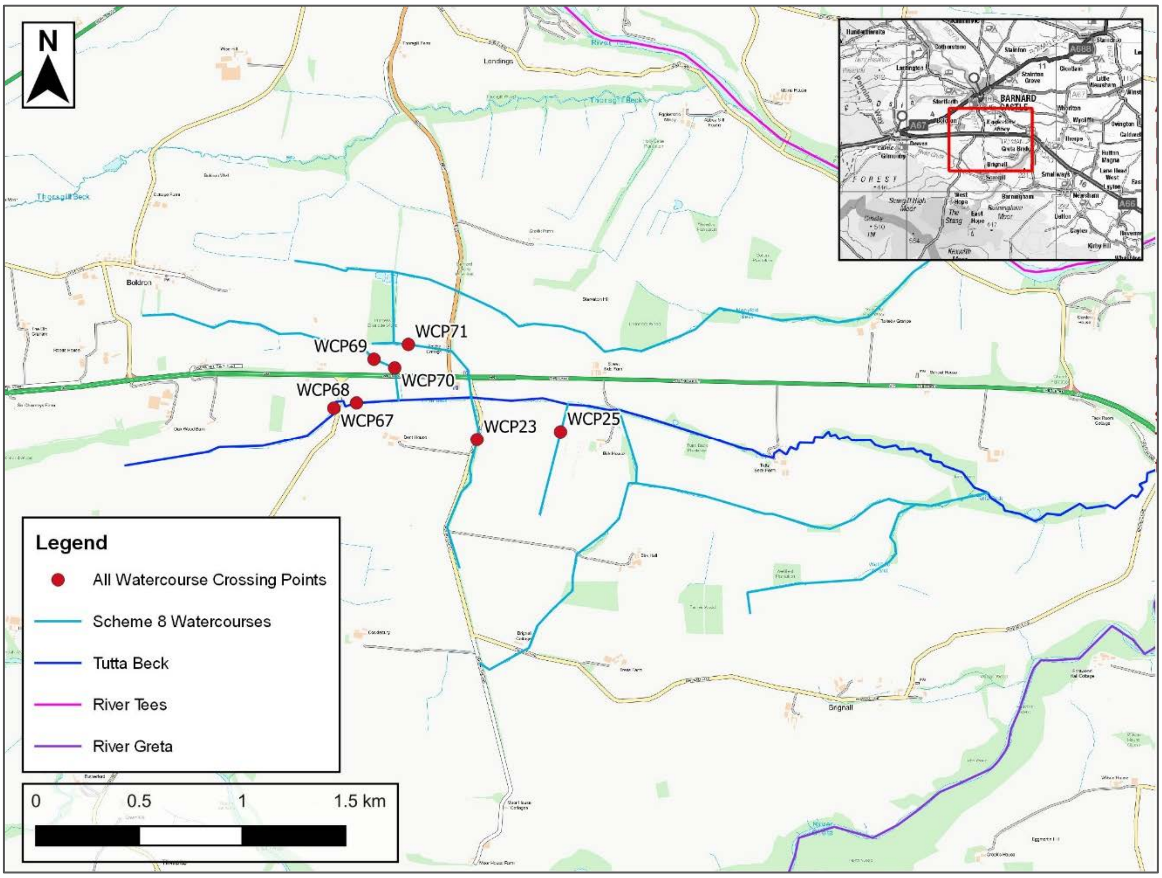

Plate 17: Scheme location for Cross Lanes to Rokeby and proposed watercourse crossing points

Proposed works

14.4.7.2 The proposed works at each identified watercourse crossing point in Plate 17: Scheme location for Cross Lanes to Rokeby and proposed watercourse crossing points are summarised below.

Watercourse Crossing Point 23 and 25

- Originally included, however due to updates to the design no structures are proposed at these locations and hence they are scoped out of further stages of the assessment.

Watercourse Crossing Point 68 (136m from WCP 68 - S08-C01 and Culvert S08-C03)

- A proposed new box culvert of 24.23m length and 1.5 x 4m (HxW).
- A proposed new box culvert of 37.68m in length and 1.5 x 4m (HxW).
- A watercourse realignment of 295m.

Watercourse Crossing Point 69

- No structure proposed at this location.

Watercourse Crossing Point 70 (Culvert S08-C02)

- A proposed new box culvert of 59.57m in length and 1.5 x 1.5m (HxW).

Watercourse Crossing Point 71 (Culverts S08-C04)

- A proposed new box culvert of 30.38m in length and 1.5 x 1.5m (HxW).

Baseline hydromorphology desktop study

Survey scope

14.4.7.3 The scheme watercourse crossing points are located within the catchments of the Tees from Percy Beck to River Greta and Greta from Gill Beck to River Tees water bodies (Figure 14.3: WFD Surface Water Bodies (Application Document 3.3)). The following section provides a summary of the geomorphological characteristics of these catchments.

Catchment and character

Tees from Percy Beck to River Greta

14.4.7.4 The source of the River Tees lies in the North Pennines AONB, south of Alston, in Cumbria. The River Tees rises at an elevation of approximately 660mAOD and flows in a south easterly direction. The water body catchment Tees from Percy Beck to River Greta drains an area of 15.36 km^2. The water body rises in Barnard Castle and flows downstream in a south easterly direction for approximately 5km towards Rokeby.

14.4.7.5 The water body catchment Tees from Percy Beck to River Greta is primarily rural with areas of grassland, woodland, and farmland. The urban town of Barnard Castle is situated in the north of the catchment.

14.4.7.6 The geology within the Tees from Percy Beck to River Greta water body catchment is mixed. The catchment consists of Stainmore Formation, characterised by Mudstone, Siltstone and Sandstone. In addition, the catchment comprises of Great Limestone Member.

Greta from Gill Beck to River Tees

14.4.7.7 The water body catchment Greta from Gill Beck to River Tees drains an area of 11.31 km^2. The water body begins in Rokeby and flows in a southerly direction towards Greta Bridge for approximately 1.6km. At Greta Bridge, the River Greta begins to flow in a south westerly direction for approximately 3.7km towards Brignall.

14.4.7.8 The Tutta Beck watercourse discharges into the River Greta at Greta Bridge. The Tutta Beck flows through Rokeby for approximately 5.7km in an easterly direction.

14.4.7.9 The water body catchment Greta from Gill Beck to River Tees is mostly rural with areas of grassland, woodland, and farmland.

14.4.7.10 The geology within the water body catchment Greta from Gill Beck to River Tees is Alston Formation, characterised by Sandstone and Four Fathom Limestone Member.

Historic trend analysis

14.4.7.11 Historic OS mapping has been used to examine the extent of historic channel change within the water body catchment. The watercourse routes illustrated in the 1888 OS mapping (the earliest OS mapping available online; Plate 18: Assessment of historic planform change of the Tutta Beck) have been compared to current watercourses to identify areas of channel migration and realignment.

14.4.7.12 There has been little change to the planform of the Cross Lanes to Rokeby watercourses in the c. 130 years. This can likely be attributed to the watercourse being re-aligned and managed to increase the amount of land available for agriculture and improve drainage.

14.4.7.13 Historic mapping reveals anthropogenic modification of the Tutta Beck planform sometime after 1956. The Tutta Beck channel appears straightened between Birk House and the Tutta Beck Plantation (Area 1 of Plate 18: Assessment of historic planform change of the Tutta Beck).

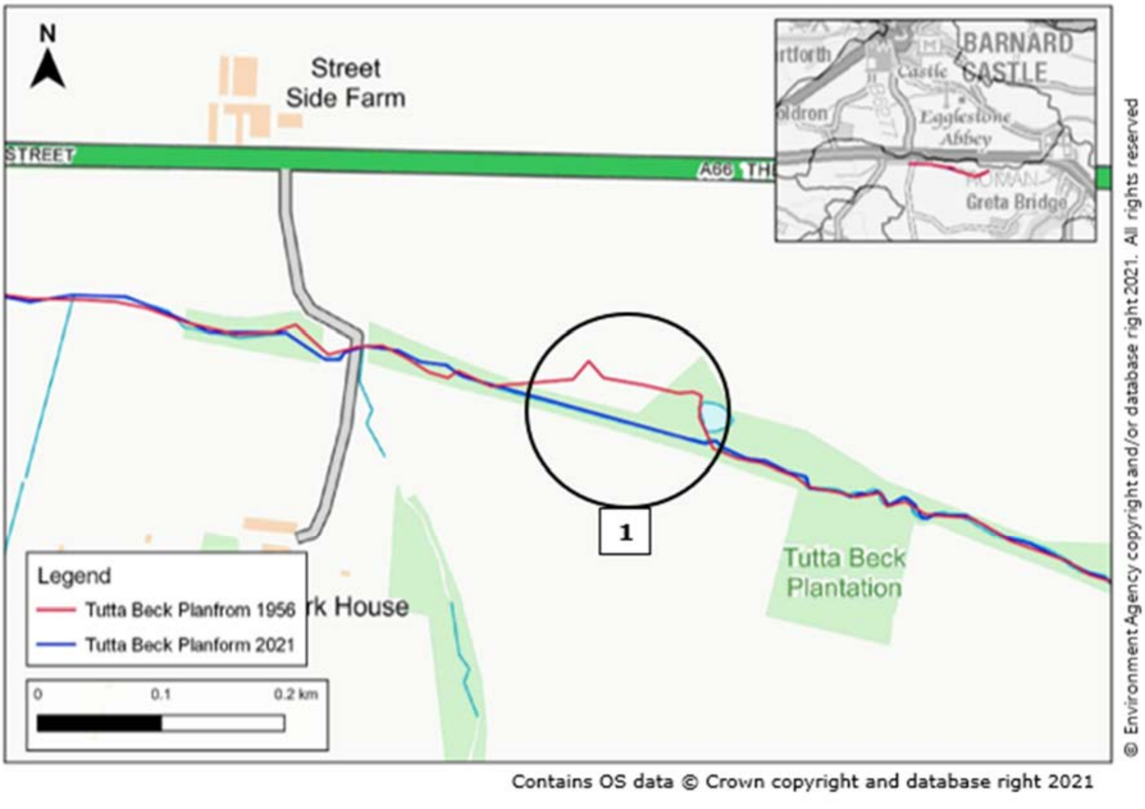

Plate 18: Assessment of historic planform change of the Tutta Beck

Assessment of LiDAR data

14.4.7.14 Several palaeo channels can be identified in the vicinity of the Cross Lanes to Rokeby watercourses. Most of the flow channels identified by LiDAR data are not visible in historic mapping. This suggests that any changes to the planform of the Cross Lanes to Rokeby watercourses happened prior to 1895. In Area 1 (Plate 19: Assessment of palaeo channels in the vicinity of Cross Lanes to Rokeby), a meandering palaeo channel on the left bank floodplain suggests that the watercourse previously migrated across the floodplain. The channel has decreased in sinuosity over time.

14.4.7.15 In Plate 19: Assessment of palaeo channels in the vicinity of Cross Lanes to Rokeby, Areas 2, 3 and 4, the watercourses are straight and appear to have been re-aligned. Palaeo channels visible in LiDAR data, show that the watercourses previously migrated across the floodplain. It is probable that the watercourses have been realigned and straightened to increase the extent of agricultural land available. In Cross Lanes to Rokeby, a lack of planform change in recent years can be explained by agricultural management.

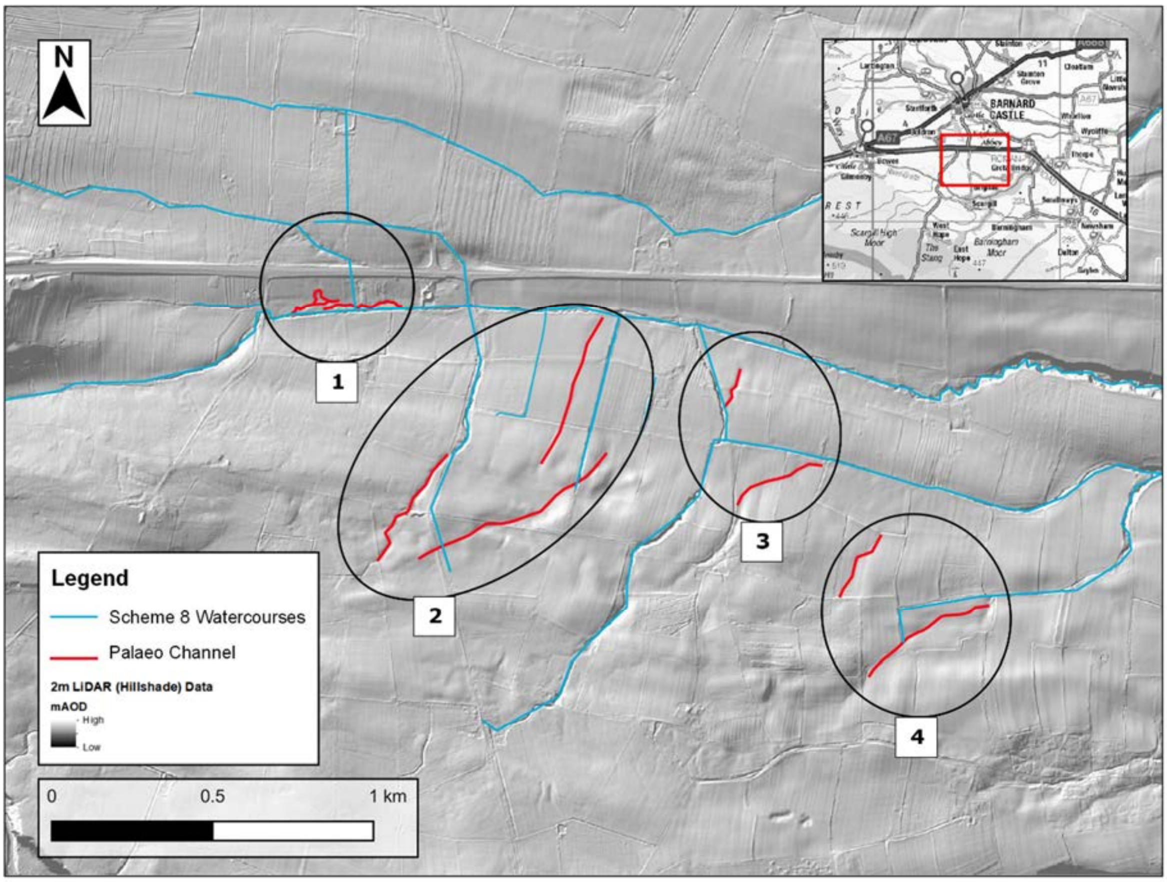

Plate 19: Assessment of palaeo channels in the vicinity of Cross Lanes to Rokeby

Baseline Hydromorphology Site Observations

Table 63: Baseline hydromorphology for each scheme

Crossing Point/ Watercourse	Site Observations
WCP67 WCP68 Punder Gill	**Wider Catchment Characteristics:** Punder Gill rises at an elevation of approximately 246mAOD. Punder Gill flows in a north easterly direction for approximately 1.2km before the watercourse is culverted beneath Rutherford Lane and becomes the Tutta Beck. The Tutta Beck continues to flow in an easterly direction through Rokeby for approximately 4.5km before discharging into the River Greta at

Crossing Point/ Watercourse	Site Observations
	Greta Bridge. Photographs of the location are shown in Annex A: Site Photograph Locations. **Observed In-Channel Modifications:** • Informal bridge structure upstream of Rutherthood Lane • Culvert at Rutherthood Lane • Bridge at Moorhouse Lane • Outfall from the road at Moorhouse Lane **Typical Flow Biotopes:** The flow within the Punder Gill channel comprises of alternating riffle and pool biotopes. As the watercourse approaches the culvert at Rutherford Lane, the channel is characterised by glide flows. The gradient is reduced, and the flow velocity of the watercourse decreases. Downstream of Rutherford Lane, there is a decline in gradient and flow velocity is reduced. In addition to a reduced gradient, the channel is overwide culvert, slowing river flow immediately downstream of the structure. The Tutta Beck watercourse is predominantly characterised by gliding flows. The watercourse varies in width along its course. At narrower reaches of the Tutta Beck, the flow depth and velocity increases. Within these narrower reaches, there are some depositional features and woody debris dams that diversify flow within the channel. At wider reaches of Tutta Beck, such as at the Moorhouse Lane bridge, the flow is reduced, changing the flow biotope to a glide flow. Further downstream of Moorhouse Lane bridge, flow velocity increases and riffle features are accompanied by alternating sequences of glide features. **Typical Bed Substrate:** The bed substrate at Punder Gill comprises of gravels and cobbles. Pool and riffle sequences create habitat in the upstream reach. Further downstream, there is an input of fine sediment caused by animal burrows on the left side bank. This has formed areas of deposition in the channel that redirect the flow to the right bank and create a sinuous channel. Further downstream, a bridge structure has reduced flow velocity causing fine material to deposit in the channel. The Tutta Beck channel is comprised of a mix of bed material. Bed material ranges from silts and sands to gravels, cobbles and boulders. The low flow energy conditions encourages the deposition of fine sediment on the channel bed. In the upstream reaches of the Tutta Beck, the bed substrate comprises of coarse sediment including gravels, cobbles and boulders. Along the

Crossing Point/ Watercourse	Site Observations
	watercourse, large woody material dams trap sediment. Coarse material is stored within the channel bed. The bed appears to be armoured as the flow velocities are not sufficient to mobilise and transport large clasts. In the downstream reaches of the Tutta Beck, the low flow velocity of the channel causes fine material to drop out of transport and deposit on the river bed. The result is an accumulation of fine bed material. An influx of fine material can be attributed to bank erosion further upstream. Downstream of the Moorhouse Lane bridge, the typical bed substrate returns to gravels and cobbles, with a reduction in fine sediment. **Typical Riparian Composition:** In the upstream reach of the Punder Gill, the watercourse has thickets of riparian tree cover. There is significant riparian cover across the left and right river bank towards Rutherford Lane. Long grass and rushes cover the riparian zone and there are wetland features across the floodplain. Macrophytes line the river channel. Downstream of Rutherford Lane, riparian tree cover increases. The Tutta Beck reach comprises of woody debris, forming natural dams in the channel. Riparian zone vegetation increases further downstream and is characterised by long grasses and rushes. Areas of the channel appear overgrown with vegetation downstream of Moorhouse Lane. **Typical Floodplain Connectivity:** In the upstream reaches, the floodplain is at a higher elevation than the existing Punder Gill channel. There is evidence of incision and bank erosion. Slump features occupy the right bank. Palaeo channels in the landscape suggest that the channel has been straightened and may be incising down in response to the increased gradient. Further downstream, wetland features indicate improved floodplain connectivity. The gradient of the channel reduces and the presence of rushes on the floodplain suggest that the floodplain is regularly wetted during heavy rainfall events.
WCP25 Unnamed Tributary of Tutta Beck 8.2	**Wider Catchment Characteristics:** The Unnamed Tributary rises to the west of Birk House and flows in a north easterly direction for approximately 570m before discharging into the Tutta Beck. Photographs of the location are shown in Annex A: Site Photograph Locations. **Typical Flow Biotopes:** There is low flow velocity in the drain.

Crossing Point/ Watercourse	Site Observations
	Typical Bed Substrate: The bed substrate is primarily comprised of fine material. The low flow energy of the tributary has led to fine material being deposited in the channel. **Typical Riparian Composition:** The riparian strip of the Unnamed Tributary is overgrown and comprised of long grasses and rushes. There is riparian tree cover along the right bank of the tributary. The surrounding agricultural land is arable farmland. **Typical Floodplain Connectivity:** The Unnamed Tributary is modified into an agricultural drain rather than a watercourse and is not connected to the floodplain. The tributary is trapezoidal in shape and the channel appears to have been straightened along a field boundary. There was no water in the Unnamed Tributary, and it is unlikely that it would be connected to the floodplain if water was present.
WCP69 WCP70 Unnamed Tributary of Punder Gill 8.1	**Wider Catchment Characteristics:** The Unnamed Tributary rises in Boldron, south of West Lane. The watercourse flows in a south easterly direction for approximately 1.3km before it is culverted beneath the existing A66. The watercourse continues to flow in a southernly direction for approximately 109m before discharging into the Punder Gill. Photographs of the location are shown in Annex A: Site Photograph Locations. **Typical Flow Biotopes:** The watercourse channel is overgrown with riparian vegetation and gliding flows are the typical flow biotope within the channel. **Typical Bed Substrate:** The bed substrate is comprised of small gravels to very fine material. **Typical Riparian Composition:** The riparian strip of the Unnamed Tributary is significant and comprised of long grasses and rushes. The presence of wet mossy grass and rushes on the floodplain suggests that the floodplain becomes regularly wetted. The surrounding agricultural land is arable farmland.
WCP71 Unnamed Tributary of Tutta Beck	**Wider Catchment Characteristics:** The Unnamed Tributary rises in Princess Charlotte Wood and flows in an easterly direction for approximately 400m towards Smithy Cottage. The drain is culverted beneath the B6277 and existing A66 networks. Past the A66, the drain flows in a southern direction for approximately 100m towards the Tutta Beck. Photographs of the location are shown in Annex A: Site Photograph Locations.

Crossing Point/ Watercourse	Site Observations
	Typical Flow Biotopes: During the field survey, the Unnamed Tributary was dry with no flow in the channel. **Typical Bed Substrate:** The bed is obscured by vegetation. It is suspected that the bed substrate is primarily comprised of fine material. **Typical Riparian Composition:** The Unnamed Tributary is overgrown with terrestrial vegetation. There is a hedgerow along the left bank of the tributary. **Typical Floodplain Connectivity:** The Unnamed Tributary is modified into an agricultural drain rather than a watercourse and is not connected to the floodplain. The tributary is trapezoidal in shape and the channel appears to have been straightened along a field boundary. There was no water in the tributary, and it is unlikely that it would be connected to the floodplain if water was present.
WCP23 Unnamed Tributary of Tutta Beck 8.1	**Wider Catchment Characteristics:** The Unnamed Tributary rises to the east of Birk Hall and travels in a northerly direction for approximately 880m along Moorhouse Lane. The drain flows to the Tutta Beck. Photographs of the location are shown in Annex A: Site Photograph Locations. **Typical Flow Biotopes:** During the field survey, the Unnamed Tributary was dry with no flow in the channel. **Typical Bed Substrate:** The bed is obscured by vegetation. It is suspected that the bed substrate is primarily comprised of fine material. **Typical Riparian Composition:** The Unnamed Tributary is overgrown with vegetation. There is riparian tree cover along the tributary. **Typical Floodplain Connectivity:** The Unnamed Tributary is modified into an agricultural drain rather than a watercourse and is not connected to the floodplain. The tributary is trapezoidal in shape and the channel appears to have been straightened along a field boundary. There was no water in the tributary, and it is unlikely that it would be connected to the floodplain if water was present.

Stage 1: Hydromorphology screening

14.4.7.16 The screening assessment aims to screen in any works that require WFD assessment and to identify which WFD water bodies are within and near to the proposed works.

14.4.7.17 Drainage channel outfalls have been screened out of the assessment as their design is secured by the Environmental Management Plan (Application Document 2.7), which is a certified document under DCO. Where hard outfalls currently exist, new drainage channel outfalls will be tied into the existing structure. Drainage channels in areas with natural banks will be designed as a natural outfall (i.e. without hard bank protection).

14.4.7.18 Table 64: Screening of each water bodyTable 64: Screening of each water body indicates which water bodies have been screened in or out of the assessment and the reasons for this decision.

14.4.7.19 The baseline status of the hydromorphology quality elements within the water bodies screened into the assessment are discussed in this section. If there is potential for the proposed works to cause deterioration in the status of a water body or prevent it from achieving its status objectives as defined in the Solway Tweed River Basin Management Plan, the relevant water body and its quality elements have been taken forward and considered further in the scoping assessment at Stage 2.

Table 64: Screening of each water body

Water body/ies	Reason	Screening outcome
Tees from Percy Beck to River Greta - heavily modified	The proposed works for Cross Lanes to Rokeby are located within the waterbody and therefore, direct impact on this waterbody is possible.	Screened In
Greta from Gill Beck to River Tees	The proposed works for Cross Lanes to Rokeby are located within the waterbody and therefore, direct impact on this waterbody is possible.	Screened In
Tees from River Greta to River Skerne - heavily modified	The waterbody is located approximately 4.8 km downstream of the easternmost point of Cross Lanes to Rokeby (WCP25). As such the waterbody is located far enough downstream from the works to not be impacted.	Screened Out

Baseline Status of screened-in water bodies

14.4.7.20 Table 65: Current WFD status of connected water body catchments in Cycle 2 (2019) summarises the water body ID, hydromorphological designation, current ecological status / potential and ecological objective for each water body screened into the assessment. This information is provided by the Solway Tweed River Basin Management Plan 2021.

Table 65: Current WFD status of connected water body catchments in Cycle 2 (2019)

Water body ID	Name of water body	Hydromorphological designation	Current Ecological Status/ Potential	Ecological Objective
GB103025072512	Tees from Percy Beck to River Greta	Heavily modified	Good	Good by 2027
GB103025072130	Greta from Gill Beck to River Tees	Not designated artificial or heavily modified	Good	Good by 2015

14.4.7.21 The tables below outline the current status of the hydromorphological quality elements and reasons for not achieving good status (RNAGS) according to the most recent WFD cycle.

WFD water body: Tees from Percy Beck to River Greta

Table 66: Hydromorphological Quality Element of Tees from Percy Beck to River Greta in Cycle 2 (2019)

Hydromorphological Quality Element	Current Status	Objective
Hydrological Regime	Supports good (2014)	Not assessed
Morphology	Not available	Not assessed

Table 67: RNAGS for Tees from Percy Beck to River Greta in Cycle 2 (2019)

SWMI*	Activities	Classification Element
Not Available	Not Available	Not Available

WFD water body: Greta from Gill Beck to River Tees

Table 68: Hydromorphological Quality Element of Greta from Gill Beck to River Tees in Cycle 2 (2019)

Hydromorphological Quality Element	Current Status	Objective
Hydrological Regime	Supports good	Supports good by 2015
Morphology	Supports good	Not available

Table 69: RNAGS for Greta from Gill Beck to River Tees in Cycle 2 (2019)

SWMI*	Activities	Classification Element
Not Available	Not Available	Not Available

*Significant Water Management Issue

Stage 2: Hydromorphology scoping

14.4.7.22 The scoping assessment identifies whether the water body's quality elements identified during the screening assessment, are at risk from the proposed works. The proposed development works are being appraised in terms of their impact on WFD status and objectives. If any quality elements are found to be at risk of detrimental impact, further assessment and/ or mitigation may be required.

Hydromorphological quality elements Tees from Percy Beck to River Greta

14.4.7.23 The following Watercourse Crossing Point was identified as falling within the Tees from Percy Beck to River Greta water body catchment:

- Watercourse Crossing Point 71 (Culvert S08-C04).

14.4.7.24 As such, the potential impacts of the proposed works at the identified crossing point on the Tees from Percy Beck to River Greta water body have been assessed. Where there is the potential for the proposed works to impact the geomorphological condition of watercourses within the Tees from Percy Beck to River Greta water body.

Watercourse Crossing Point 71 (Culvert S08-04)

14.4.7.25 The proposed works at this location include a new box culvert of 30.38m in length and 1.5 x 1.5m (HxW).

14.4.7.26 Table 70: Assessment of works against the hydromorphological quality elements presents an assessment of the proposed works against the hydromorphological quality elements of the Tees from Percy Beck to River Greta water body.

Table 70: Assessment of works against the hydromorphological quality elements

WFD Quality Element	Current Status	Potential Impact	Further assessment and/or mitigation required?
Hydrology: Quantity and Dynamics of flow	Not Assessed	The new box culvert of 30.38m in length and 1.5 x 1.5m (HxW) is unlikely to alter the dynamics of flow (e.g., flow velocity, water depth, wetted area etc.) at the Unnamed Tributary of Tutta Beck. The tributary was dry upon inspection and can be described as already degraded as a result of anthropogenic and agricultural pressures. As such, the proposed works are unlikely to lead to a degradation of the quantity and dynamics of flow. Therefore, this quality element will not be considered as part of the impact assessment for Tees from Percy Beck to River Greta water body.	No
Hydrology: Connection to ground water bodies	Not Assessed	The proposed works involve the installation of a new box culvert. This is unlikely to impact the existing connectivity of the watercourse to ground water bodies. The watercourse is a dry ditch and not a significant contributor to ground water. As such, this reduction in connectivity	No

WFD Quality Element	Current Status	Potential Impact	Further assessment and/or mitigation required?
		between the tributary and ground water bodies is not considered to be significant enough to impact ground water connectivity. Therefore, this quality element will not be considered as part of the impact assessment for Tees from Percy Beck to River Greta water body.	
River Continuity	Not Assessed	The Unnamed Tributary of Tutta Beck is a dry ditch. As such, there will be no impact to river continuity. Therefore, this quality element will not be considered as part of the impact assessment for the Tees from Percy Beck to River Greta water body.	No
Morphology: River width and depth	Not Assessed	The Unnamed Tributary of Tutta Beck is a dry ditch. As such, there will be no impact to river width and depth. Therefore, this quality element will not be considered as part of the impact assessment for the Tees from Percy Beck to River Greta water body.	No
Morphology: Structure and substrate of the river bed	Not Assessed	The Unnamed Tributary of Tutta Beck is a dry ditch. As such, there will be no impact to the structure and substrate of the river bed. Therefore, this quality element will not be considered as part of the impact assessment for the Tees from Percy Beck to River Greta water body.	No
Morphology: Structure of the riparian zone	Not Assessed	The Unnamed Tributary of Tutta Beck is a dry ditch. As such, there will be no impact to the structure of the riparian zone. Therefore, this quality element will not be considered as part of the impact assessment for the Tees from Percy Beck to River Greta water body.	No

Hydromorphological quality elements Greta from Gill Beck to River Tees

14.4.7.27 The following Watercourse Crossing Points were identified as falling within the Greta from Gill Beck to River Tees water body catchment:

- Watercourse Crossing Point 23
- Watercourse Crossing Point 25
- Watercourse Crossing Point 68 (Culverts S08-C01 and S08-C03)
- Watercourse Crossing Point 69
- Watercourse Crossing Point 70 (Culvert S08-C02).

14.4.7.28 As such, the potential impacts of the proposed works at each identified crossing point will have on the Greta from Gill Beck to River Tees water body have been assessed. Where there is the potential for the proposed works to impact the geomorphological condition of watercourses within the Greta from Gill Beck to River Tees water body, the requirement for a further assessment within Section 0 has been stipulated.

Watercourse Crossing Point 23

14.4.7.29 No designs have been submitted for this Watercourse Crossing Point, therefore no potential impacts are identified at this stage and the crossing point has been scoped out of the assessment.

Watercourse Crossing Point 25

14.4.7.30 No designs have been submitted for this Watercourse Crossing Point, therefore no potential impacts are identified at this stage and the crossing point has been scoped out of the assessment.

Watercourse Crossing Point 68 (Culverts S08-C01 and S08-C03)

14.4.7.31 The proposed works at this location includes:

- A new box culvert of 24.23m length and 1.5 x 4m (HxW)
- A new box culvert of 37.68m in length and 1.5 x 4m (HxW)
- A watercourse realignment of 295m.

14.4.7.32 Table 71: Assessment of works against the hydromorphological quality elements presents an assessment of the proposed works against the hydromorphological quality elements of the Greta from Gill Beck to River Tees water body.

Table 71: Assessment of works against the hydromorphological quality elements

WFD Quality Element	Current Status	Potential Impact	Further assessment and/or mitigation required?
Hydrology: Quantity and Dynamics of flow	Not Assessed	The installation of two new box culverts one at 24.23m length and 1.5 x 4m (HxW), and the other at 37.68m in length and 1.5 x 4m (HxW). A watercourse realignment of 295m has also been proposed. From the outline plan of the scheme, the realignment seems equivalent to current length and planform and the realigned channel appears to be within a low lying area when overlaying the LiDAR and could be a paleochannel (Plate 19: Assessment of palaeo channels in the vicinity of Cross Lanes to Rokeby, area 1) however further details of the realignment are required to assess this proposal. The realigned channel will convey flow through culverts under two roads. These proposed culverts cover a significant portion of a river reach that still exhibits good morphological condition (e.g. riffle glide sequences in narrow reaches, depositional features and woody debris dams). The proposed culverts and river realignment will alter the dynamics of flow	Yes

WFD Quality Element	Current Status	Potential Impact	Further assessment and/or mitigation required?
		(e.g., flow velocity, water depth, wetted area etc.) on a local scale. As such, the proposed works are likely to lead to a degradation of the quantity and dynamics of flow. Therefore, this quality element will be considered as part of the impact assessment for the Greta from Gill Beck to River Tees water body.	
Hydrology: Connection to ground water bodies	Not Assessed	The proposed works involve the installation of two new box culverts and a realignment of the watercourse. Depending on the designs for the realignment, this is likely to impact the existing connectivity of the Punder Gill to ground water bodies. As such, this reduction in connectivity between the surface waterbody and ground water bodies is may be significant enough to impact ground water connectivity. Therefore, this quality element will be considered as part of the impact assessment for the Greta from Gill Beck to River Tees water body.	Yes
River Continuity	Not Assessed	The installation of two new box culverts (24.23m length and 1.5 x 4m (HxW), 37.68m in length and 1.5 x 4m (HxW) and a watercourse realignment of 295m) to convey flow under a road is proposed for a significant portion of a river reach that still exhibits good morphological condition (e.g. riffle glide sequences in narrow reaches, depositional features and woody debris dams). As such, there is likely to be an impact to river continuity as the channel exhibits good morphological features upstream and downstream of the proposed works site. Therefore, this quality element will be considered as part of the impact assessment for the Greta from Gill Beck to River Tees water body.	Yes
Morphology: River width and depth	Not Assessed	The Punder Gill is characterised by a varying width and depth upstream and downstream of the proposed works site. As such, there is likely to be an impact to river width and depth. Therefore, this quality element will be considered as part of the impact assessment for the Greta from Gill Beck to River Tees water body.	Yes

WFD Quality Element	Current Status	Potential Impact	Further assessment and/or mitigation required?
Morphology: Structure and substrate of the river bed	Not Assessed	Bed material in the watercourse ranges from silts and sands to gravels, cobbles and boulders. Depending on the bed materials used, the gradient and other design considerations, there will likely be an impact to the river structure and substrate of the river bed. Therefore, this quality element will be considered as part of the impact assessment for the Greta from Gill Beck to River Tees water body.	Yes
Morphology: Structure of the riparian zone	Not Assessed	The Punder Gill is characterised by riparian zone vegetation of long grasses and rushes Depending on the design considerations for the riparian zone, there will likely be an impact to the structure of the riparian zone. Therefore, this quality element will be considered as part of the impact assessment for the Greta from Gill Beck to River Tees water body.	Yes

Watercourse Crossing Point 69

14.4.7.33 No designs have been submitted for this Watercourse Crossing Point, therefore no potential impacts are identified at this stage and the crossing point has been scoped out of the assessment.

Watercourse Crossing Point 70 (Culvert S08-C02)

14.4.7.34 The proposed works at this location includes a new box culvert of 59.57m in length and 1.5 x 1.5m (HxW).

14.4.7.35 Table 72: Assessment of works against the hydromorphological quality elements presents an assessment of the proposed works against the hydromorphological quality elements of the Greta from Gill Beck to River Tees water body.

Table 72: Assessment of works against the hydromorphological quality elements

WFD Quality Element	Current Status	Potential Impact	Further assessment and/or mitigation required?
Hydrology: Quantity and Dynamics of flow	Not Assessed	The unnamed Tributary of Punder Gill 8.1, is degraded for agricultural use as a drain. The flow dynamics are poor, with little flow observed, and a predominance of glide flow biotopes. The culvert 59.57m in length and 1.5 x 1.5m (HxW) is unlikely to alter the dynamics	No

WFD Quality Element	Current Status	Potential Impact	Further assessment and/or mitigation required?
		of flow (e.g., flow velocity, water depth, wetted area etc.). As such, the proposed works are unlikely to lead to a degradation of the quantity and dynamics of flow. Therefore, this quality element will not be considered as part of the impact assessment for the Greta from Gill Beck to River Tees water body.	
Hydrology: Connection to ground water bodies	Not Assessed	The proposed works are unlikely to impact the existing connectivity of the Unnamed Tributary of Punder Gill 8.1 to ground water bodies. The watercourse is not considered to be a significant contributor to ground water due to the poor flow and low quantity of water in the watercourse. As such, this reduction in connectivity between the surface waterbody and ground water bodies is not significant enough to impact ground water connectivity. Therefore, this quality element will not be considered as part of the impact assessment for the Greta from Gill Beck to River Tees water body.	No
River Continuity	Not Assessed	The Unnamed Tributary of Punder Gill 8.1 does not exhibit good morphological diversity in terms of features or processes and has relatively little flow. The channel is degraded for agricultural use. As such, the proposed works are unlikely to impact river continuity. Therefore, this quality element will not be considered as part of the impact assessment for the Greta from Gill Beck to River Tees water body.	No
Morphology: River width and depth	Not Assessed	The Unnamed Tributary of Punder Gill 8.1 does not exhibit good morphological diversity in terms of features or processes and has relatively little flow. The channel is degraded for agricultural use. As such, there will be no impact to river width and depth. Therefore, this quality element will not be considered as part of the impact assessment for the Greta from Gill Beck to River Tees water body.	No
Morphology: Structure and substrate of the river bed	Not Assessed	The Unnamed Tributary of Punder Gill 8.1 does not exhibit good morphological diversity in terms of features or processes and has relatively little flow. The channel is degraded for agricultural use. As such, there will be no impact to the structure and substrate of the	No

WFD Quality Element	Current Status	Potential Impact	Further assessment and/or mitigation required?
		river bed. Therefore, this quality element will not be considered as part of the impact assessment for the Greta from Gill Beck to River Tees water body.	
Morphology: Structure of the riparian zone	Not Assessed	The Unnamed Tributary of Punder Gill 8.1 is characterised by rushes and reeds. The channel is degraded for agricultural use. As such, there will be no impact to the structure of the riparian zone. Therefore, this quality element will not be considered as part of the impact assessment for the Greta from Gill Beck to River Tees water body.	No

Impact assessment

14.4.7.36 The impact assessment needs to consider if there is a pathway linking the pressure to the quality elements. If there is no pathway there can be no impact on the quality elements and there is no need for any further assessment of that quality element to be carried out. If there is a potential pathway the assessment must consider if the activity, and the pressure it creates, may cause deterioration of the quality elements.

14.4.7.37 In order to effectively assess the potential impacts of the proposed works and decide upon suitable mitigation measures, a good understanding of the proposed scheme and design is required. Should any revisions be made to the proposed works that could impact any of the WFD quality elements, this section should be revised at detailed design.

14.4.7.38 The mitigation measures stipulated within the impact assessment are secured by the Project Design Principles (Application Document 5.11) and the Environmental Management Plan (Application Document 2.7), which are certified documents under DCO.

14.4.7.39 Provided the mitigation measures stipulated within the impact assessment are implemented at the detailed design stage, cumulative impacts from all the proposed works to the hydromorphology quality elements of the Greta from Gill Beck to River Tees WFD water body will be mitigated sufficiently.

Impact assessment for the Greta from Gill Beck to River Tees water body

14.4.7.40 Table 73: Impacts and mitigation measures of Watercourse Crossing Point 68 (Culverts S08-C01 and S08-C03) discusses each of the quality elements identified as being potentially at risk in the scoping assessment for each structure assessed in the Greta from Gill Beck to River Tees water body. Mitigation measures are required to mitigate the effects of the proposed works. It should be noted that these mitigation measures differ to the mitigation measures identified for any Heavily Modified water body.

Table 73: Impacts and mitigation measures of Watercourse Crossing Point 68 (Culverts S08-C01 and S08-C03)

WFD Quality Element	Pathway (direct / indirect/ none)	Potential Impact/ Mitigation measures
Hydrology: Quantity and Dynamics of flow	Direct	**Permanent Impact:** The proposed new box culverts and watercourse realignment will lead to a loss of open channel on the Punder Gill. The new box culverts and realignment are proposed for a significant portion (18.9%) of the remaining natural reach of the channel and will alter the dynamics of flow (e.g., flow velocity, water depth, wetted area etc.). Additionally, the realignment will require careful design to ensure there are no impacts to the quantity and dynamics of flow. The channel gradient is likely to change following variations in channel length and bed levels associated with the realignment and de-culverting. This has the potential to impact upon flow velocities and shear stresses within the channel, which can lead to changes in sediment processes such as erosion and / or deposition. **Mitigation:** To understand the impact on the quantity and dynamics of flow, additional hydraulic modelling analysis using both low flows and flood flows is essential. Using shear stress, velocity and water level analysis, the implications of de-culverting and realigning the Unnamed Tributary of Trout Beck 4.6 can be fully understood. Modifications to the realigned channel geometry, including the width and depth of the channel, and channel gradient can then be investigated to encourage natural geomorphological processes to be maintained and improved. This will need to be assessed by a geomorphologist. To compensate for the loss of natural flow dynamics and diversity on the Punder Gill, riparian planting of trees in the realignment section of the watercourse will be carried out and a riparian buffer strip will be created. The introduction of a dense riparian buffer strip along the river banks upstream of the structure will provide a natural source of woody material to the watercourse. Naturally occurring woody material in the channel increases flow and sediment diversity, which encourages localised variation in flow velocities. This develops a natural pattern of river width and depth diversity over time, which contributes to naturally sinuous flow mechanics developing across a river reach. The introduction of natural woody material into the channel can be assisted by installing root wads or securing large wood at Punder Gill. This

WFD Quality Element	Pathway (direct / indirect/ none)	Potential Impact/ Mitigation measures
		would restore the potential loss of flow diversity as a result of the proposed culvert extension.
Hydrology: Connection to ground water bodies	Direct	**Permanent Impact:** The proposed new box culverts and watercourse realignment is likely to lead to a loss of connection of the Punder Gill to ground water bodies. The new box culverts and watercourse realignment are proposed for a significant portion of the remaining natural reach of the channel. If the installed bed material is impermeable, it is likely to create a barrier and disconnect the watercourse from the ground water bodies. **Mitigation:** The design of the culverts and realignment must consider the connection of the watercourse with the hyporheic zone and ground water bodies. This can be achieved by ensuring the realignment bed is permeable, using the existing bed material where possible. It is essential that a geomorphologist is consulted.
River Continuity	Direct	**Permanent Impact:** The proposed new box culverts and watercourse realignment will disrupt the river continuity of the Punder Gill as the proposed works cover a significant portion of the natural reach of the channel. **Mitigation:** To mitigate the impacts to river continuity, the design of the realignment, the design must be sympathetic to the current conditions upstream and downstream. If the realignment reach is significantly different to the current conditions, this will impact the channel character and create an inconsistent channel. Characteristics of the current channel, upstream and downstream must incorporated in the designs to ensure that the channel remains within character and therefore does not impact the longitudinal river continuity. Similar considerations are to made for lateral connectivity and the designs must consider bank condition, geomorphic processes, riparian vegetation and connectivity to the floodplain. A geomorphologist will need to be consulted to input on the designs of the realignment and ensure that geomorphic processes and characteristics are considered in the design. Compensation is required for the loss of natural channel and geomorphic diversity on the Punder Gill. Compensation should be a 10% condition uplift of a1.5 times length of watercourse that is within the red line boundary of the realignment within the waterbody reach.

WFD Quality Element	Pathway (direct / indirect/ none)	Potential Impact/ Mitigation measures
Morphology: River width and depth	Direct	**Permanent Impact:** The replacement of open channel with the proposed culverts will result in a change to the existing width and depth of the Punder Gill. Following the completion of the culvert installations, the width and depth of the channel will be dictated by the geometry of the culvert bases. As a result, this reflects a degradation of the river width and depth compared to the current conditions. **Mitigation:** The design of the realignment must be sympathetic to the current conditions at the location of the watercourse to be realigned and also upstream and downstream. A geomorphologist will need to be consulted to input on the designs and ensure that geomorphic processes and characteristics are considered in the design Compensation is required for the loss of natural channel and geomorphic diversity on the Punder Gill. Compensation must be a 10% condition uplift of a 1.5 times length of watercourse that is within the red line boundary of the realignment within the waterbody reach.
Morphology: Structure and substrate of the river bed	Direct	**Permanent Impact:** The replacement of open channel with the proposed culvert installations will result in a change to the existing condition of the river bed substrate on the Punder Gill. Following the completion of the culvert, the natural river bed substrate will be replaced with the culvert base. Additionally, the material and techniques used for the channel realignment is likely to also affect the structure and substrate of the river bed. Appropriate river bed substrate will need to be placed on the river bed to ensure that the existing structure and substrate of the river bed is maintained or improved as part of the works, and that the risk of bed scour or fine sediment deposition is not exacerbated. **Mitigation:** Comparisons of existing and post-development shear stresses and flow velocities within the realigned and de-culverted channel through a range of flows from low flows to flood flows will be necessary to identify a suitable D50 size of bed material. This will facilitate and encourage natural geomorphological processes to be maintained and improved within the channel. Where possible, natural materials derived from the original channel must be re-installed. In the realignment reach, designs must look to improve the sediment regime with a 10% condition uplift to

WFD Quality Element	Pathway (direct / indirect/ none)	Potential Impact/ Mitigation measures
		compensate for the loss of open channel. Geomorphological features can be incorporated into the designs to achieve this uplift. More guidance can be found in the Manual of River Restoration Techniques, published by the River Restoration Centre. Compensation is required for the loss of natural channel and geomorphic diversity on the Punder Gill. Compensation must be a 10% condition uplift of a 1.5 times length of watercourse that is within the red line boundary of the realignment within the waterbody reach
Morphology: Structure of the riparian zone	Direct	**Permanent Impact:** The installation of culverts on the Punder Gill will involve the replacement of the existing riparian zone with an embankment to support the existing A66. In addition, the replacement of a section of open channel with culverts will significantly reduce the connectivity of the watercourse to the riparian zone and surrounding floodplain. This combined loss of riparian zone and floodplain connectivity will lead to a degradation of the riparian zone on the Punder Gill. **Mitigation:** It is required that in the realignment reach, the designs incorporate a 10% uplift to mitigate for the loss of riparian habitat at the culvert structures. To compensate the loss of riparian habitat and structure, a buffer strip will be established from the top of the left and right banks, and riparian planting of tree cover is undertaken. Tree planting must match species currently found in the riparian zone of the Punder Gill. This will ensure that the existing riparian habitat conditions are preserved and enhanced. Compensation is required for the loss of natural channel and geomorphic diversity on the Punder Gill. Compensation should be a 10% condition uplift of a1.5 times length of watercourse that is within the red line boundary of the realignment within the waterbody reach

Water body Mitigation Measures

14.4.7.41 The Tees from Percy Beck to River Greta water body is classified as a Heavily Modified Water Body (HMWB). However, there are no hydromorphology mitigation measures identified in the Solway Tweed River Basin Management Plan 2021 to contribute to better ecological potential. The water body is currently awaiting classification of its HMWB designation. As no mitigation measures have been identified, the ability of the proposed works to deliver mitigation measures, or the risk that the works could prevent their implementation, cannot be considered further in this assessment.

14.4.7.42 The Greta from Gill Beck to River Tees water body is not classified as heavily modified or artificial. Therefore, there are no hydromorphology mitigation measures assigned to this water body identified in the Solway Tweed River Basin Management Plan 2021.

WFD hydromorphology assessment objectives

Table 74: Hydromorphology assessment of proposed works against WFD objectives for the Solway Tweed River Basin Management Plan 2021

WFD Hydromorphology Assessment Objectives	Assessment of works
Objective 1: The proposed works do not cause deterioration in the Status of the Ecological Elements of the water body	Provided the required mitigation measures detailed in Table 73: Impacts and mitigation measures of Watercourse Crossing Point 68 (Culverts S08-C01 and S08-C03) and Section 14.4.9 are adhered to, the proposed works will not cause a deterioration in the status of the Greta from Gill Beck to River Tees or Tees from Percy Beck to River Greta water bodies.
Objective 2: The proposed works do not compromise the ability of the water body to achieve its WFD status objectives	The proposed works do not compromise the ability of the Greta from Gill Beck to River Tees or Tees from Percy Beck to River Greta water bodies to achieve Good hydromorphology status, provided the mitigation measures detailed in Table 73: Impacts and mitigation measures of Watercourse Crossing Point 68 (Culverts S08-C01 and S08-C03) and Section 14.4.9 are adhered to.
Objective 3: The proposed works do not cause a permanent exclusion or compromised achievement of the WFD objectives in other bodies of water within the same RBD	Impacts arising from the proposals at the scheme will be direct and local to the fluvial environment on site. The impacts arising from the proposed works will not impact on areas elsewhere in the catchment and will not impact other WFD waterbodies within the RBMP.
Objective 4: The proposed works contribute to the delivery of the WFD objectives	The proposed works will contribute to the delivery of the WFD objectives by ensuring no detrimental impact to the water body at the water body scale, and by providing localised hydromorphological enhancements, provided the mitigation measures detailed in Table 73 are adhered to

Cross Lanes to Rokeby key considerations

14.4.7.43 The impact assessment determines whether the proposed works have the potential to significantly impact any of the hydromorphology quality elements screened into the assessment. Specific mitigation measures required to prevent the deterioration of specific quality elements are considered in Table 73: Impacts and mitigation measures of Watercourse Crossing Point 68 (Culverts S08-C01 and S08-C03). Additional mitigation measures that must be considered at each of the proposed structures screened into the assessment are listed in section 14.4.9.

14.4.7.44 The mitigation measures stipulated within the impact assessment are secured by the Project Design Principles (Application Document 5.11) and the Environmental Management Plan (Application Document 2.7), which are certified documents under DCO.

14.4.7.45 Provided the mitigation measures stipulated within the impact assessment and in Section 14.4.9 are implemented at the detailed design stage, cumulative impacts from all the proposed works to the hydromorphology quality elements of the Greta from Gill Beck to River Tees water body WFD water bodies will be mitigated sufficiently.

Summary

14.4.7.46 The works proposed at Cross Lanes are likely to directly impact the following hydromorphology quality elements for Greta from Gill Beck to River Tees water body at Watercourse Crossing Point 68 (Culverts S08-C01 and S08-C03):

- Hydrology: Quantity and Dynamics of flow
- Hydrology: Connection to ground water bodies
- River Continuity
- Morphology: River width and depth
- Morphology: Structure and substrate of the river bed
- Morphology: Structure of the riparian zone.

14.4.7.47 The stipulated mitigation and compensation measures required to achieve the WFD objectives include:

- Hydraulic modelling to understand the impact on quantity and dynamics of flow
- Riparian tree planting
- Riparian buffer strips
- Installation of natural woody material in the channel
- Ensuring the realigned channel allows for interaction with the hyporheic zone and ground water
- Ensuring the design of the realigned channel is sympathetic to the conditions and character of the existing channel
- Consulting a geomorphologist on the designs
- Compensation for loss of natural channel by improving two times length of watercourse from poor to good condition
- Shear stress, flow and velocity analysis to determine impacts and appropriate size of materials for the channel
- 10% uplift of condition of the realigned channel from baseline conditions using Biodiversity Net Gain.

14.4.7.48 The assessment reported in this assessment is based on a precautionary worst case scenario. As such, the mitigation identified in this assessment as being required to mitigate the likely significant effects reported are based on this worst case scenario. It may be the case that as detailed design of the Project evolves, it becomes apparent that a lesser form of mitigation is required to achieve the same outcome. As such, the EMP secures the ‘maximum’ extent of mitigation required (as identified in this assessment) but also, where appropriate, includes mechanisms (e.g. by way of further surveys or modelling) to establish, pre-construction and during detailed design, whether the identified mitigation can be refined such that a lesser extent is required to achieve the outcome reported in this assessment. The fundamental point is that the mitigation identified in this assessment is secured by the EMP(Application Document 2.7), where required to achieve the outcome reported in this assessment.

14.4.8 Stephen Bank to Carkin Moor

Scheme overview and proposed works

Scheme location

14.4.8.1 The scheme location for Stephen Bank to Carkin Moor, and the proposed watercourse crossing points, are shown in Plate 20: Scheme location for Stephen Bank to Carkin Moor and proposed watercourse crossing points.

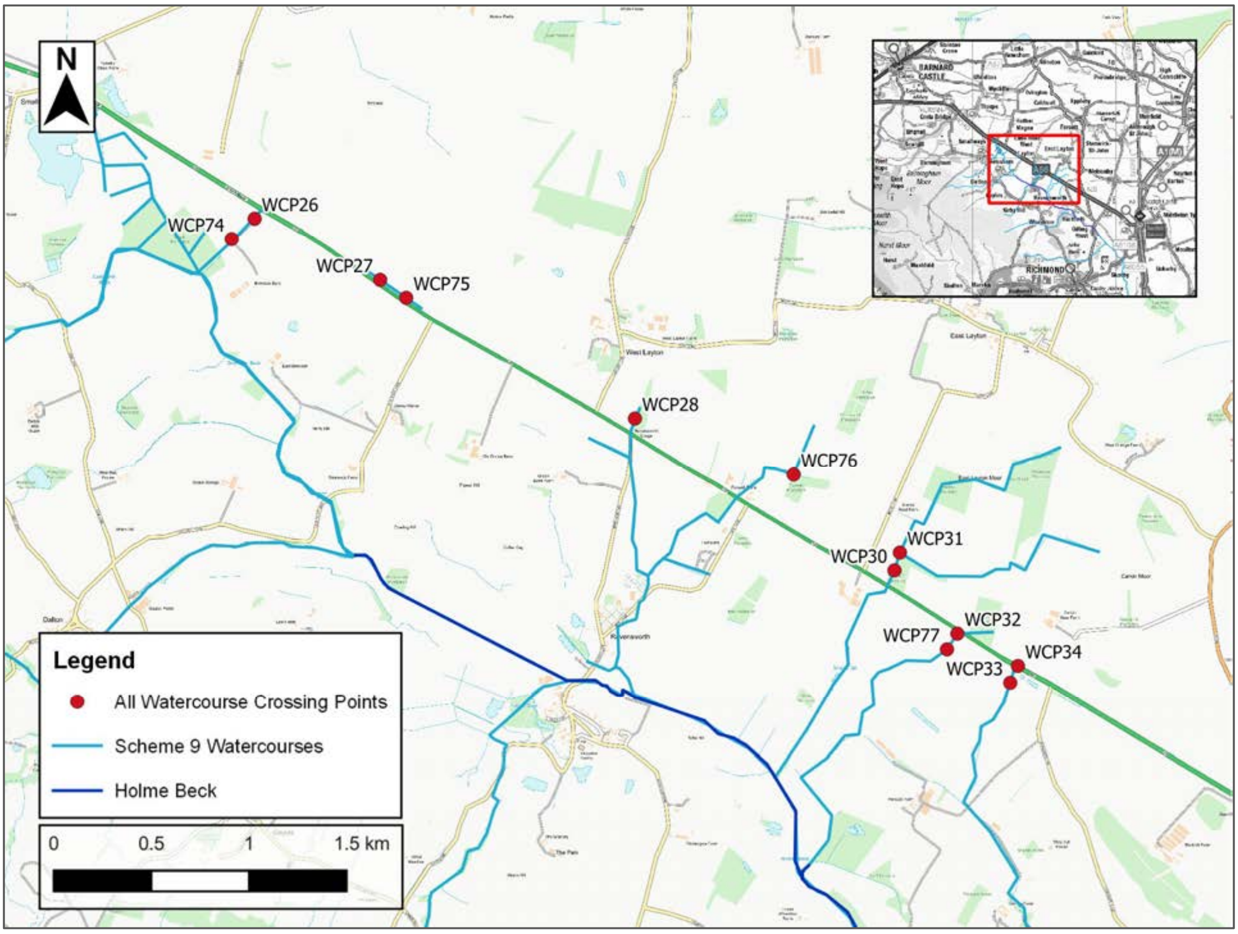

Plate 20: Scheme location for Stephen Bank to Carkin Moor and proposed watercourse crossing points

Proposed works

14.4.8.2 The proposed works at each identified watercourse crossing point in Plate 20: Scheme location for Stephen Bank to Carkin Moor and proposed watercourse crossing points are summarised below. Design drawings and specifications have been referenced if additional detail is required.

Watercourse Crossing Point 74

- No structure proposed at this location

Watercourse Crossing Point 26 (Culvert S09-C02)

- A proposed new pipe culvert of 9.8m in length and a 0.45m diameter

Watercourse Crossing Point 28 (Ravensworth Culvert S09-C04)

- A proposed new pipe culvert of 49.4m in length and a 1.5m diameter

Watercourse Crossing Point 76 (Fox Culvert S09-C05)

- A proposed new box culvert of 99.2m length and 2 x 2m (HxW)

Watercourse Crossing Point 30 (Moor Lane Culvert S09-C07)

- A proposed new box culvert of 99.3m in length and 1.5 x 2.25m (HxW)

Watercourse Crossing Point 32 (Street Plantation Culverts S09-C09)

- An existing culvert of 43.3m length to be replaced by a new pipe culvert of 68.7m in length and a 1.5m diameter

Watercourse Crossing Point 77 (Carkin Moor Culvert S09-C10)

- A proposed new pipe culvert of 27.3m in length and a 1.5m diameter

Watercourse Crossing Point 34 (Cloven Hill Culverts S09-C011)

- An existing box culvert of 22.7m in length and internal space of 1.5 x 1.8m (HxW) is to be extended both upstream (by 19.4m) and downstream (by 26.5m) to a total length of 68.6m.

Watercourse Crossing Point 33 (Cloven Hill Culvert 2 S09-C013)

- A proposed new pipe culvert of 44.2m in length and a 1.5m diameter

Watercourse Crossing Point 31 (Moor Lane Culvert S09-C17)

- A proposed new box culvert of 8.7m in length and 1.5 x 2.25m (HxW) to culvert under a bridleway

Baseline Hydromorphology Desktop Study

Survey Scope

14.4.8.3 The scheme watercourse crossing points are located within the Skeeby/Holme/Dalton Beck from Source to River Swale water body catchment (ES Figure 14.3: WFD Surface Water Bodies (Application Document 3.3)). The following section provides a summary of the geomorphological characteristics of these catchments.

Catchment and character

14.4.8.4 The Skeeby/Holme/Dalton Beck catchment drains an area of 79.45 km^2. The source of the water body is Cottonmill Beck, south of the village of

Newsham. Cottonmill Beck rises at an elevation of approximately 179m AOD and flows in a south easterly direction. The watercourse discharges into Darlton Beck approximately 4.2km downstream. Darlton Beck continues to flow in a south easterly direction for 1.3km until it reaches Ravensworth and discharges into Holme Beck. Approximately 7.5km downstream, south of Gilling West, the water body discharges into Skeeby Beck. Skeeby Beck continues to flow in a southernly direction for approximately 5.2km before the watercourse discharges into the River Swale.

14.4.8.5 The Skeeby/Holme/Dalton Beck catchment is mostly rural with areas of grassland, woodland and farmland.

14.4.8.6 The Skeeby/Holme/Dalton Beck catchment is characterised by Yoredale Group geology. The geology within the catchment is Alston Formation, consisting of limestone with subordinate sandstone and argillaceous rocks.

Historic trend analysis

14.4.8.7 Historic OS mapping has been used to examine the extent of historic channel change within the water body catchment. The watercourse routes illustrated in the 1888 OS mapping (the earliest OS mapping available online) have been compared to current watercourses to identify areas of channel migration and realignment.

14.4.8.8 In general, there has been little change to the planform of the water body in the c. 130 years since the earliest mapping available online. The water body flows through agricultural land and parallel to the existing A66. A lack of change to the planform of the Stephen Bank to Carkin Moor watercourses can be attributed to anthropogenic management. The watercourses appear to have been straightened to increase drainage for farming. They are culverted beneath the existing A66 network.

Assessment of LiDAR Data

14.4.8.9 Several palaeo channels can be identified throughout Stephen Bank to Carkin Moor. The watercourses of Stephen Bank to Carkin Moor appear straight in present and historic mapping. LiDAR data highlights sinuous palaeo channels along each watercourse. This suggests that the planform of the watercourses has changed and that they have been modified sometime prior to 1888. To the west of Ravensworth, the Holme Beck watercourse appears to have been straightened. In Area 1 (Plate 21: Assessment of palaeo channels in the vicinity of Stephen Bank to Carkin Moor) the planform of the Holme Beck has decreased in sinuosity significantly. In Area 2 (Plate 21: Assessment of palaeo channels in the vicinity of Stephen Bank to Carkin Moor), a meandering paleochannel suggests that the watercourse channel has reduced in sinuosity over time. The palaeo channels identified across Skeeby/Holme/Dalton Beck indicate that the watercourses were previously more complex and diverse in terms of their planform. A lack of planform change in recent years can be explained by anthropogenic management. It is likely that the watercourses have been realigned and straightened to increase the extent of agricultural land and improve drainage.

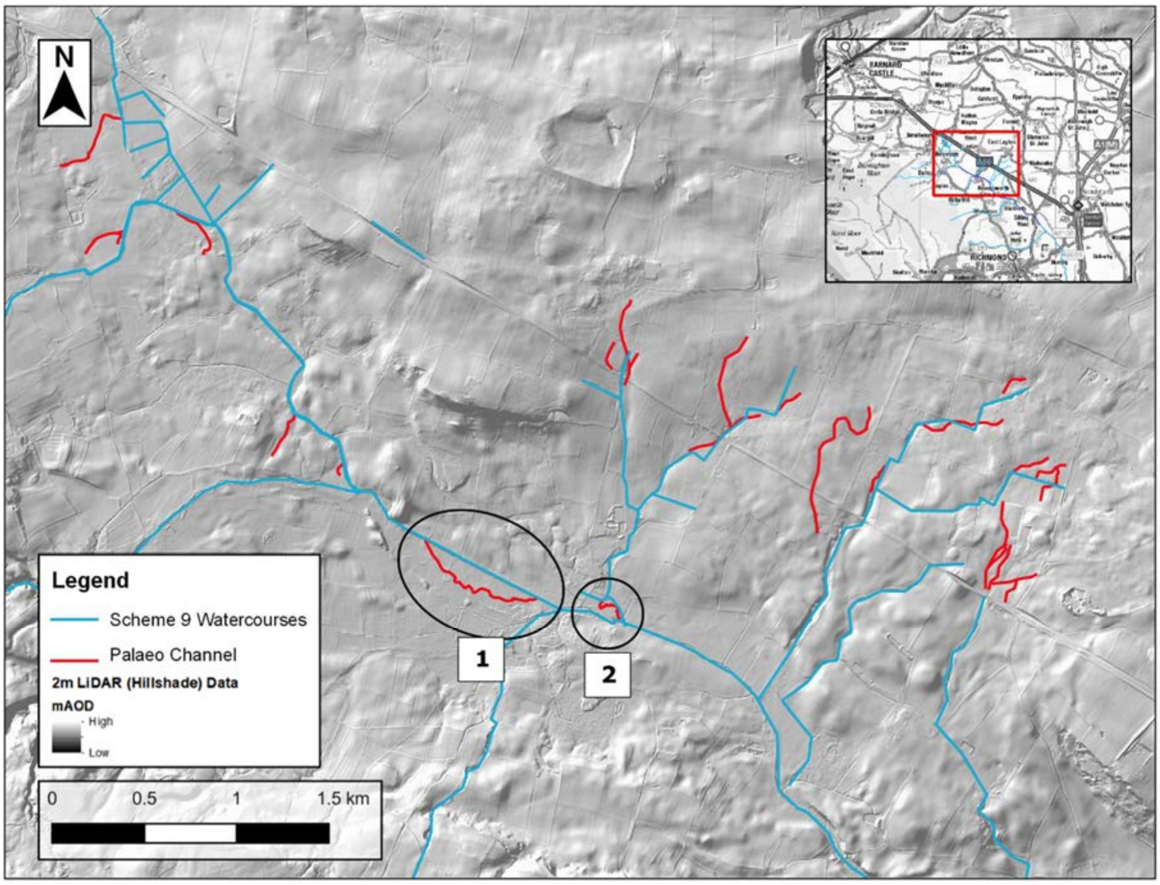

Plate 21: Assessment of palaeo channels in the vicinity of Stephen Bank to Carkin Moor

Baseline Hydromorphology Site Observations

Table 75: Stephen Bank to Carkin Moor baseline hydromorphology for each scheme

Crossing Point/ Watercourse	Site Observations
WCP74 WCP26 Unnamed Tributary of Cottonmill Beck 9.3	**Wider Catchment Characteristics:** The Unnamed Tributary is located to the south of the A66 at Stephen Bank in Richmond. The tributary flows in a south westerly direction for approximately 200m and is culverted up to Black Forest, where the tributary discharges into the Cottonmill Beck. Photographs of the location are shown in Annex A: Site Photograph Locations. **Observed In-Channel Modifications:** • Culvert 200m south of the A66 **Typical Flow Biotopes:** The Unnamed Tributary of Cottonmill Beck 9.3 is dry with no flow in the channel at the time of the site visit(Table 1: Hydromorphology survey dates). At the downstream end of the drain there is a ponded area.

Crossing Point/ Watercourse	Site Observations
	Typical Bed Substrate: The bed substrate along the Unnamed Tributary is predominantly fine material. This could be derived locally from the channel banks or could be sourced from surrounding agricultural field via overland flow routes during rainfall events. The low flow conditions mean that the fine sediment settles on the bed rather than being transported to downstream reaches. **Typical Riparian Composition:** Across the extent of the Unnamed Tributary, there is good riparian cover. From the A66, the tributary flows along a hedgerow which is located on the right bank. The channel is overgrown with dense vegetation. The watercourse enters a forested area downstream of the culvert. **Floodplain Connectivity:** The Unnamed Tributary flows along a road. This suggests that the channel has been positioned for drainage. The tributary sits below ground level and the dry channel suggests that flow is unlikely to enter the floodplain and there was no evidence of floodplain connectivity.
WCP27 WCP75 Unnamed Tributary of Browson Beck 9.1	**Wider Catchment Characteristics:** The Unnamed Tributary is located to the north of the existing A66, east of West Layton. The tributary runs parallel to the A66 for approximately 340m. Photographs of the location are shown in Annex A: Site Photograph Locations. **Typical Flow Biotopes:** The tributary was dry with no flow in the channel. **Typical Bed Substrate:** The bed was obscured by vegetation. It is suspected that the bed substrate is primarily comprised of fine material. **Typical Riparian Composition:** The Unnamed Tributary is overgrown with vegetation. There is riparian tree cover along the drain. **Floodplain Connectivity:** The dry channel of the Unnamed Tributary suggests that flow is unlikely to enter the floodplain and there was no evidence of floodplain connectivity.
WCP28 Unnamed Tributary of Holme Beck 9.6	**Wider Catchment Characteristics:** The Unnamed Tributary rises in West Layton at Ravenswoth Lodge. The watercourse is culverted beneath the existing A66 network and flows in a southerly direction for approximately 1.3km towards Ravensworth. At Ravensworth, the watercourse flows in a south

Crossing Point/ Watercourse	Site Observations
	easterly direction and discharges into the Holme Beck. Photographs of the location are shown in Annex A: Site Photograph Locations. **Typical Flow Biotopes:** Upstream, the watercourse lies in an ephemeral valley with no flow. It is likely that recent woodland planting has caused the watercourse to dry up. Downstream of the A66, the flow level increases slightly with still, pooled water in the channel. **Typical Bed Substrate:** The bed substrate along the watercourse is predominantly fine material. This could be derived locally from the channel banks or could be sourced from surrounding agricultural field via overland flow routes during rainfall events. The low flow conditions mean that the fine sediment settles on the bed rather than being transported to downstream reaches. **Typical Riparian Composition:** Upstream of the A66, the ephemeral valley lies in a woodland area with significant tree cover. Downstream of the A66, the watercourse flows along a hedgerow which is located on the left bank. The channel is well vegetated with long grass. **Floodplain Connectivity:** The channel appears to have been aligned along Waitlands Lane and it is probable that the watercourse is used for farmland drainage. Flow from within the channel is unlikely to enter the floodplain and there is no evidence of floodplain connectivity.
WCP76 Unnamed Tributary of Holme Beck 9.5	**Wider Catchment Characteristics:** The Unnamed Tributary rises in West Layton, to the east of Pinmoorhill forest. The watercourse flows in a south easterly direction along two field boundaries before crossing through Foxwell Farm. The watercourse is culverted at the existing A66. At the A66, the watercourse continues to flow in a south easterly direction for approximately 1.2km towards Ravensworth. At Ravensworth, the watercourse flows in a south easterly direction and discharges into the Holme Beck. Photographs of the location are shown in Annex A: Site Photograph Locations. **Observed In-Channel Modifications:** • Outfall at Foxwell Farm • Culvert at the A66 • Culvert to the east of New Lane • Sewage outfall to the east of New Lane **Typical Flow Biotopes:**

Crossing Point/ Watercourse	Site Observations
	Upstream of the A66, the flow velocities within the watercourse channel are poor with no flow in some places leading to long, pooled sections. Further downstream at Foxwell Farm, the flow levels increase, and gliding flows are the typical biotope. Downstream of the A66, flow reduces and the watercourse is characterised by low flow, possibly pooled sections, with no distinguishable flow caused by a low gradient. **Typical Bed Substrate:** North of the A66, the bed substrate along the watercourse is predominantly fine material. Bank erosion on the right and left bank suggests that fine material is entering the channel from the riverbank in times of high rainfall. Additionally, an influx of fine material into the channel can be attributed to poaching by livestock. Evidence of poaching can be found along the left bank. A lack of flow in the watercourse has caused fine sediment to be stored within the reach. South of the A66, the bed substrate changes from fine material to coarser gravels and cobbles, with some silty deposition. Coarse material is stored within the channel bed. The bed appears to be armoured as the flow velocities are not sufficient to mobilise and transport large clasts. This creates a heterogeneous river bed. **Typical Riparian Composition:** In the vicinity of Foxwell Farm, riparian cover is poor. Livestock poaching has caused degradation of the banks and prevented vegetation growth. There is an occasional 'J shaped' tree on the right bank, indicating channel incision erosion of the toe. South of the A66 and downstream of the second culvert, riparian vegetation increases. A low energy flow regime has allowed vegetation to colonise and stabilise within the channel bed. The presence of nettles indicates that there is eutrophication within the reach. This is likely to be caused by drainage from agricultural land. The watercourse has thickets of riparian tree cover. **Floodplain Connectivity:** Upstream, the watercourse is not connected to the floodplain. The watercourse is trapezoidal in shape and there is evidence of bed incision. Palaeo channels in the landscape suggest that the channel has been moved and may be incising down in response to the increased gradient. Towards the A66, floodplain connectivity improves but not to a large extent. Downstream of the A66, the floodplain is disconnected. The floodplain is raised above the watercourse and there is evidence of incision on the left bank.

Crossing Point/ Watercourse	Site Observations
WCP31 Unnamed Tributary of Mains Gill 9.1 WCP30 Mains Gill	**Wider Catchment Characteristics:** The Unnamed Tributary rises at East Layton Moor in Westmoor Forest. The watercourse flows in a south westerly direction for approximately 1.3km towards Mainsgill Forest. The watercourse is culverted underneath the A66 and continues to flow in a south westerly direction for approximately 1.2km before discharging into the Holme Beck. Photographs of the location are shown in Annex A: Site Photograph Locations. **Observed In-Channel Modifications:** • Informal culvert in Middle Forest. **Typical Flow Biotopes:** In the upstream reach of the watercourse, flow velocity is poor. At the culvert in Middle Forest, a build-up of sediment has impounded the flow. Downstream of Middle Forest, low flow energy can be attributed to a reduction in channel gradient. Gliding flows are the typical flow biotope within the channel in this reach. In Mainsgill Forest, the channel gradient and flow velocity increases. The channel comprises of alternating riffle and pool biotopes. Natural woody debris dams create small areas of impoundment along the reach and increase the flow diversity. Further downstream of Mainsgill Forest, flow velocity decreases and a dry channel is observed. It is probable that the watercourse is used for agricultural drainage in this location. **Typical Bed Substrate:** In Middle Forest, the typical bed substrate comprises of gravels and fine sediment. In areas without channel modification, a gravel bed is present with some larger cobbles. In the vicinity of the informal culvert, the river bed is comprised of fine material. The culvert is small and raised, causing an impoundment of flow. Low flow velocity results in the deposition of fine sediment in the channel bed. The accumulation of fine material is further compounded by dredging of the river. Dredging has reduced the channel gradient and slowed flow in the reach. As a result, fine sediment has settled within the channel. In Mainsgill Forest, the typical bed substrate in the watercourse increases in size. The channel bed comprises of gravels, cobbles and boulders which are stored within the reach. Coarse material is stored within the channel bed. The bed appears to be armoured as the flow velocities are not sufficient to mobilise and transport large clasts. This creates a more heterogeneous river bed.

Crossing Point/ Watercourse	Site Observations
	Further downstream, the gradient lowers and the bed substrate size reduces significantly. The channel bed is homogeneous and comprised of fine material. **Typical Riparian Composition:** The Unnamed Tributary flows through several woodland areas. Upstream, at Middle Forest, trees occupy both riverbanks. The riparian zone is generally well vegetated, although dredging has reduced riparian cover in some locations. Further downstream, the riverbank is lined with long grass and the surrounding agricultural land is arable farmland. At Mainsgill Forest, riparian tree cover increases, with tree vegetation and woody material along the riverbanks. This woody material can provide a source of woody material for the channel. Upstream of a culvert within Mainsgill Forest there is woody material and woody dams present in the channel however downstream of this culvert has been dredged and all material removed. **Floodplain Connectivity:** At Middle Forest, in areas of dredging, the floodplain is no longer connected to the watercourse channel. The channel is deeply incised and the parent bed material is exposed. Further downstream, in the vicinity of Mainsgill Forest, floodplain connectivity improves and over deepening is less prominent.
WCP32 WCP77 Unnamed Tributary of Holme Beck 9.8	**Wider Catchment Characteristics:** The Unnamed Tributary rises to the south of the A66 in Street Forest. The watercourse is culverted beneath the A66 and flows in a south westerly direction for approximately 1.4km. The watercourse flows in a southernly direction for 600m before discharging into the Holme Beck, north of Lower Washton Barns. Photographs of the location are shown in Annex A: Site Photograph Locations. **Typical Flow Biotopes:** Upstream, the watercourse channel is dry in places with little flow observed. Downstream, flow remains poor. The watercourse is characterised by low flow with no distinguishable flow biotopes. **Observed In-Channel Modifications:** • Culvert south of the existing A66. **Typical Bed Substrate:** The bed substrate along the watercourse is predominantly fine material. A lack of flow in the watercourse has caused fine sediment to be stored within the reach.

Crossing Point/ Watercourse	Site Observations
	Typical Riparian Composition: Immediately downstream of the A66, the watercourse flows along a field boundary, with hedgerows and the occasional tree. The channel is well vegetated with long grass. Further downstream, the watercourse enters a woodland area and riparian tree cover increases. **Floodplain connectivity:** Upstream, the watercourse is not connected to the floodplain. The watercourse bank is trapezoidal in shape and the channel appears to have been straightened along a field boundary. Flow from within the channel is unlikely to enter the floodplain. Downstream, floodplain connectivity improves slightly.
WCP33 Unnamed Tributary of Holme Beck 9.2 WCP34 Unnamed Tributary of Holme Beck 9.7	**Wider Catchment Characteristics:** The Unnamed Tributary rises south of the A66 to the west of Warrener Lane. The watercourse flows in a south westerly direction for approximately 760m before it is culverted at Pondale farm. The watercourse continues to flow in a south easterly direction for approximately 1km towards Comfort Lane. At Comfort Lane, the watercourse is culverted and flows for a further 270m before discharging into the Hartforth Beck. Photographs of the location are shown in Annex A: Site Photograph Locations. **Observed In-Channel Modifications:** Culvert at the existing A66. **Typical Flow Biotopes:** There is low flow velocity in the unnamed watercourse. **Typical Bed Substrate:** The bed substrate along the watercourse is predominantly fine material with gravels. **Typical Riparian Composition:** The watercourse flows between two hedgerows. The channel bed is colonised by grass. A low energy flow regime has allowed vegetation to stabilise within the channel. **Floodplain connectivity:** The watercourse is not connected to the floodplain and the channel is incised. The watercourse bank is trapezoidal in shape and the channel appears to have been straightened along a field boundary. Flow from within the channel is unlikely to enter the floodplain.

Stage 1: Hydromorphology screening

14.4.8.10 The screening assessment aims to screen in any works that require WFD assessment and to identify which WFD water bodies are within and near to the proposed works.

14.4.8.11 Drainage channel outfalls have been screened out of the assessment as their design is secured by the EMP (Application Document 2.7), which is a certified document under DCO. Where hard outfalls currently exist, new drainage channel outfalls will be tied into the existing structure. Drainage channels in areas with natural banks will be designed as a natural outfall (i.e. without hard bank protection).

14.4.8.12 Table 76: Screening of each water body indicates which water bodies have been screened in or out of the assessment and the reasons for this decision.

14.4.8.13 The baseline status of the hydromorphology quality elements within the water bodies screened into the assessment are discussed in this section. If there is potential for the proposed works to cause deterioration in the status of a water body or prevent it from achieving its status objectives as defined in the Solway Tweed River Basin Management Plan, the relevant water body and its quality elements have been taken forward and considered further in the scoping assessment at Stage 2.

Table 76: Screening of each water body

Water body/ies	Reason	Screening outcome
Skeeby/Holme/Dalton Bk from Source to River Swale	The proposed works for Stephen Bank to Carkin Moor are located within the waterbody and therefore, direct impact on this waterbody is possible.	Screened In
Swale from Clapgate Beck to Bedale Beck - heavily modified	The waterbody is located approximately 11 km downstream of the southernmost point of Stephen Bank to Carkin Moor (WCP33). As such the waterbody is located far enough downstream from the works to not be impacted.	Screened Out

Baseline status of screened-in water bodies

14.4.8.14 Table 77: Current WFD status of connected water body catchments in Cycle 2 (2019) summarises the water body ID, hydromorphological designation, current ecological status / potential and ecological objective for each water body screened into the assessment. This information is provided by the Solway Tweed River Basin Management Plan 2021.

Table 77: Current WFD status of connected water body catchments in Cycle 2 (2019)

Water body ID	Name of water body	Hydromorphological designation	Current Ecological Status/ Potential	Ecological Objective
GB104027069180	Skeeby/Holme/Dalton Bk from Source to River Swale	Not designated artificial or heavily modified	Moderate	Good by 2021

14.4.8.15 The tables below outline the current status of the hydromorphological quality elements and reasons for not achieving good status (RNAGS) according to the most recent WFD cycle.

Table 78: Hydromorphological quality elements of Skeeby/Holme/Dalton Bk from Source to River Swale in Cycle 2 (2019)

Hydromorphological Quality Element	Current Status	Objective
Hydrological Regime	Supports good	Supports good by 2021
Morphology	Supports good	Not available

Table 79: RNAGS for Skeeby/Holme/Dalton Bk from Source to River Swale in Cycle 2 (2019)

SWMI*	Activities	Classification Element
Physical Modification	Land drainage - operational management Barriers - ecological discontinuity	Fish
Diffuse Source	Riparian/in-river activities (inc. bankside erosion) Barriers - ecological discontinuity	Fish

*Significant Water Management Issue

Stage 2: Hydromorphology Scoping

14.4.8.16 The scoping assessment identifies whether the water body catchments quality elements, identified during the screening assessment, are at risk from the proposed works. The proposed development works are being appraised in terms of their impact on WFD status and objectives. If any quality elements are found to be at risk of detrimental impact, further assessment and/ or mitigation may be required.

Hydromorphological quality elements of the Skeeby/Holme/Dalton Bk from Source to River Swale

14.4.8.17 The following Watercourse Crossing Points were identified as falling within the Skeeby/Holme/Dalton Bk from Source to River Swale water body catchment:

- Watercourse Crossing Point 74
- Watercourse Crossing Point 26 (Culvert S09-C02)

- Watercourse Crossing Point 28 (Ravensworth Culvert S09-C04)
- Watercourse Crossing Point 76 (Fox Culvert S09-C05)
- Watercourse Crossing Point 30 (Culvert S09-C07)
- Watercourse Crossing Point omitted (Culvert S09-C08)
- Watercourse Crossing Point 32 (Street Plantation Culverts S09-C09)
- Watercourse Crossing Point 77 (Carkin Moor Culvert S09-C10)
- Watercourse Crossing Point 34 (Cloven Hill Culvert S09-C11)
- Watercourse Crossing Point 33 (Cloven Hill Culvert 2 S09-C13)
- Watercourse Crossing Point 31 (Moor Lane Culvert S09-C17).

14.4.8.18 As such, the potential impacts of the proposed works at each identified crossing point will have on the Skeeby/Holme/Dalton Beck from Source to River Swale water body have been assessed. Where there is the potential for the proposed works to impact the geomorphological condition of watercourses within the Skeeby/Holme/Dalton Bk from Source to River Swale water body.

Watercourse Crossing Point 74

14.4.8.19 No designs have been submitted for this Watercourse Crossing Point, therefore no potential impacts are identified at this stage and the crossing point has been scoped out of the assessment. Watercourse Crossing Point 26 (Culvert S09-C02)

14.4.8.20 The proposed works at this location include a new pipe culvert of 9.8m in length and a 0.45m diameter.

14.4.8.21 Table 80: Assessment of works at Watercourse Crossing Point 26 (Culvert S09-C02) on the Unnamed Drain at Stephen Bank, Richmond, which is within the Skeeby/Holme/Dalton Beck from Source to River Swale water body catchment assesses the potential impacts arising from proposed works at Watercourse Crossing Point 26 (Culvert S09-C02) on the Unnamed Drain at Stephen Bank, Richmond, which is within the Skeeby/Holme/Dalton Beck from Source to River Swale water body catchment.

Table 80: Assessment of works at Watercourse Crossing Point 26 (Culvert S09-C02) on the Unnamed Drain at Stephen Bank, Richmond, which is within the Skeeby/Holme/Dalton Beck from Source to River Swale water body catchment

WFD Quality Element	Current Status	Potential Impact	Further assessment and/or mitigation required?
Hydrology: Quantity and Dynamics of flow	Not Assessed	The new pipe culvert of 9.8m length and 0.45m diameter may alter the dynamics of flow (e.g., flow velocity, water depth, wetted area etc.) on a local scale at the Unnamed Tributary of Cottonmill Beck 9.3. However, the existing flow dynamics on the unnamed drain are homogeneous and lack geomorphological diversity as the tributary was dry upon inspection and can be described as already degraded as a result of	No

WFD Quality Element	Current Status	Potential Impact	Further assessment and/or mitigation required?
		anthropogenic and agricultural pressures. As such, the proposed works are unlikely to lead to a degradation of the quantity and dynamics of flow. Therefore, this quality element will not be considered as part of the impact assessment for the Skeeby/Holme/Dalton Beck from Source to River Swale water body.	
Hydrology: Connection to ground water bodies	Not Assessed	The proposed works involve the installation of a new pipe culvert. This is unlikely to impact the existing connectivity of the watercourse to ground water bodies. This is a dry ditch and not a significant contributor to ground water. As such, this reduction in connectivity between the drain and ground water bodies is not significant enough to impact ground water connectivity. Therefore, this quality element will not be considered as part of the impact assessment for the Skeeby/Holme/Dalton Beck from Source to River Swale water body as part of the impact assessment.	No
River Continuity	Not Assessed	The Unnamed Tributary of Cottonmill Beck 9.3 is a dry ditch. As such, there will be no impact to river continuity. Therefore, this quality element will not be considered as part of the impact assessment for the Skeeby/Holme/Dalton Beck from Source to River Swale water body as part of the impact assessment.	No
Morphology: River width and depth	Not Assessed	The Unnamed Tributary of Cottonmill Beck 9.3 a dry ditch. As such, there will be no impact to river width and depth. Therefore, this quality element will not be considered as part of the impact assessment for the Skeeby/Holme/Dalton Beck from Source to River Swale water body as part of the impact assessment.	No
Morphology: Structure and substrate of the river bed	Not Assessed	The Unnamed Tributary of Cottonmill Beck 9.3 is a dry ditch. As such, there will be no impact to the structure and substrate of the river bed. Therefore, this quality element will not be considered as part of the impact assessment for the Skeeby/Holme/Dalton Beck from Source to River Swale water body as part of the impact assessment.	No

WFD Quality Element	Current Status	Potential Impact	Further assessment and/or mitigation required?
Morphology: Structure of the riparian zone	Not Assessed	The Unnamed Tributary of Cottonmill Beck 9. 3 is a dry ditch covered by a hedgerow and overgrown vegetation. As such, there will be no impact to the structure of the riparian zone. Therefore, this quality element will not be considered as part of the impact assessment for the Skeeby/Holme/Dalton Beck from Source to River Swale water body as part of the impact assessment.	No

Watercourse Crossing Point 28 (Ravensworth Culvert S09-C04)

14.4.8.22 The proposed works at this location include a new pipe culvert of 49.4m in length and a 1.5m diameter.

14.4.8.23 Table 81: Assessment of works at Watercourse Crossing Point 28 (Ravensworth Culvert S09-C04) on the Unnamed Watercourse at Ravensworth Lodge, West Layton, which is within the Skeeby/Holme/Dalton Beck from Source to River Swale water body catchment assesses the potential impacts arising from proposed works at Watercourse Crossing Point 28 (Ravensworth Culvert S09-C04) on the Unnamed Watercourse at Ravensworth Lodge, West Layton, which is within the Skeeby/Holme/Dalton Beck from Source to River Swale water body catchment.

Table 81: Assessment of works at Watercourse Crossing Point 28 (Ravensworth Culvert S09-C04) on the Unnamed Watercourse at Ravensworth Lodge, West Layton, which is within the Skeeby/Holme/Dalton Beck from Source to River Swale water body catchment

WFD Quality Element	Current Status	Potential Impact	Further assessment and/or mitigation required?
Hydrology: Quantity and Dynamics of flow	Not Assessed	The Unnamed Tributary of Holme Beck 9.6 is an ephemeral valley with no flow. A new pipe culvert of 49.4m length and 1.5m diameter will not alter the dynamics of flow (e.g., flow velocity, water depth, wetted area etc.) on a local scale. As such, the proposed works are unlikely to lead to a degradation of the quantity and dynamics of flow. Therefore, this quality element will not be considered as part of the impact assessment for the Skeeby/Holme/Dalton Beck from Source to River Swale water body.	No
Hydrology: Connection to ground water bodies	Not Assessed	The proposed works involve the installation of a new pipe culvert. This is unlikely to impact the existing connectivity of the watercourse to ground water bodies. This is a	No

WFD Quality Element	Current Status	Potential Impact	Further assessment and/or mitigation required?
		dry ephemeral valley and not a significant contributor to ground water. As such, this reduction in connectivity between the surface waterbody and ground water bodies is not significant enough to impact ground water connectivity. Therefore, this quality element will not be considered as part of the impact assessment for the Skeeby/Holme/Dalton Beck from Source to River Swale water body as part of the impact assessment.	
River Continuity	Not Assessed	The Unnamed Tributary of Holme Beck 9.6is an ephemeral valley with no flow. As such, there will be no impact to river continuity. Therefore, this quality element will not be considered as part of the impact assessment for the Skeeby/Holme/Dalton Beck from Source to River Swale water body as part of the impact assessment.	No
Morphology: River width and depth	Not Assessed	The Unnamed Tributary of Holme Beck 9.6 is an ephemeral valley with no flow. As such, there will be no impact to the river width and depth. Therefore, this quality element will not be considered as part of the impact assessment for the Skeeby/Holme/Dalton Beck from Source to River Swale water body as part of the impact assessment.	No
Morphology: Structure and substrate of the river bed	Not Assessed	The Unnamed Tributary of Holme Beck 9.6 is an ephemeral valley with no flow. As such, there will be no impact to the structure and substrate of the river bed. Therefore, this quality element will not be considered as part of the impact assessment for the Skeeby/Holme/Dalton Beck from Source to River Swale water body as part of the impact assessment.	No
Morphology: Structure of the riparian zone	Not Assessed	The Unnamed Tributary of Holme Beck 9.6 is an ephemeral valley with no flow within a newly planted woodland. As such, there will be no impact to the structure of the riparian zone. Therefore, this quality element will not be considered as part of the impact assessment for the Skeeby/Holme/Dalton Beck from Source to River Swale water body as part of the impact assessment.	No

Watercourse Crossing Point 76 (Fox Culvert S09-C05)

14.4.8.24 The proposed works at this location include a new box culvert of 99.2m length and 2m x 2m in size (HxW).

14.4.8.25 Table 82: Assessment of works at Watercourse Crossing Point 76 (Fox Culvert S09-C05) on the Unnamed Watercourse at Foxwell Farm, which is within the Skeeby/Holme/Dalton Beck from Source to River Swale water body catchment assesses the potential impacts arising from proposed works at Watercourse Crossing Point 76 (Fox Culvert S09-C05) on the Unnamed Watercourse at Foxwell Farm, which is within the Skeeby/Holme/Dalton Beck from Source to River Swale water body catchment.

Table 82: Assessment of works at Watercourse Crossing Point 76 (Fox Culvert S09-C05) on the Unnamed Watercourse at Foxwell Farm, which is within the Skeeby/Holme/Dalton Beck from Source to River Swale water body catchment

WFD Quality Element	Current Status	Potential Impact	Further assessment and/or mitigation required?
Hydrology: Quantity and Dynamics of flow	Not Assessed	The Unnamed Tributary of Holme Beck 9.5 is a straightened and trapezoidal waterbody that is degraded for agricultural use as a drain. The flow dynamics are poor with gliding flows and pooled sections with no distinguishable flow. A new box culvert of 99.2m length and 2m x 2m in size (HxW). May alter the dynamics of flow (e.g., flow velocity, water depth, wetted area etc.) on a local scale. However, the proposed works are unlikely to lead to a degradation of the quantity and dynamics of flow. Therefore, this quality element will not be considered as part of the impact assessment for the Skeeby/Holme/Dalton Beck from Source to River Swale water body.	No
Hydrology: Connection to ground water bodies	Not Assessed	The proposed works involve the installation of a new box culvert. This is unlikely to impact the existing connectivity of the Unnamed Tributary of Holme Beck 9.5 to ground water bodies. The watercourse is no considered to be a significant contributor to ground water due to the poor flow and low quantity of water in the watercourse. As such, the potential reduction in connectivity between the surface waterbody and ground water bodies as a result of the proposed culvert is not considered significant enough to impact ground water connectivity. Therefore, this quality element will not be considered as part of the impact assessment for the Skeeby/Holme/Dalton Beck from	No

WFD Quality Element	Current Status	Potential Impact	Further assessment and/or mitigation required?
		Source to River Swale water body as part of the impact assessment.	
River Continuity	Not Assessed	The Unnamed Tributary of Holme Beck 9.5 is a straightened and trapezoidal waterbody with relatively little flow. The channel is degraded for agricultural use as a drain. As such, there will be no impact to river continuity. Therefore, this quality element will not be considered as part of the impact assessment for the Skeeby/Holme/Dalton Beck from Source to River Swale water body as part of the impact assessment.	No
Morphology: River width and depth	Not Assessed	The Unnamed Tributary of Holme Beck 9.5 is a straightened and trapezoidal waterbody with relatively little flow. The channel is degraded for agricultural use as a drain. As such, there will be no impact to the river width and depth. Therefore, this quality element will not be considered as part of the impact assessment for the Skeeby/Holme/Dalton Beck from Source to River Swale water body as part of the impact assessment.	No
Morphology: Structure and substrate of the river bed	Not Assessed	The Unnamed Tributary of Holme Beck 9.5 is a straightened and trapezoidal waterbody with relatively little flow. The channel is degraded for agricultural use as a drain. As such, there will be no impact to the structure and substrate of the river bed. Therefore, this quality element will not be considered as part of the impact assessment for the Skeeby/Holme/Dalton Beck from Source to River Swale water body as part of the impact assessment.	No
Morphology: Structure of the riparian zone	Not Assessed	The Unnamed Tributary of Holme Beck 9.5 is a straightened and trapezoidal waterbody with relatively little flow. The channel is degraded for agricultural use as a drain with poached banks and indications of eutrophication with overgrown nettles in the riparian zone. As such, there will be no impact to the structure of the riparian zone. Therefore, this quality element will not be considered as part of the impact assessment for the Skeeby/Holme/Dalton Beck from Source to River Swale water body as part of the impact assessment.	No

Watercourse Crossing Point 30 (Moor Lane Culvert S09-C07)

14.4.8.26 The proposed works at this location include a new box culvert of 99.3m in length and 1.5m x 2.25m in size (HxW).

14.4.8.27 Table 83: Assessment of works at Watercourse Crossing Point 30 (Moor Lane Culvert S09-C07), which is within the Skeeby/Holme/Dalton Beck from Source to River Swale water body catchment assesses the potential impacts arising from proposed works at Watercourse Crossing Point 30 (Moor Lane Culvert S09-C07) on the Unnamed Watercourse at Mainsgill Forest, which is within the Skeeby/Holme/Dalton Beck from Source to River Swale water body catchment.

Table 83: Assessment of works at Watercourse Crossing Point 30 (Moor Lane Culvert S09-C07), which is within the Skeeby/Holme/Dalton Beck from Source to River Swale water body catchment

WFD Quality Element	Current Status	Potential Impact	Further assessment and/or mitigation required?
Hydrology: Quantity and Dynamics of flow	Not Assessed	The Unnamed Tributary of Mains Gill 9.1 is straightened and trapezoidal upstream and is degraded for agricultural use as a drain. However, at the Mainsgill Forest the channel gradient and flow velocity increases. The channel comprises of alternating riffle and pool biotopes. Further downstream the channel is culverted under the current A66. A new box culvert of 99.3m length and 1.5m x 2.25m in size (HxW) is proposed for a significant portion of what is considered to be one of the few remaining river reaches that still exhibits good morphological condition. This proposed culvert will alter the dynamics of flow (e.g., flow velocity, water depth, wetted area etc.) on a local scale. As such, the proposed works are likely to lead to a degradation of the quantity and dynamics of flow. Therefore, this quality element will be considered as part of the impact assessment for the Skeeby/Holme/Dalton Beck from Source to River Swale water body.	Yes
Hydrology: Connection to ground water bodies	Not Assessed	The proposed works involve the installation of a new box culvert. This is unlikely to impact the existing connectivity of the Mains Gill to ground water bodies. As such, this reduction in connectivity between the surface waterbody and ground water bodies is not significant enough to impact ground water connectivity. Therefore, this quality element will not be considered as part of the impact assessment for the Skeeby/Holme/Dalton	No

WFD Quality Element	Current Status	Potential Impact	Further assessment and/or mitigation required?
		Beck from Source to River Swale water body as part of the impact assessment.	
River Continuity	Not Assessed	The Unnamed Tributary of Mains Gill 9.1 is straightened and trapezoidal upstream and is degraded for agricultural use as a drain. However, at the Mainsgill Forest the channel gradient and flow velocity increases. The channel comprises of alternating riffle and pool biotopes. Further downstream the channel is culverted under the current A66. As such, there will be no impact to river continuity as the channel is degraded upstream and downstream. Therefore, this quality element will not be considered as part of the impact assessment for the Skeeby/Holme/Dalton Beck from Source to River Swale water body as part of the impact assessment.	No
Morphology: River width and depth	Not Assessed	The Unnamed Tributary of Mains Gill 9.1 is straightened and trapezoidal upstream and is degraded for agricultural use as a drain. However, at the Mainsgill Forest the channel gradient and flow velocity increases. The channel comprises of alternating riffle and pool biotopes. Further downstream the channel is culverted under the current A66. A new box culvert of 99.3m length and 1.5m x 2.25m in size (HxW) is proposed for a significant portion of what is considered to be one of the few remaining river reaches that still exhibits good morphological condition. Consequently, the proposed structure will likely impact the river width and depth. Further detail is needed to appropriately assess this risk. Therefore, this quality element will be considered for the Skeeby/Holme/Dalton Beck from Source to River Swale water body as part of the impact assessment.	Yes
Morphology: Structure and substrate of the river bed	Not Assessed	The Unnamed Tributary of Mains Gill 9.1 is straightened and trapezoidal upstream that is degraded for agricultural use as a drain. However, at the Mainsgill Forest the channel gradient and flow velocity increases. The channel comprises of alternating riffle and pool biotopes in the gravel and cobble bed. Then downstream the channel is culverted	Yes

WFD Quality Element	Current Status	Potential Impact	Further assessment and/or mitigation required?
		under the current A66. As such, there is likely to be an impact to the structure and substrate of the river bed. Therefore, this quality element will be considered as part of the impact assessment for the Skeeby/Holme/Dalton Beck from Source to River Swale water body as part of the impact assessment.	
Morphology: Structure of the riparian zone	Not Assessed	The Mains Gill consists of riparian tree cover and is well vegetated. As such, there is likely to be an impact to the structure of the riparian zone. Therefore, this quality element will be considered as part of the impact assessment for the Skeeby/Holme/Dalton Beck from Source to River Swale water body as part of the impact assessment.	Yes

Watercourse Crossing Point 32 (Street Plantation Culverts S09-C09)

14.4.8.28 The proposed works at this location includes an existing culvert of 43.3m length to be replaced by a new pipe culvert of 68.7m in length and a 1.5m diameter.

14.4.8.29 Table 84: Assessment of works at Watercourse Crossing Point 32 (Street Plantation Culverts S09-C09) on the Unnamed Watercourse at Street Forest, which is within the Skeeby/Holme/Dalton Beck from Source to River Swale water body catchment assesses the potential impacts arising from proposed works at Watercourse Crossing Point 32 (Street Plantation Culverts S09-C09) on the Unnamed Watercourse at Street Forest, which is within the Skeeby/Holme/Dalton Beck from Source to River Swale water body catchment.

Table 84: Assessment of works at Watercourse Crossing Point 32 (Street Plantation Culverts S09-C09) on the Unnamed Watercourse at Street Forest, which is within the Skeeby/Holme/Dalton Beck from Source to River Swale water body catchment

WFD Quality Element	Current Status	Potential Impact	Further assessment and/or mitigation required?
Hydrology: Quantity and Dynamics of flow	Not Assessed	The Unnamed Tributary of Holme Beck 9.8 is a straightened and trapezoidal waterbody that is degraded for agricultural use as a drain. The flow dynamics are poor with little flow and no distinguishable flow biotopes observed. It is proposed at this location for an existing culvert of 43.3m length to be replaced and a new pipe culvert of 68.7m in length and a 1.5m diameter. This is unlikely	No

WFD Quality Element	Current Status	Potential Impact	Further assessment and/or mitigation required?
		to alter the dynamics of flow (e.g., flow velocity, water depth, wetted area etc.). As such, the proposed works are unlikely to lead to a degradation of the quantity and dynamics of flow. Therefore, this quality element will not be considered as part of the impact assessment for the Skeeby/Holme/Dalton Beck from Source to River Swale water body.	
Hydrology: Connection to ground water bodies	Not Assessed	The proposed works involve the installation of a replacement and extension of an existing culvert. This is unlikely to impact the existing connectivity of the Unnamed Tributary of Holme Beck 9.8 to ground water bodies. The watercourse is not considered to be a significant contributor to ground water due to the poor flow and low quantity of water in the watercourse. As such, this reduction in connectivity between the surface waterbody and ground water bodies is not significant enough to impact ground water connectivity. Therefore, this quality element will not be considered as part of the impact assessment for the Skeeby/Holme/Dalton Beck from Source to River Swale water body as part of the impact assessment.	No
River Continuity	Not Assessed	The Unnamed Tributary of Holme Beck 9.8 is a straightened and trapezoidal waterbody with relatively little flow. The channel is degraded for agricultural use as a drain. As such, there will be no impact to river continuity. Therefore, this quality element will not be considered as part of the impact assessment for the Skeeby/Holme/Dalton Beck from Source to River Swale water body as part of the impact assessment.	No
Morphology: River width and depth	Not Assessed	The Unnamed Tributary of Holme Beck 9.8 is a straightened and trapezoidal waterbody with relatively little flow. The channel is degraded for agricultural use as a drain. As such, there will be no impact to the river width and depth. Therefore, this quality element will not be considered as part of the impact assessment for the Skeeby/Holme/Dalton Beck from Source to River Swale water body as part of the impact assessment.	No

WFD Quality Element	Current Status	Potential Impact	Further assessment and/or mitigation required?
Morphology: Structure and substrate of the river bed	Not Assessed	The Unnamed Tributary of Holme Beck 9.8 is a straightened and trapezoidal waterbody with relatively little flow. The channel is degraded for agricultural use as a drain. As such, there will be no impact to the structure and substrate of the river bed. Therefore, this quality element will not be considered as part of the impact assessment for the Skeeby/Holme/Dalton Beck from Source to River Swale water body as part of the impact assessment.	No
Morphology: Structure of the riparian zone	Not Assessed	The Unnamed Tributary of Holme Beck 9.8 is a straightened and trapezoidal waterbody with relatively little flow. The channel is degraded for agricultural use as a drain with a grassed channel. As such, there will be no impact to the structure of the riparian zone. Therefore, this quality element will not be considered as part of the impact assessment for the Skeeby/Holme/Dalton Beck from Source to River Swale water body as part of the impact assessment.	No

Watercourse Crossing Point 77 (Carkin Moor Culvert S09-C10)

14.4.8.30 The proposed works at this location include a new pipe culvert of 27.3m in length and a 1.5m diameter.

14.4.8.31 Table 85: Assessment of works at Watercourse Crossing Point 77 (Carkin Moor Culvert S09-C10) on the Unnamed Watercourse at Street Forest, which is within the Skeeby/Holme/Dalton Beck from Source to River Swale water body catchment assesses the potential impacts arising from proposed works at Watercourse Crossing Point 77 (Carkin Moor Culvert S09-C10) on the Unnamed Watercourse at Street Forest, which is within the Skeeby/Holme/Dalton Beck from Source to River Swale water body catchment.

Table 85: Assessment of works at Watercourse Crossing Point 77 (Carkin Moor Culvert S09-C10) on the Unnamed Watercourse at Street Forest, which is within the Skeeby/Holme/Dalton Beck from Source to River Swale water body catchment

WFD Quality Element	Current Status	Potential Impact	Further assessment and/or mitigation required?
Hydrology: Quantity and Dynamics of flow	Not Assessed	The Unnamed Tributary of Holme Beck 9.8 is a straightened and trapezoidal waterbody that is degraded for agricultural use as a drain. The flow dynamics are poor with little flow and no distinguishable flow biotopes observed. A new culvert of 27.3m in length and a 1.5m diameter is proposed. This is unlikely to alter the dynamics of flow (e.g., flow velocity, water depth, wetted area etc.). As such, the proposed works are unlikely to lead to a degradation of the quantity and dynamics of flow. Therefore, this quality element will not be considered as part of the impact assessment for the Skeeby/Holme/Dalton Beck from Source to River Swale water body.	No
Hydrology: Connection to ground water bodies	Not Assessed	The proposed works involve the installation of a new pipe culvert of 27.3m in length and a 1.5m diameter. This is unlikely to impact the existing connectivity of the Unnamed Tributary of Holme Beck 9.8. The watercourse is not considered to be a significant contributor to ground water due to the poor flow and low quantity of water in the watercourse. As such, this reduction in connectivity between the surface waterbody and ground water bodies is not significant enough to impact ground water connectivity. Therefore, this quality element will not be considered as part of the impact assessment for the Skeeby/Holme/Dalton Beck from Source to River Swale water body as part of the impact assessment.	No
River Continuity	Not Assessed	The Unnamed Tributary of Holme Beck 9.8 is a straightened and trapezoidal waterbody with relatively little flow. The channel is degraded for agricultural use as a drain. As such, there will be no impact to river continuity. Therefore, this quality element will not be considered as part of the impact assessment for the Skeeby/Holme/Dalton Beck from Source to River Swale water body as part of the impact assessment.	No

WFD Quality Element	Current Status	Potential Impact	Further assessment and/or mitigation required?
Morphology: River width and depth	Not Assessed	The Unnamed Tributary of Holme Beck 9.8 is a straightened and trapezoidal waterbody relatively little flow. The channel is degraded for agricultural use as a drain. As such, there will be no impact to the river width and depth. Therefore, this quality element will not be considered as part of the impact assessment for the Skeeby/Holme/Dalton Beck from Source to River Swale water body as part of the impact assessment.	No
Morphology: Structure and substrate of the river bed	Not Assessed	The Unnamed Tributary of Holme Beck 9.8 is a straightened and trapezoidal waterbody with relatively little flow. The channel is degraded for agricultural use as a drain. As such, there will be no impact to the structure and substrate of the river bed. Therefore, this quality element will not be considered as part of the impact assessment for the Skeeby/Holme/Dalton Beck from Source to River Swale water body as part of the impact assessment.	No
Morphology: Structure of the riparian zone	Not Assessed	The Unnamed Tributary of Holme Beck 9.8 is a straightened and trapezoidal waterbody with relatively little flow. The channel is degraded for agricultural use as a drain with a grassed channel. As such, there will be no impact to the structure of the riparian zone. Therefore, this quality element will not be considered as part of the impact assessment for the Skeeby/Holme/Dalton Beck from Source to River Swale water body as part of the impact assessment.	No

Watercourse Crossing Point 34 (Cloven Hill Culverts S09-C11)

14.4.8.32 The proposed works at this location is that an existing box culvert of 22.7m in length and internal space of 1.5 x 1.8m (HxW) is to be extended both upstream (by 19.4m) and downstream (by 26.5m) to a total length of 68.6m.

14.4.8.33 Table 86: Assessment of works at Watercourse Crossing Point 34 (Cloven Hill Culverts S09-C11) on the Unnamed Watercourse west of Warrener Lane, which is within the Skeeby/Holme/Dalton Beck from Source to River Swale water body catchment assesses the potential impacts arising from proposed works at Watercourse Crossing Point 34 (Cloven Hill Culverts S09-C11) on the Unnamed Watercourse west of Warrener Lane, which is within the Skeeby/Holme/Dalton Beck from Source to River Swale water body catchment.

Table 86: Assessment of works at Watercourse Crossing Point 34 (Cloven Hill Culverts S09-C11) on the Unnamed Watercourse west of Warrener Lane, which is within the Skeeby/Holme/Dalton Beck from Source to River Swale water body catchment

WFD Quality Element	Current Status	Potential Impact	Further assessment and/or mitigation required?
Hydrology: Quantity and Dynamics of flow	Not Assessed	The Unnamed Tributary of Holme Beck 9.2 is a straightened and trapezoidal waterbody that is degraded for agricultural use as a drain. The flow dynamics are poor, with little flow observed and no distinguishable flow biotopes. The culvert extensions will result in a total length of 68.6m. This is unlikely to alter the dynamics of flow (e.g., flow velocity, water depth, wetted area etc.). As such, the proposed works are unlikely to lead to a degradation of the quantity and dynamics of flow. Therefore, this quality element will not be considered as part of the impact assessment for the Skeeby/Holme/Dalton Beck from Source to River Swale water body.	No
Hydrology: Connection to ground water bodies	Not Assessed	The proposed works the extension of a culvert to a total length of 68.6m. This is unlikely to impact the existing connectivity of the Unnamed Tributary of Holme Beck 9.2 to ground water bodies. The watercourse is not considered to be a significant contributor to ground water due to the poor flow and low quantity of water in the watercourse. As such, this reduction in connectivity between the surface waterbody and ground water bodies is not significant enough to impact ground water connectivity. Therefore, this quality element will not be considered as part of the impact assessment for the Skeeby/Holme/Dalton Beck from Source to River Swale water body as part of the impact assessment.	No
River Continuity	Not Assessed	The Unnamed Tributary of Holme Beck 9.2 is a straightened and trapezoidal waterbody with relatively little flow. The channel is degraded for agricultural use as a drain. As such, there will be no impact to river continuity. Therefore, this quality element will not be considered as part of the impact assessment for the Skeeby/Holme/Dalton Beck from Source to River Swale water body as part of the impact assessment.	No

WFD Quality Element	Current Status	Potential Impact	Further assessment and/or mitigation required?
Morphology: River width and depth	Not Assessed	The Unnamed Tributary of Holme Beck 9.2 is a straightened and trapezoidal waterbody with relatively little flow. The channel is degraded for agricultural use as a drain. As such, there will be no impact to river width and depth. Therefore, this quality element will not be considered as part of the impact assessment for the Skeeby/Holme/Dalton Beck from Source to River Swale water body as part of the impact assessment.	No
Morphology: Structure and substrate of the river bed	Not Assessed	The Unnamed Tributary of Holme Beck 9.2 is a straightened and trapezoidal waterbody with relatively flow. The channel is degraded for agricultural use as a drain. As such, there will be no impact to the structure and substrate of the river bed. Therefore, this quality element will not be considered as part of the impact assessment for the Skeeby/Holme/Dalton Beck from Source to River Swale water body as part of the impact assessment.	No
Morphology: Structure of the riparian zone	Not Assessed	The Unnamed Tributary of Holme Beck 9.2 is a straightened and trapezoidal waterbody with relatively little flow. The channel is degraded for agricultural use as a drain with a hedgerow boundary and grassed channel. As such, there will be no impact to the structure of the riparian zone. Therefore, this quality element will not be considered as part of the impact assessment for the Skeeby/Holme/Dalton Beck from Source to River Swale water body as part of the impact assessment.	No

Watercourse Crossing Point 33 (Cloven Hill Culvert 2 S09-C13)

14.4.8.34 The proposed works at this location include a new pipe culvert of 44.2m in length and a 1.5m diameter.

14.4.8.35 Table 87: Assessment of works at Watercourse Crossing Point 33 (Cloven Hill Culvert 2 S09-C13) on the Unnamed Watercourse west of Warrener Lane, which is within the Skeeby/Holme/Dalton Beck from Source to River Swale water body catchment assesses the potential impacts arising from proposed works at Watercourse Crossing Point 33 (Cloven Hill Culvert 2 S09-C13) on the Unnamed Watercourse west of Warrener Lane, which is within the Skeeby/Holme/Dalton Beck from Source to River Swale water body catchment.

Table 87: Assessment of works at Watercourse Crossing Point 33 (Cloven Hill Culvert 2 S09-C13) on the Unnamed Watercourse west of Warrener Lane, which is within the Skeeby/Holme/Dalton Beck from Source to River Swale water body catchment

WFD Quality Element	Current Status	Potential Impact	Further assessment and/or mitigation required?
Hydrology: Quantity and Dynamics of flow	Not Assessed	The Unnamed Tributary of Holme Beck 9.2 is a straightened and trapezoidal waterbody that is degraded for agricultural use as a drain. The flow dynamics are poor, with little flow observed and no distinguishable flow biotopes. A new pipe culvert of 44.2m in length and a 1.5m diameter is proposed. This is unlikely to significantly alter the dynamics of flow (e.g., flow velocity, water depth, wetted area etc.). As such, the proposed works are unlikely to lead to a degradation of the quantity and dynamics of flow. Therefore, this quality element will not be considered as part of the impact assessment for the Skeeby/Holme/Dalton Beck from Source to River Swale water body.	No
Hydrology: Connection to ground water bodies	Not Assessed	The proposed works involve the installation of new culvert. This is unlikely to impact the existing connectivity of the Unnamed Watercourse west of Warrener Lane to ground water bodies. The watercourse is not considered to be a significant contributor to ground water due to the poor flow and low quantity of water in the watercourse. As such, this reduction in connectivity between the surface waterbody and ground water bodies is not significant enough to impact ground water connectivity. Therefore, this quality element will not be considered as part of the impact assessment for the Skeeby/Holme/Dalton Beck from Source to River Swale water body as part of the impact assessment.	No
River Continuity	Not Assessed	The Unnamed Tributary of Holme Beck 9.2 is a straightened and trapezoidal waterbody with relatively little flow. The channel is degraded for agricultural use as a drain. As such, there will be no impact to river continuity. Therefore, this quality element will not be considered as part of the impact assessment for the Skeeby/Holme/Dalton Beck from Source to River Swale water body as part of the impact assessment.	No

WFD Quality Element	Current Status	Potential Impact	Further assessment and/or mitigation required?
Morphology: River width and depth	Not Assessed	The Unnamed Tributary of Holme Beck 9.2 is a straightened and trapezoidal waterbody with relatively little flow. The channel is degraded for agricultural use as a drain. As such, there will be no impact to river width and depth. Therefore, this quality element will not be considered as part of the impact assessment for the Skeeby/Holme/Dalton Beck from Source to River Swale water body as part of the impact assessment.	No
Morphology: Structure and substrate of the river bed	Not Assessed	The Unnamed Tributary of Holme Beck 9.2 is a straightened and trapezoidal waterbody with relatively little flow. The channel is degraded for agricultural use as a drain. As such, there will be no impact to the structure and substrate of the river bed. Therefore, this quality element will not be considered as part of the impact assessment for the Skeeby/Holme/Dalton Beck from Source to River Swale water body as part of the impact assessment.	No
Morphology: Structure of the riparian zone	Not Assessed	The Unnamed Tributary of Holme Beck 9.2 is a straightened and trapezoidal waterbody with relatively little flow. The channel is degraded for agricultural use as a drain with a hedgerow boundary and grassed channel. As such, there will be no impact to the structure of the riparian zone. Therefore, this quality element will not be considered as part of the impact assessment for the Skeeby/Holme/Dalton Beck from Source to River Swale water body as part of the impact assessment.	No

Watercourse Crossing Point 31 (Moor Lane Culvert S09-C17)

14.4.8.36 The proposed works at this location include a new box culvert of 8.7m in length and 1.5m x 2.25m (HxW) to convey flow under a bridleway.

14.4.8.37 Table 88: Assessment of works at Watercourse Crossing Point 31 (Moor Lane Culvert S09-C17) on the Unnamed Watercourse at Foxwell Farm, which is within the Skeeby/Holme/Dalton Beck from Source to River Swale water body catchment assesses the potential impacts arising from proposed works at Watercourse Crossing Point 31 (Moor Lane Culvert S09-C17) on the Unnamed Watercourse at Mainsgill Forest, which is within the Skeeby/Holme/Dalton Beck from Source to River Swale water body catchment.

Table 88: Assessment of works at Watercourse Crossing Point 31 (Moor Lane Culvert S09-C17) on the Unnamed Watercourse at Foxwell Farm, which is within the Skeeby/Holme/Dalton Beck from Source to River Swale water body catchment

WFD Quality Element	Current Status	Potential Impact	Further assessment and/or mitigation required?
Hydrology: Quantity and Dynamics of flow	Not Assessed	The Unnamed Tributary of Mains Gill 9.1 is straightened and trapezoidal upstream and is degraded for agricultural use as a drain. However, at the Mainsgill Forest the channel gradient and flow velocity increases. The channel comprises of alternating riffle and pool biotopes. Further downstream the channel is culverted under the current A66. A new box culvert of 8.7m in length and 1.5m x 2.25m in size (HxW) to convey flow under a bridleway is proposed for a significant portion of what is considered to be one of the few remaining river reaches that still exhibits good morphological condition. Note that the proposed culvert is in conjunction with WCP30 Moor Lane Culvert S09-C07. This proposed culvert will alter the dynamics of flow (e.g., flow velocity, water depth, wetted area etc.) on a local scale. As such, the proposed works are likely to lead to a degradation of the quantity and dynamics of flow. Therefore, this quality element will be considered as part of the impact assessment for the Skeeby/Holme/Dalton Beck from Source to River Swale water body.	Yes
Hydrology: Connection to ground water bodies	Not Assessed	The proposed works involve the installation of a new box culvert (in combination with WCP30 Moor Lane Culvert S09-C07). This is unlikely to impact the existing connectivity of the Unnamed Tributary of Mains Gill 9.1 to ground water bodies. As such, this reduction in connectivity between the surface waterbody and ground water bodies is not significant enough to impact ground water connectivity. Therefore, this quality element will not be considered as part of the impact assessment for the Skeeby/Holme/Dalton Beck from Source to River Swale water body as part of the impact assessment.	No
River Continuity	Not Assessed	The Unnamed Tributary of Mains Gill 9.1 is straightened and trapezoidal upstream and is degraded for agricultural use as a drain. However, at the Mainsgill Forest the channel gradient and flow velocity increases. The	No

WFD Quality Element	Current Status	Potential Impact	Further assessment and/or mitigation required?
		channel comprises of alternating riffle and pool biotopes. Further downstream the channel is culverted under the current A66. As such, there will likely be no impact to river continuity as the channel is degraded upstream and downstream. Therefore, this quality element will not be considered as part of the impact assessment for the Skeeby/Holme/Dalton Beck from Source to River Swale water body as part of the impact assessment.	
Morphology: River width and depth	Not Assessed	The Unnamed Tributary of Mains Gill 9.1 is straightened and trapezoidal upstream and is degraded for agricultural use as a drain. However, at the Mainsgill Forest the channel gradient and flow velocity increases. The channel comprises of alternating riffle and pool biotopes. Further downstream the channel is culverted under the current A66. A new box culvert of 8.7m in length and 1.5m x 2.25m in size (HxW) is proposed for a significant portion of what is considered to be one of the few remaining river reaches that still exhibits good morphological condition. Consequently, the proposed structure will likely impact the river width and depth. Further detail is needed to appropriately assess this risk. Therefore, this quality element will be considered as part of the impact assessment for the Skeeby/Holme/Dalton Bk from Source to River Swale water body.	Yes
Morphology: Structure and substrate of the river bed	Not Assessed	The Unnamed Tributary of Mains Gill 9.1 is straightened and trapezoidal upstream and is degraded for agricultural use as a drain. However, at the Mainsgill Forest the channel gradient and flow velocity increases. The channel comprises of alternating riffle and pool biotopes in the gravel and cobble bed. Further downstream the channel is culverted under the current A66. As such, there is likely to be an impact to the structure and substrate of the river bed. Therefore, this quality element will be considered as part of the impact assessment for the Skeeby/Holme/Dalton Beck from Source to	Yes

WFD Quality Element	Current Status	Potential Impact	Further assessment and/or mitigation required?
		River Swale water body as part of the impact assessment.	
Morphology: Structure of the riparian zone	Not Assessed	The Unnamed Tributary of Mains Gill 9.1 consists of riparian tree cover and is well vegetated. As such, there is likely to be an impact to the structure of the riparian zone. Therefore, this quality element will be considered as part of the impact assessment for the Skeeby/Holme/Dalton Beck from Source to River Swale water body as part of the impact assessment.	Yes

Impact assessment

14.4.8.38 The impact assessment needs to consider if there is a pathway linking the pressure to the quality element. If there is no pathway there can be no impact on the quality element and there is no need for any further assessment of that quality element to be carried out. If there is a potential pathway the assessment must consider if the activity, and the pressure it creates, may cause deterioration of the quality element.

14.4.8.39 The mitigation measures stipulated within the impact assessment are secured by the Project Design Principles (Application Document 5.11) and the EMP (Application Document 2.7), which are certified documents under DCO.

14.4.8.40 In order to effectively assess the potential impacts of the proposed works and decide upon suitable mitigation measures, a good understanding of the proposed scheme and design is required. Should any revisions be made to the proposed works that could impact any of the WFD quality elements, this section must be revised.

14.4.8.41 Table 89: Impacts and mitigation measures of Watercourse Crossing Points 30 and 31 discusses each of the quality elements identified as being potentially at risk in the scoping assessment. Mitigation measures are required to mitigate the effects of the proposed works.

14.4.8.42 Provided the mitigation measures stipulated within the impact assessment and in section 14.4.9 are implemented at the detailed design stage, cumulative impacts from all the proposed works to the hydromorphology quality elements of the Skeeby/Holme/Dalton Beck water body will be mitigated sufficiently.

Table 89: Impacts and mitigation measures of Watercourse Crossing Points 30 and 31

WFD Quality Element	Pathway (direct / indirect/ none)	Potential Impact/ Mitigation measures
Hydrology: Quantity and Dynamics of flow	Direct	**Permanent Impact:** The proposed new box culverts of 99.3m length and 1.5m x 2.25m (HxW) and 8.7m in length and 1.5m x 2.25m (HxW) on the Mains Gill and the Unnamed Tributary of Mains Gill 9.1 will lead to a loss of open channel. The new box culverts are proposed for a significant portion of the last remaining natural reach of the channel and will alter the dynamics of flow (e.g., flow velocity, water depth, wetted area etc.). **Mitigation:** To compensate for the loss of natural flow dynamics and diversity on the Mains Gill and the Unnamed Tributary of Mains Gill 9.1, riparian planting of tree cover is required in a currently degraded section of the watercourse upstream. The introduction of a dense riparian buffer strip along the river banks upstream of the structure will provide a natural source of woody material to the watercourse. Naturally occurring woody material in the channel increases flow and sediment diversity, which encourages localised variation in flow velocities. This develops a natural pattern of river width and depth diversity over time, which contributes to naturally sinuous flow mechanics developing across a river reach. The natural introduction of woody material into the channel can be assisted by installing root wads or securing large wood to the banks. This would restore the potential loss of flow diversity as a result of the proposed culvert extension. It is essential that a geomorphologist is consulted on the designs of these mitigations.
Morphology: River width and depth	Direct	**Permanent Impact:** The replacement of open channel with the proposed culverts will result in a change to the existing width and depth of the Mains Gill and the Unnamed Tributary of Mains Gill 9.1. Following the completion of the culvert installations, the width and depth of the channel will be dictated by the geometry of the culvert bases. As a result, this reflects a degradation of the river width and depth compared to the current conditions. **Mitigation:** To compensate the loss of natural diversity in channel width and depth on the Mains Gill and the Unnamed Tributary of Mains Gill 9.1, riparian planting of tree cover is required. The introduction of a dense riparian buffer strip along the river banks of the watercourse upstream of the structures will provide a natural source of woody material to the watercourse. Naturally occurring woody material in the channel increases flow diversity and encourages localised scour of riverbanks and deposition of sediment in the channel. This aids the development of a more natural pattern of river width and depth over time. The natural introduction of woody material into the

WFD Quality Element	Pathway (direct / indirect/ none)	Potential Impact/ Mitigation measures
		channel can be assisted by installing root wads or securing large wood at strategic locations along the Unnamed Watercourse at Mainsgill Forest. It is essential that a geomorphologist is consulted on the designs of these mitigations.
Morphology: Structure and substrate of the river bed	Direct	**Permanent Impact:** The replacement of open channel with the proposed culvert installations will result in a change to the existing condition of the river bed substrate on the Mains Gill and the Unnamed Tributary of Mains Gill 9.1. Following the completion of the culvert, the natural river bed substrate will be replaced with the culvert base. **Mitigation:** To compensate the loss and degradation of the natural river bed substrate on the Mains Gill and the Unnamed Tributary of Mains Gill 9.1, riparian planting of tree cover is required. The introduction of a dense riparian buffer strip along the river banks of both watercourses upstream of the structures will provide a natural source of woody material to the watercourse. Naturally occurring woody material in the channel creates localised diversity in sediment transport mechanics. This encourages localised pockets of sediment deposition and erosion, generating a heterogeneous river bed structure. The natural introduction of woody material into the channel can be assisted by installing root wads or securing large wood at strategic locations along Mains Gill and the Unnamed Tributary of Mains Gill 9.1. It is essential that a geomorphologist is consulted on the designs of these mitigations.
Morphology: Structure of the riparian zone	Direct	**Permanent Impact:** The installation of culverts on the Mains Gill and the Unnamed Tributary of Mains Gill 9.1 will involve the replacement of the existing riparian zone with an embankment to support the existing A66. In addition, the replacement of a section of open channel with culverts will significantly reduce the connectivity of the watercourse to the riparian zone and surrounding floodplain. This combined loss of riparian zone and floodplain connectivity will lead to a degradation of the riparian zone on the Mains Gill and the Unnamed Tributary of Mains Gill 9.1. **Mitigation:** To compensate the loss of riparian habitat and structure, it is required that a buffer strip must be established from the top of the left and right banks, and riparian planting of tree cover is undertaken. On the Unnamed Tributary of Mains Gill 9.1, the most suitable location for this is the river reach upstream (north) of the Mainsgill Forest. Establishing a buffer strip on the left and right bank floodplain will provide additional riparian habitat benefits and improve geomorphological function. Planting riparian woodland in

WFD Quality Element	Pathway (direct / indirect/ none)	Potential Impact/ Mitigation measures
		this reach will mitigate against the risk of riparian habitat degradation associated with the proposed culverts. Moreover, riparian planting in this reach will provide geomorphological benefits, such as the potential for woody debris recruitment to the channel and the potential improved floodplain connectivity as a result. It is essential that a geomorphologist is consulted on the designs of these mitigations.

Water body mitigation measures

14.4.8.43 The Skeeby/Holme/Dalton Beck from Source to River Swale water body is not classified as heavily modified or artificial. Therefore, there are no hydromorphology mitigation measures assigned to this water body identified in the Solway Tweed River Basin Management Plan 2021.

WFD hydromorphology assessment objectives

Table 90: Hydromorphology Assessment of proposed works against WFD objectives for the Solway Tweed River Basin Management Plan 2021

WFD Hydromorphology Assessment Objectives	Assessment of works
Objective 1: The proposed works do not cause deterioration in the Status of the Ecological Elements of the water body	Provided the required mitigation measures detailed in Table 89: Impacts and mitigation measures of Watercourse Crossing Points 30 and 31 and Section 14.4.9are adhered to, the proposed works will not cause a deterioration in the status of the Skeeby/Holme/Dalton Beck from Source to River Swale water bodies.
Objective 2: The proposed works do not compromise the ability of the water body to achieve its WFD status objectives	The proposed works do not compromise the ability of the Skeeby/Holme/Dalton Beck from Source to River Swale water bodies to achieve Good hydromorphology status, provided the mitigation measures detailed in Table 89: Impacts and mitigation measures of Watercourse Crossing Points 30 and 31 and Section 14.4.9 are adhered to.
Objective 3: The proposed works do not cause a permanent exclusion or compromised achievement of the WFD objectives in other bodies of water within the same RBD	Impacts arising from the proposals at the scheme will be direct and local to the fluvial environment on site. The impacts arising from the proposed works will not impact on areas elsewhere in the catchment and will not impact other WFD waterbodies within the RBMP.
Objective 4: The proposed works contribute to the delivery of the WFD objectives	The proposed works will contribute to the delivery of the WFD objectives by ensuring no detrimental impact to the water body at the water body scale, and by providing localised hydromorphological enhancements, provided

WFD Hydromorphology Assessment Objectives	Assessment of works
	the mitigation measures detailed in Table 89: Impacts and mitigation measures of Watercourse Crossing Points 30 and 31 and Section 14.4.9 are adhered to

Stephen Bank to Carkin Moor key considerations

14.4.8.44 The impact assessment determines whether the proposed works have the potential to significantly impact any of the hydromorphology quality elements screened into the assessment. Specific mitigation measures required to prevent the deterioration of specific quality elements are considered in Table 90: Hydromorphology Assessment of proposed works against WFD objectives. Additional mitigation measures that must be considered at each of the proposed structures screened into the assessment are listed in section 14.4.9.

14.4.8.45 The mitigation measures stipulated within the impact assessment are secured by the Project Design Principles (Application Document 5.11) and the EMP (Application Document 2.7), which are certified documents under DCO.

14.4.8.46 Provided the mitigation measures stipulated within the impact assessment and in Section 14.4.9 are implemented at the detailed design stage, cumulative impacts from all the proposed works to the hydromorphology quality elements of the Skeeby/Holme/Dalton Beck from Source to River Swale water bodies will be mitigated sufficiently.

Summary

14.4.8.47 The WFD scoping (Stage 2) stage identified that the proposed works at the following watercourse crossing points assessed will have a detrimental impact to the Skeeby/Holme/Dalton Beck from Source to River Swale WFD water body without appropriate **mitigation:**

- Watercourse Crossing Point 30 (Culvert S09-C07)
- Watercourse Crossing Point 31 (Moor Lane Culvert S09-C17).

14.4.8.48 The works proposed at Scheme 9, Stephen Bank to Carkin Moor are likely to directly impact the following hydromorphology quality elements for Skeeby/Holme/Dalton Beck from Source to River Swale water body at Watercourse Crossing Point 30 (Culvert S09-C07) and Watercourse Crossing Point 31 (Moor Lane Culvert S09-C17):

- Hydrology: Quantity and Dynamics of flow
- Morphology: River width and depth
- Morphology: Structure and substrate of the river bed
- Morphology: Structure of the riparian zone.

14.4.8.49 The mitigation and compensation measures required to achieve the WFD objectives include:

- Riparian tree planting
- Riparian buffer strips

- Installation of natural woody material in the channel
- Consulting a geomorphologist on the designs.

14.4.8.50 The assessment reported in this assessment is based on a precautionary worst case scenario. As such, the mitigation identified in this assessment as being required to mitigate the likely significant effects reported are based on this worst case scenario. It may be the case that as detailed design of the Project evolves, it becomes apparent that a lesser form of mitigation is required to achieve the same outcome. As such, the EMP secures the 'maximum' extent of mitigation required (as identified in this assessment) but also, where appropriate, includes mechanisms (e.g. by way of further surveys or modelling) to establish, pre-construction and during detailed design, whether the identified mitigation can be refined such that a lesser extent is required to achieve the outcome reported in this assessment. The fundamental point is that the mitigation identified in this assessment is secured by the EMP, where required to achieve the outcome reported in this assessment.

14.4.9 Mitigation measures for all schemes

14.4.9.1 The following mitigation measures need to be implemented across all schemes

14.4.9.2 Post construction surveys will be undertaken of all new culverts to review the effectiveness of embedded mitigation and the function of channels. If there is any evidence of excessive erosion or sedimentation further actions will be implemented by National Highways to remedy the impact.

- A site drainage plan and sediment management plan must be established during the construction phase of the proposed works, to mitigate against the risk of fine sediment release into the surrounding watercourses.
- Stored sediment following excavation must be covered to prevent surface water flows from mobilising sediment and moving it into the water environment.
- Water quality monitoring stations must be set up upstream and downstream of each work site to monitor the impact that the construction has on water quality.
- During excavation sediment barriers must be erected to prevent the transfer of loose sediment from the excavation site.
- Access tracks must be cambered to shed water. Runoff from tracks and other hard standing areas must pass through silt traps to ensure no sediment enters the channel.
- Work likely to generate or expose sediment must be conducted in dry periods, to minimise the risk of erosion and mobilisation of sediment (in the summer). However, it must be taken into account that extended dry periods can increase volumes of dust created by works. Contingency measures for wet weather must be built into the construction method statement.
- Water pumped from excavations must be discharged to areas of ground capable of absorbing water, or to settlement ponds to prevent sediment being carried into the water environment.
- Access tracks must be constructed in such a way that they will not be susceptible to erosion and do not directly drain into the water environment.

14.4.9.3 The good practice measures set out in the following published guidance documents must be adhered to:

- CIRIA C697 - The SUDS (Sustainable Urban Drainage) Manual
- CIRIA C698 - Site Handbook for the Construction of SuDS
- CIRIA C532 - Control of Water Pollution from Construction Sites - Guidance for Consultants and Contractors
- CIRIA C648 - Control of Water Pollution from Linear Construction Projects - Technical Guidance
- Pollution Prevention Guideline (PPG) 5: Work and Maintenance In or Near Water.

14.4.9.4 The assessment reported in this assessment is based on a precautionary worst case scenario. As such, the mitigation identified in this assessment as being required to mitigate the likely significant effects reported are based on this worst case scenario. It may be the case that as detailed design of the Project evolves, it becomes apparent that a lesser form of mitigation is required to achieve the same outcome. As such, the EMP secures the 'maximum' extent of mitigation required (as identified in this assessment) but also, where appropriate, includes mechanisms (e.g. by way of further surveys or modelling) to establish, pre-construction and during detailed design, whether the identified mitigation can be refined such that a lesser extent is required to achieve the outcome reported in this assessment. The fundamental point is that the mitigation identified in this assessment is secured by the EMP, where required to achieve the outcome reported in this assessment.

14.4.10 References

Highways England (2020) Design Manual for Roads and Bridges LA 113 Road drainage and the water environment

Annex A: Site Photograph Locations


Photo Location 1: Left bank facing downstream


Photo Location 2: Right bank facing upstream


Photo Location 3: Right bank facing upstream

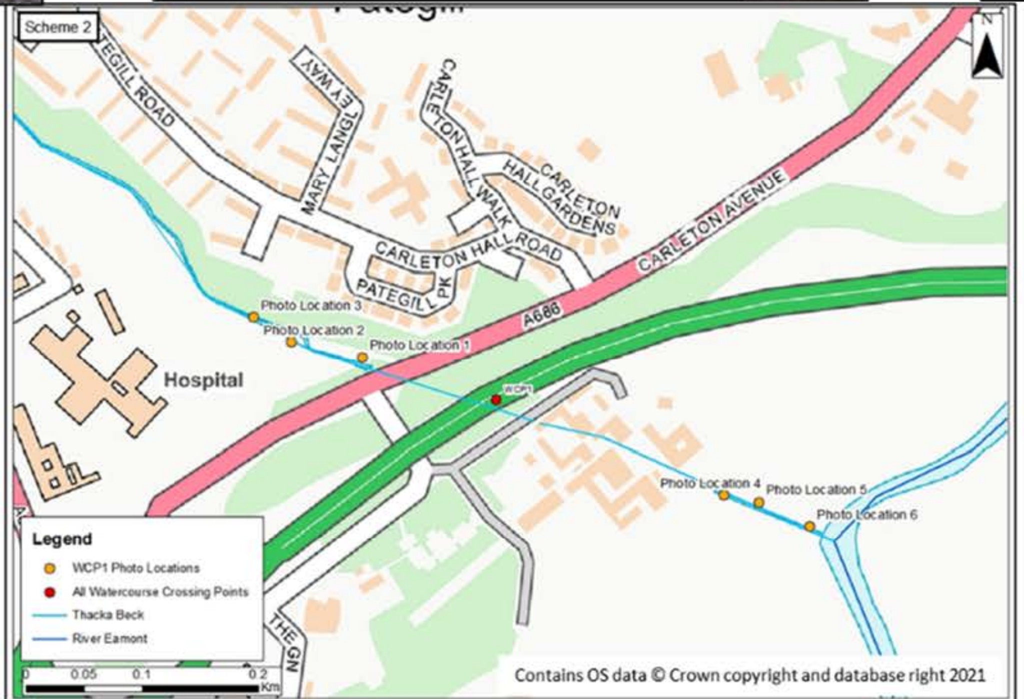


Photo Location 6: Left bank facing right bank


Photo Location 5: Left bank facing right bank


Photo Location 4: Left bank facing downstream

Plate A-22: WCP1 (Thacka Beck) site photograph locations

Photo Location 1: Left bank facing downstream

Photo Location 2: Left bank facing upstream

Photo Location 3: Right bank facing Watercourse

Photo Location 4: Left bank facing downstream at culvert

Plate A-23: WCP2 (Culvert 303) (Unnamed Tributary of Lightwater 3.1) site photograph locations

Photo Location 1: Right bank facing downstream

Photo Location 2: Right bank facing left bank

Photo Location 3: Culvert facing downstream

Photo Location 4: Left bank facing upstream

Photo Location 5: Left bank facing downstream

Photo Location 6: Floodplain facing upstream

Plate A-24:WCP3 and WCP78 (Lightwater Culvert) (Lightwater) site photograph locations


Photo Location 1: Left bank facing upstream


Photo Location 2: Left bank facing upstream


Photo Location 3: Right bank facing left bank

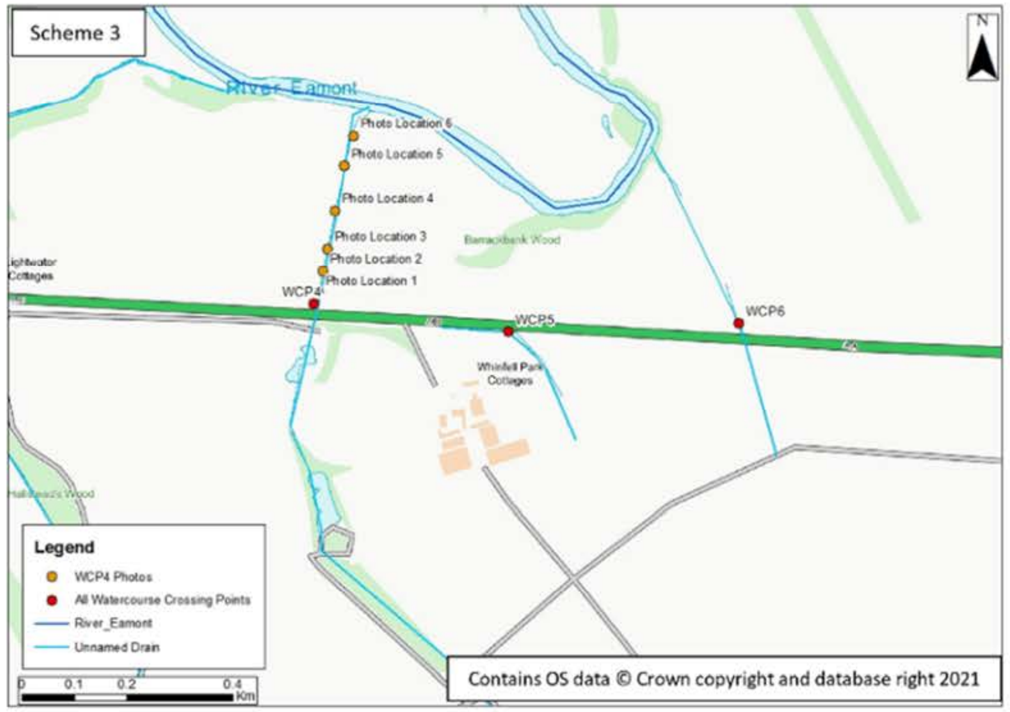


Photo Location 4: Left floodplain


Photo Location 5: Left bank facing downstream


Photo Location 6: Right bank facing culvert downstream

Plate A-25: WCP4 (Culvert 301) (Unnamed Tributary of the Eamont 3.3) site photograph locations

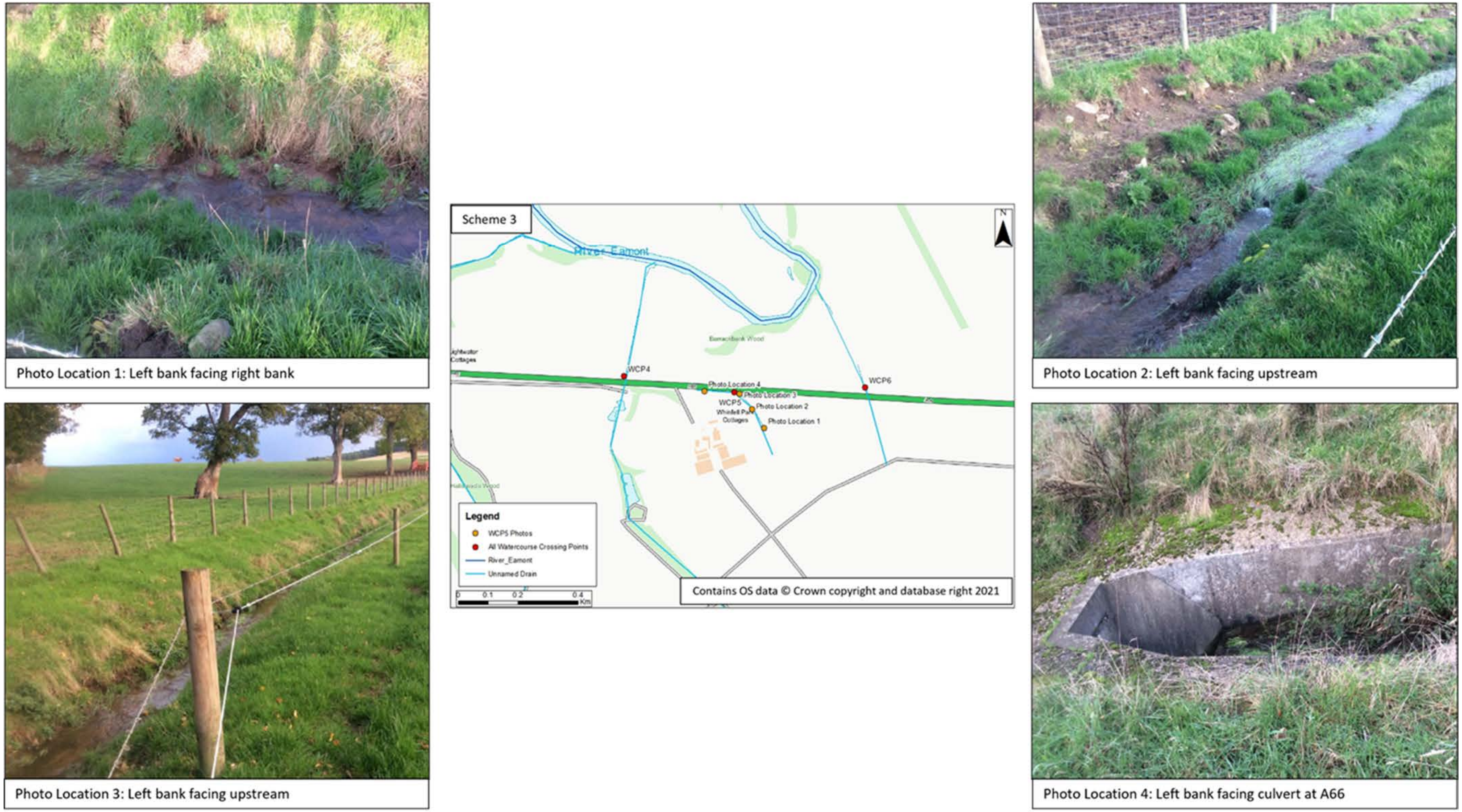

Plate A-26: WCP5 (Unnamed Culvert - Whinfell) (Unnamed Tributary of the Eamont 3.4) site photograph locations

Photo Location 1: Left bank facing Watercourse

Photo Location 2: Left bank facing downstream

Photo Location 3: Left bank facing upstream

Photo Location 5: Left bank facing upstream

Photo Location 6: Left bank facing upstream

Photo Location 5: Left bank facing downstream

Plate A-27: WCP6 (Culvert 302) (Unnamed Tributary of the Eamont 3.5) site photograph locations

Photo Location 1: Floodplain facing Watercourse

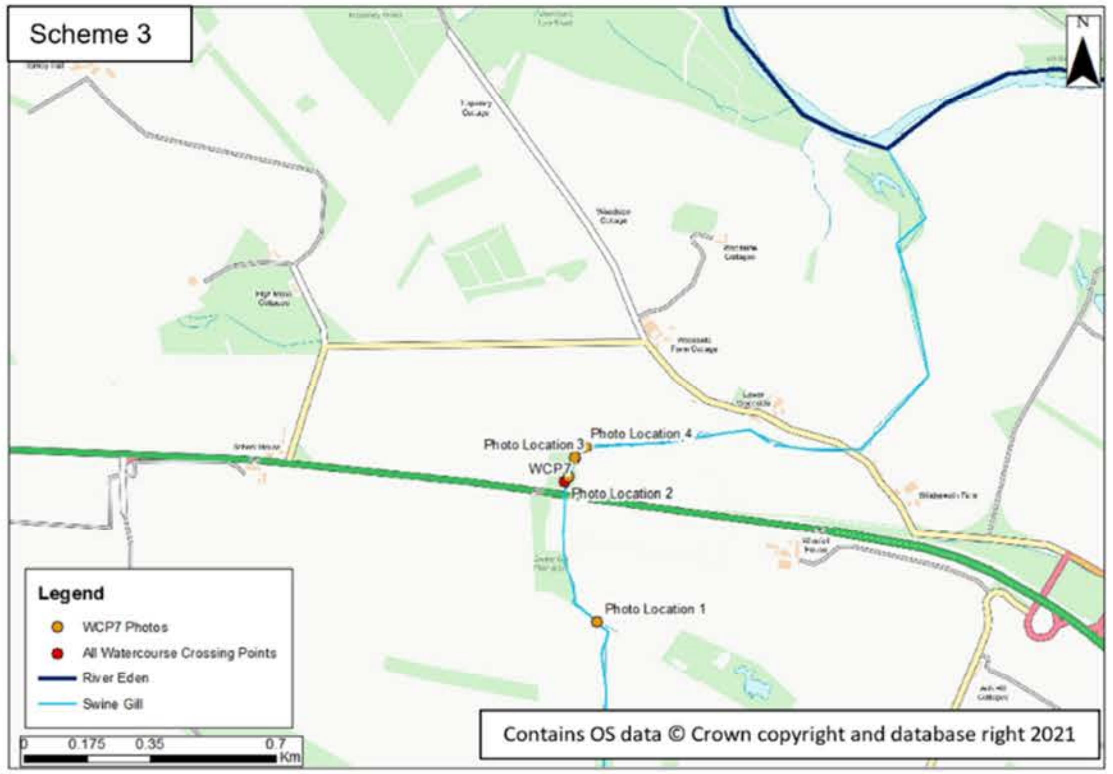

Photo Location 2: Left bank facing upstream at culvert

Photo Location 3: Right floodplain facing Watercourse

Photo Location 4: Right bank facing left bank

Plate A-28:WCP7 (Swine Gill Culvert) (Swine Gill) site photograph locations

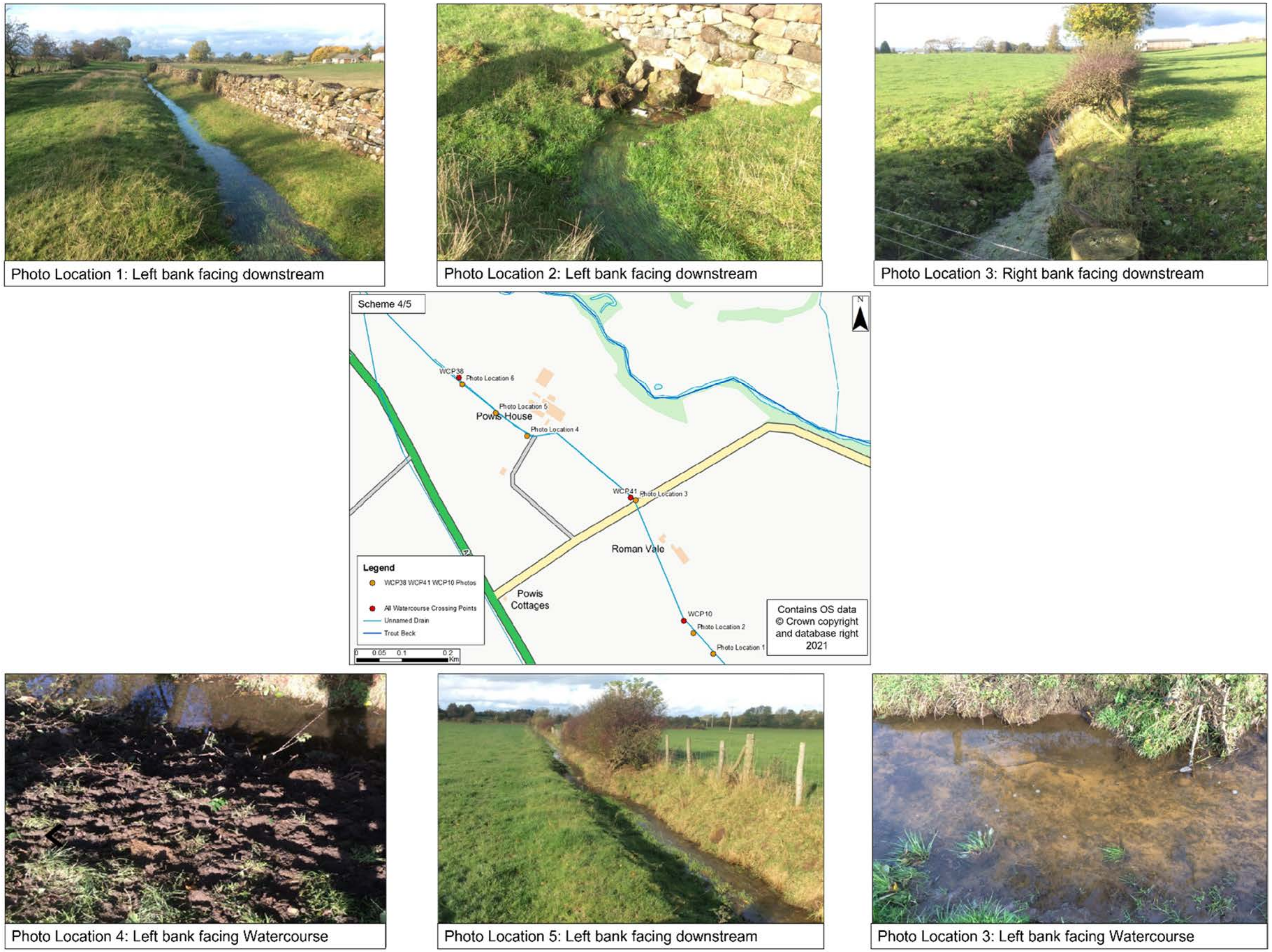

Plate A-29:WCP 38, WCP41, WCP10 (Unnamed Tributary of Trout Beck 4.6) site photograph locations

Photo Location 4: Right bank facing upstream

Photo Location 3: Facing Watercourse

Photo Location 4: Right bank facing upstream

Photo Location 4: Right bank facing upstream

Plate A-30:WCP42 (Unnamed Tributary of Trout Beck 4.5) site photograph locations

Photo Location 1: Right bank facing upstream

Photo Location 2: Left bank facing right bank

Photo Location 3: Left bank facing downstream

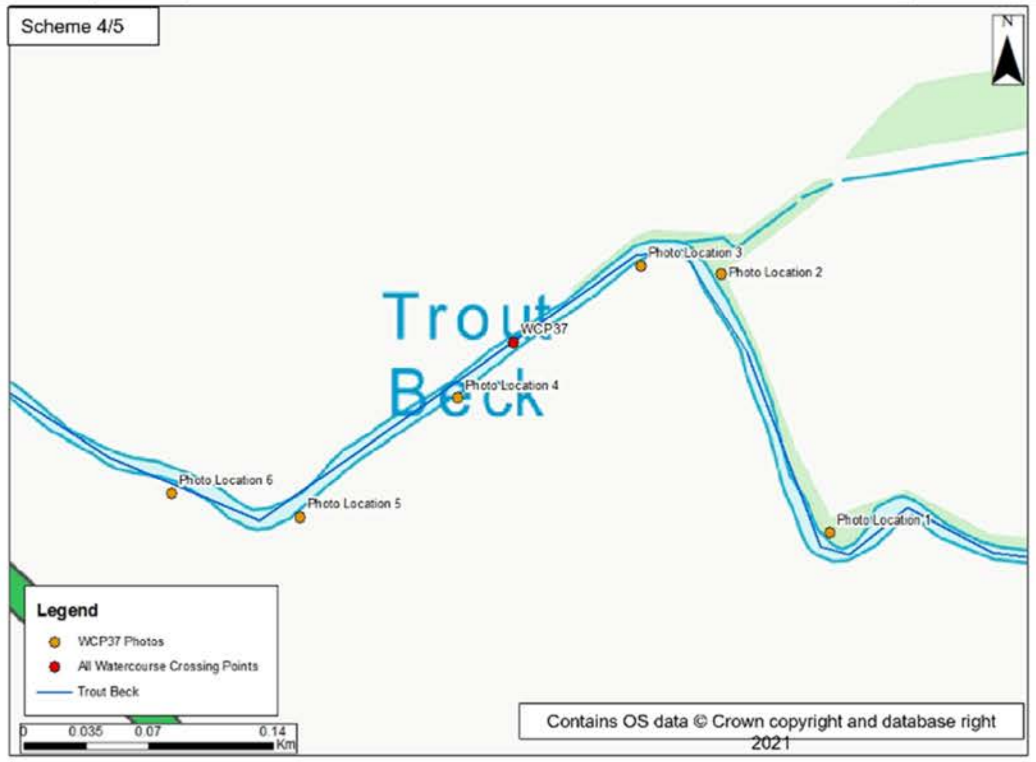

Photo Location 4: Left bank facing right bank

Photo Location 5: Left bank facing upstream

Photo Location 6: Left bank facing right bank

Plate A-31: WCP37 (Work No. 0405-1E) (Trout Beck) site photograph locations

Photo Location 1: Left floodplain facing Watercourse

Photo Location 2: Left bank facing downstream

Photo Location 3: Left bank facing downstream

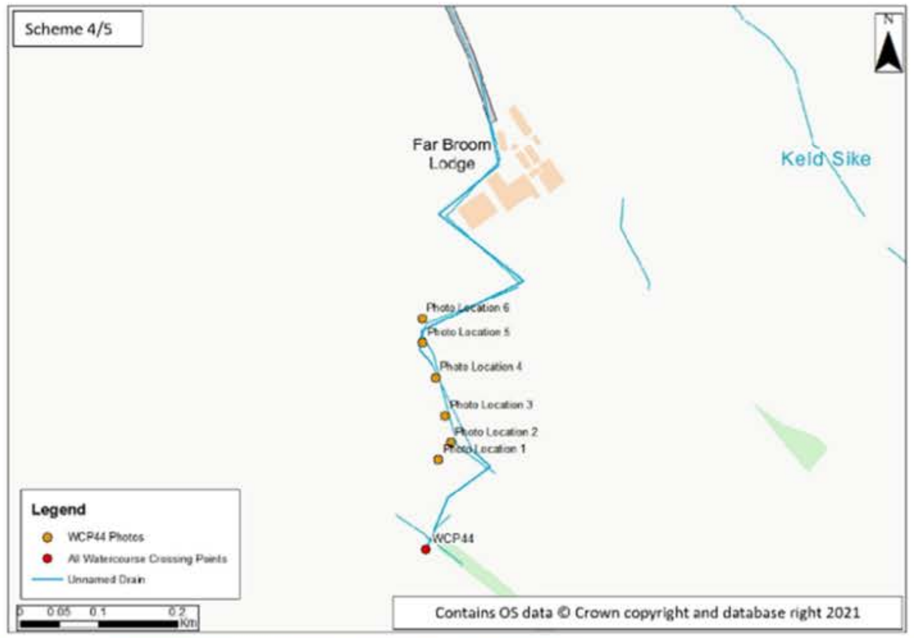

Photo Location 4: Left bank facing right bank

Photo Location 6: Left floodplain facing upstream

Photo Location 6: Right bank facing upstream

Plate A-32: WCP44 (No Works) (Unnamed Tributary of Trout Beck 4.3) site photograph locations

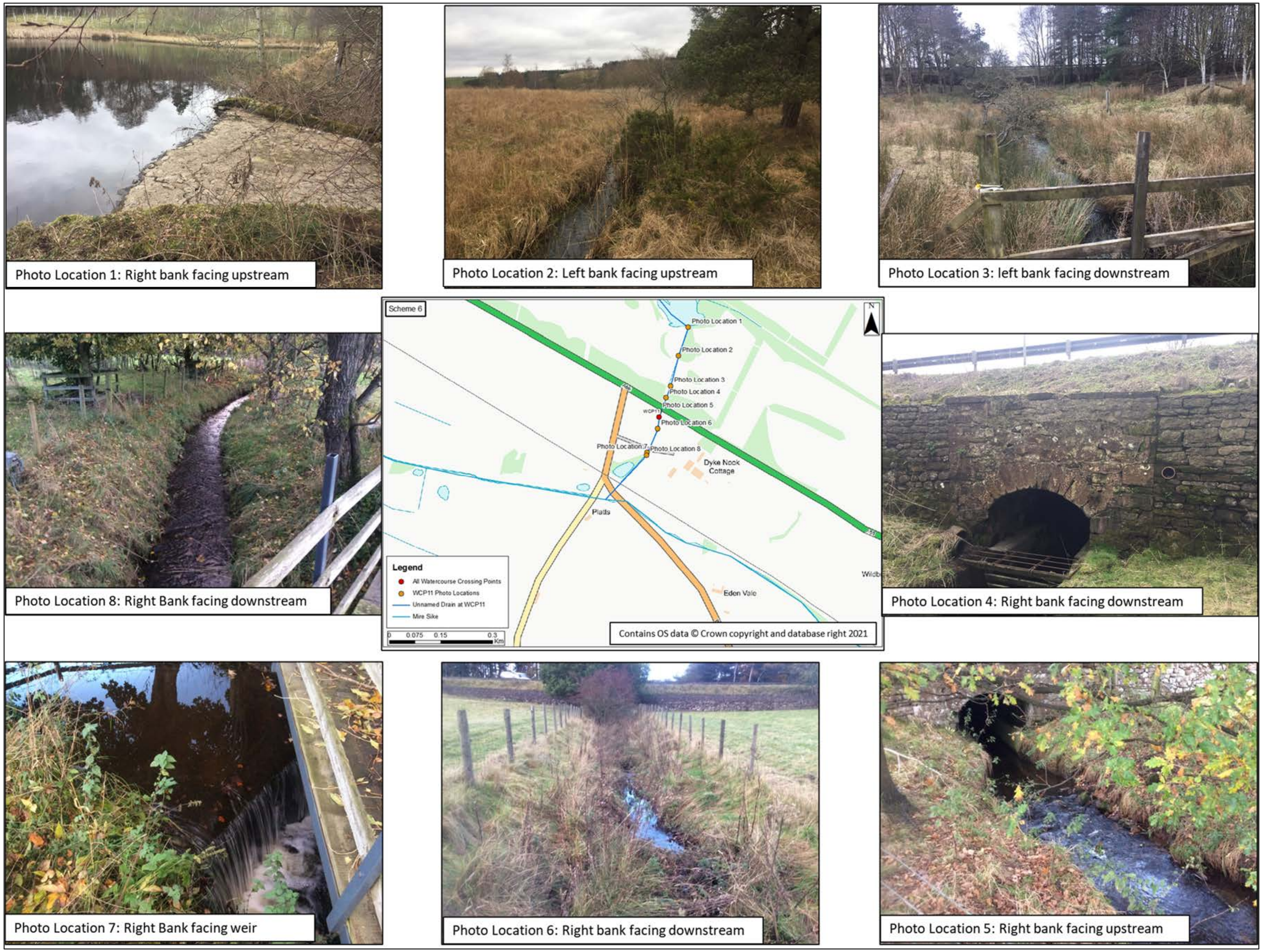

Plate A-33: WCP11 (Unnamed Tributary of the Mire Sike 6.12) site photograph locations

Plate A-34: Mire Sike Downstream of WCP11 site photograph locations

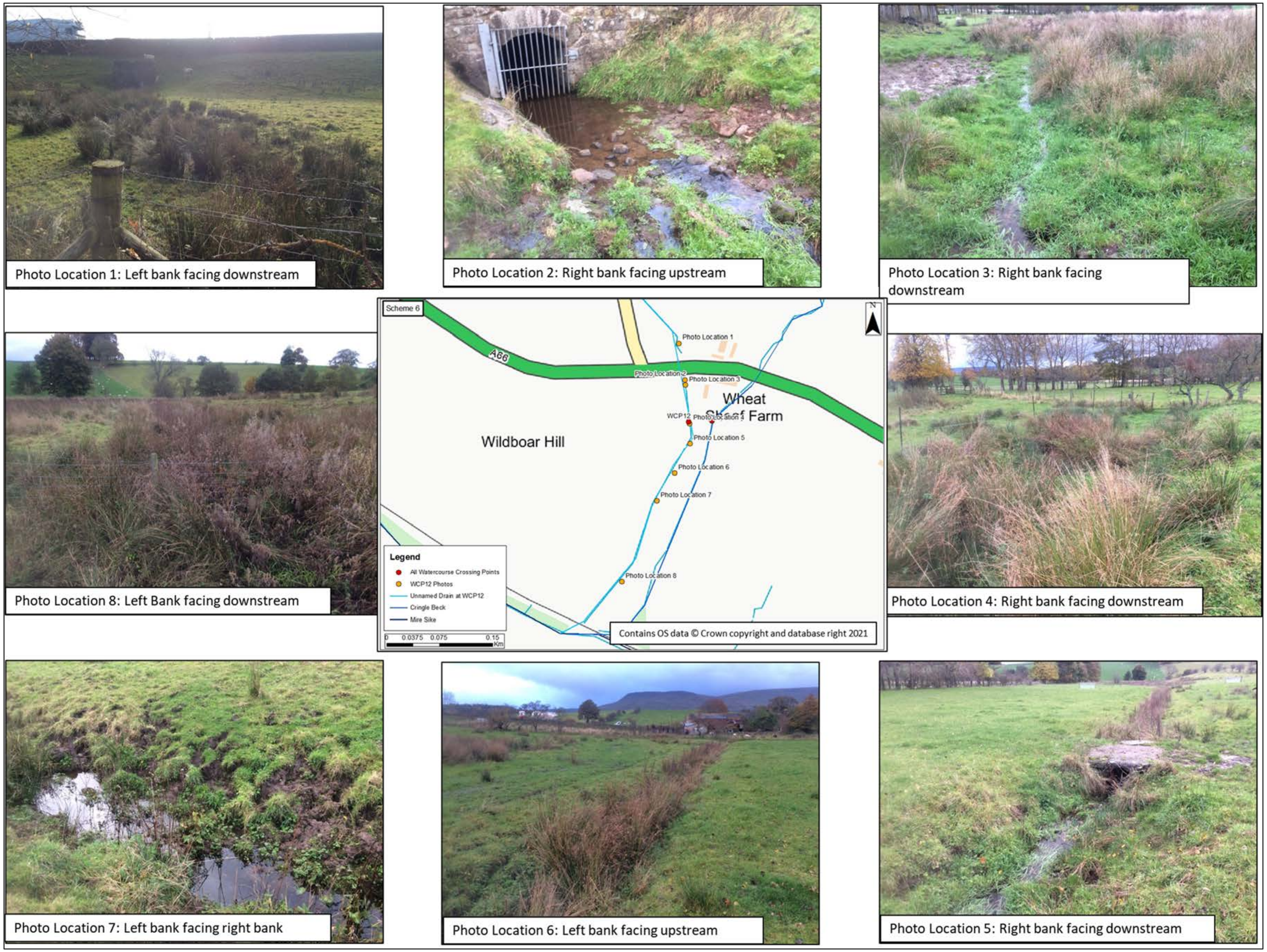

Plate A-35: WCP12 (Unnamed Tributary of the Cringle Beck 6.1) site photograph locations

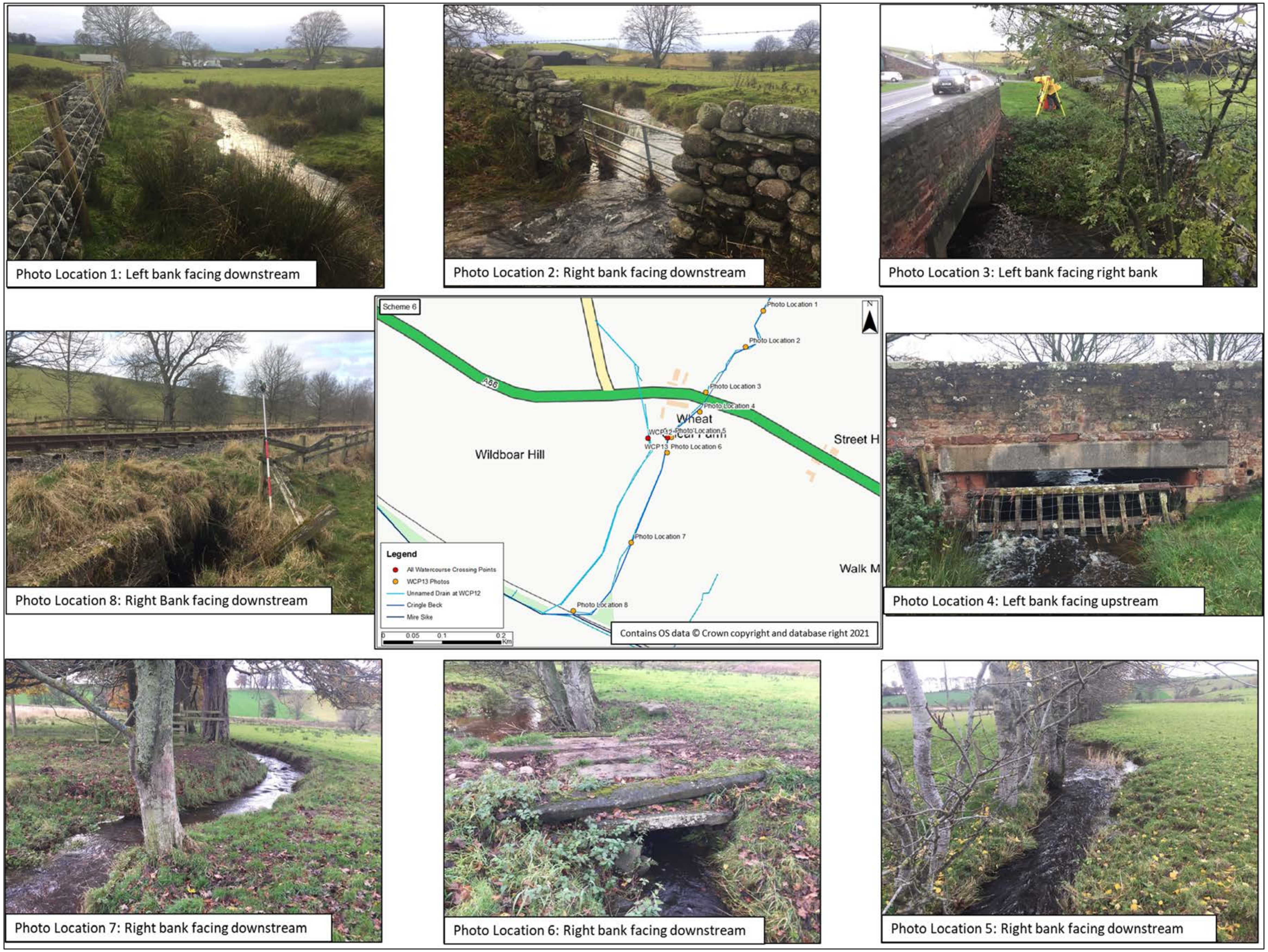

Plate A-36: WCP13 (Cringle Beck) site photograph locations

Plate A-37: WCP50 (Moor Beck (Offtake)) site photograph locations

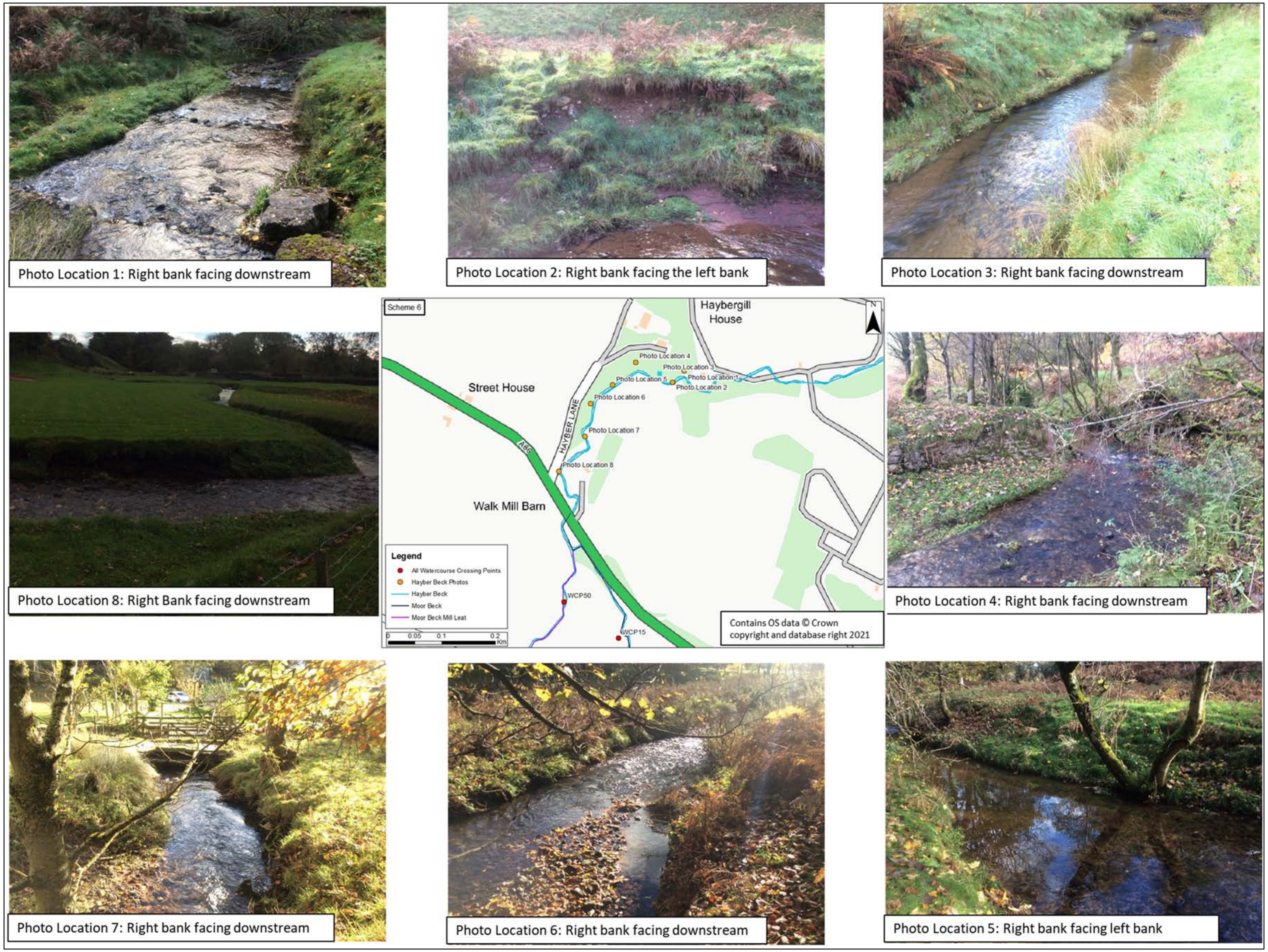

Plate A-38: Hayber Beck site photograph locations

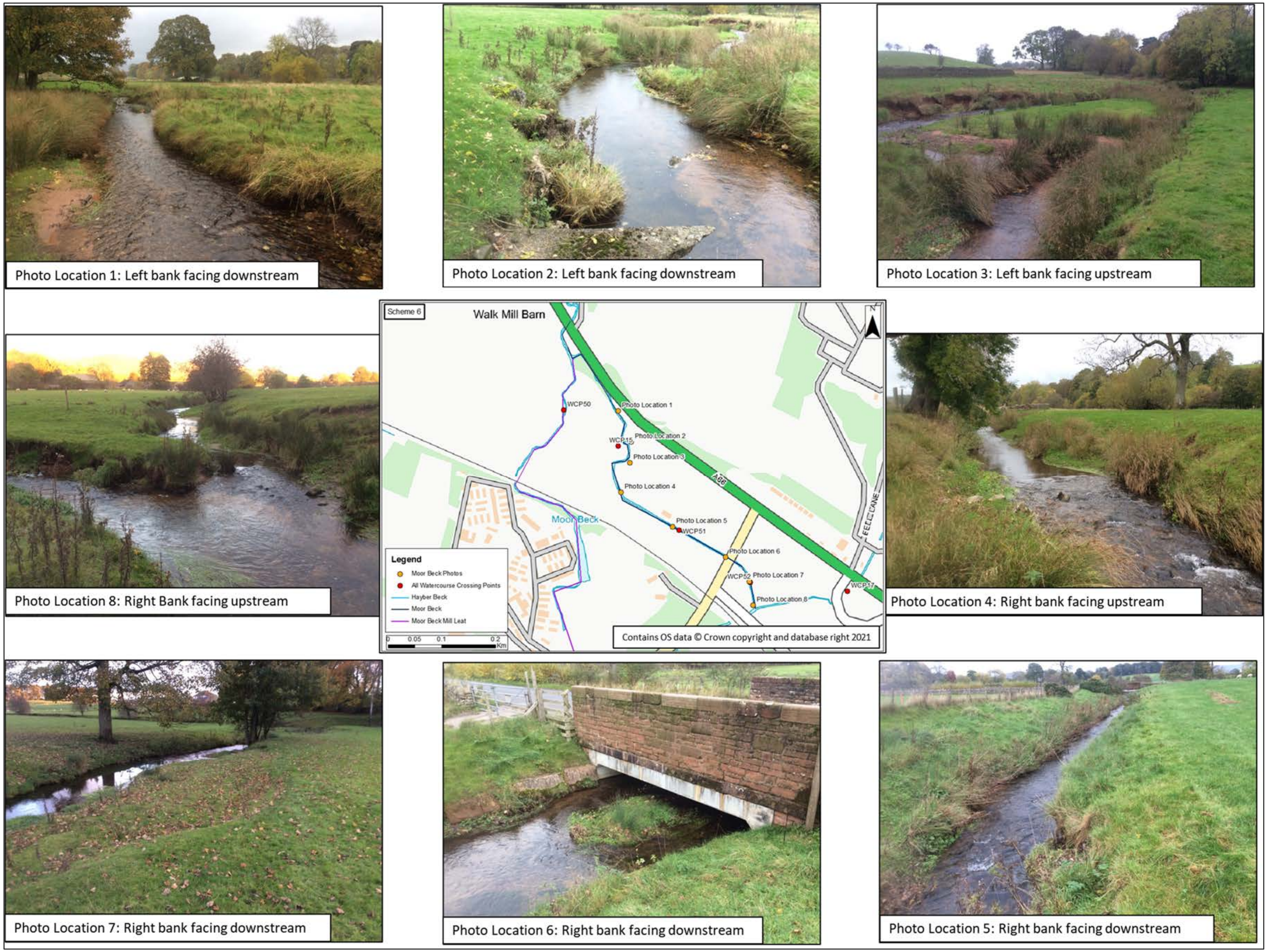

Plate A-39: WCP15, WCP51 (Moor Beck) site photograph locations

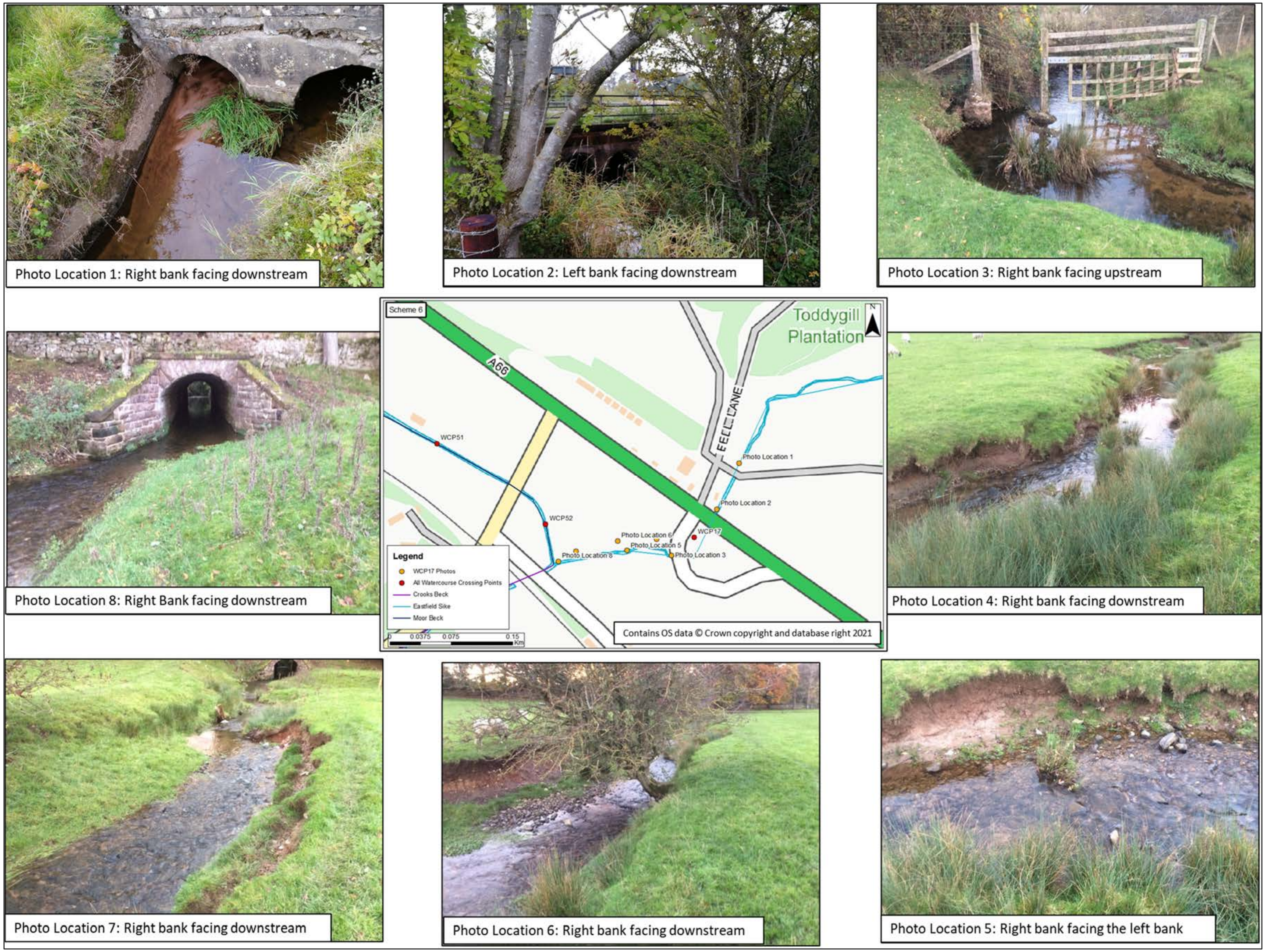

Plate A-40: WCP17 (Eastfield Sike) site photograph locations

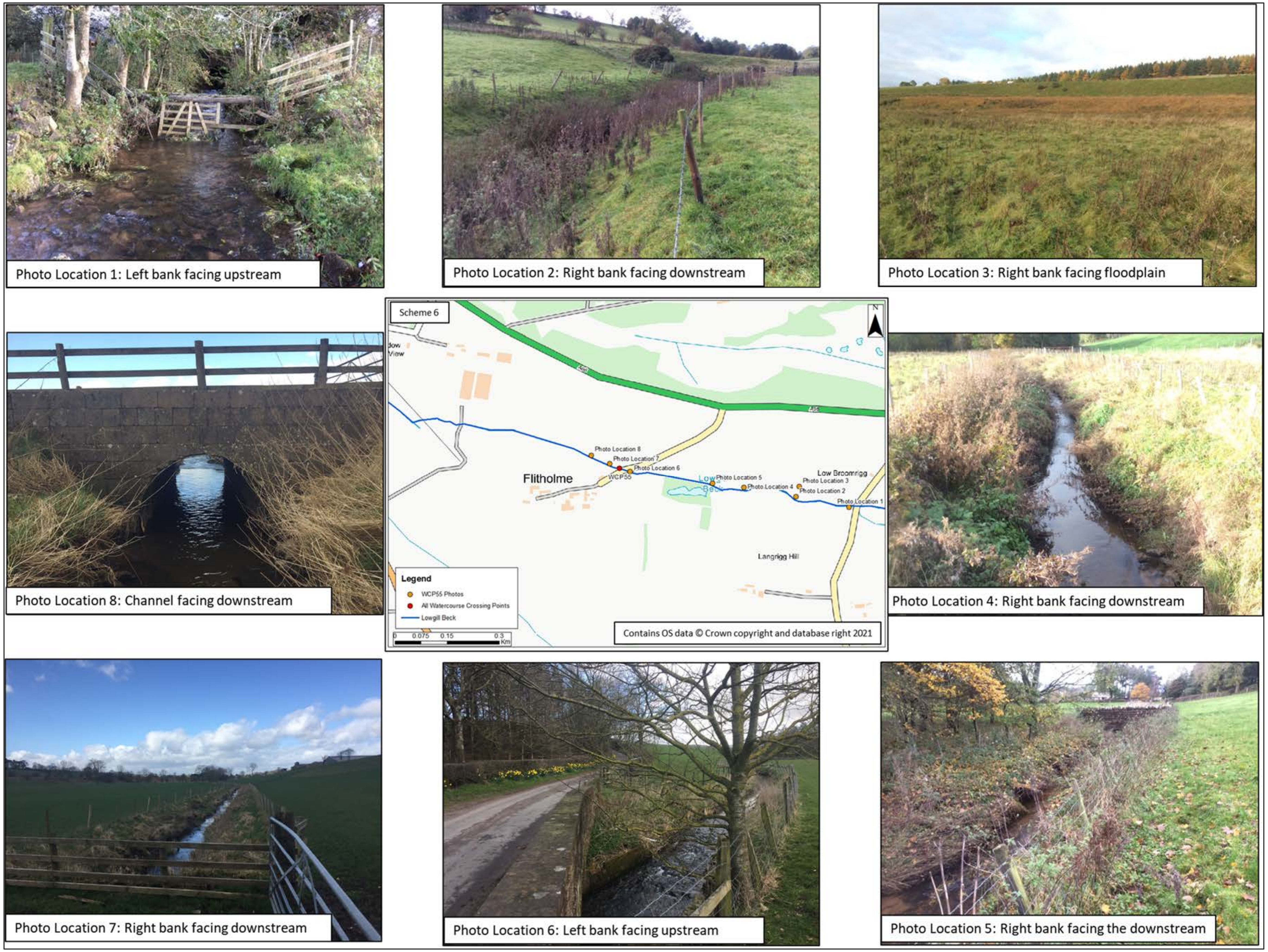

Plate A-41: WCP55 (Lowgill Beck) site photograph locations

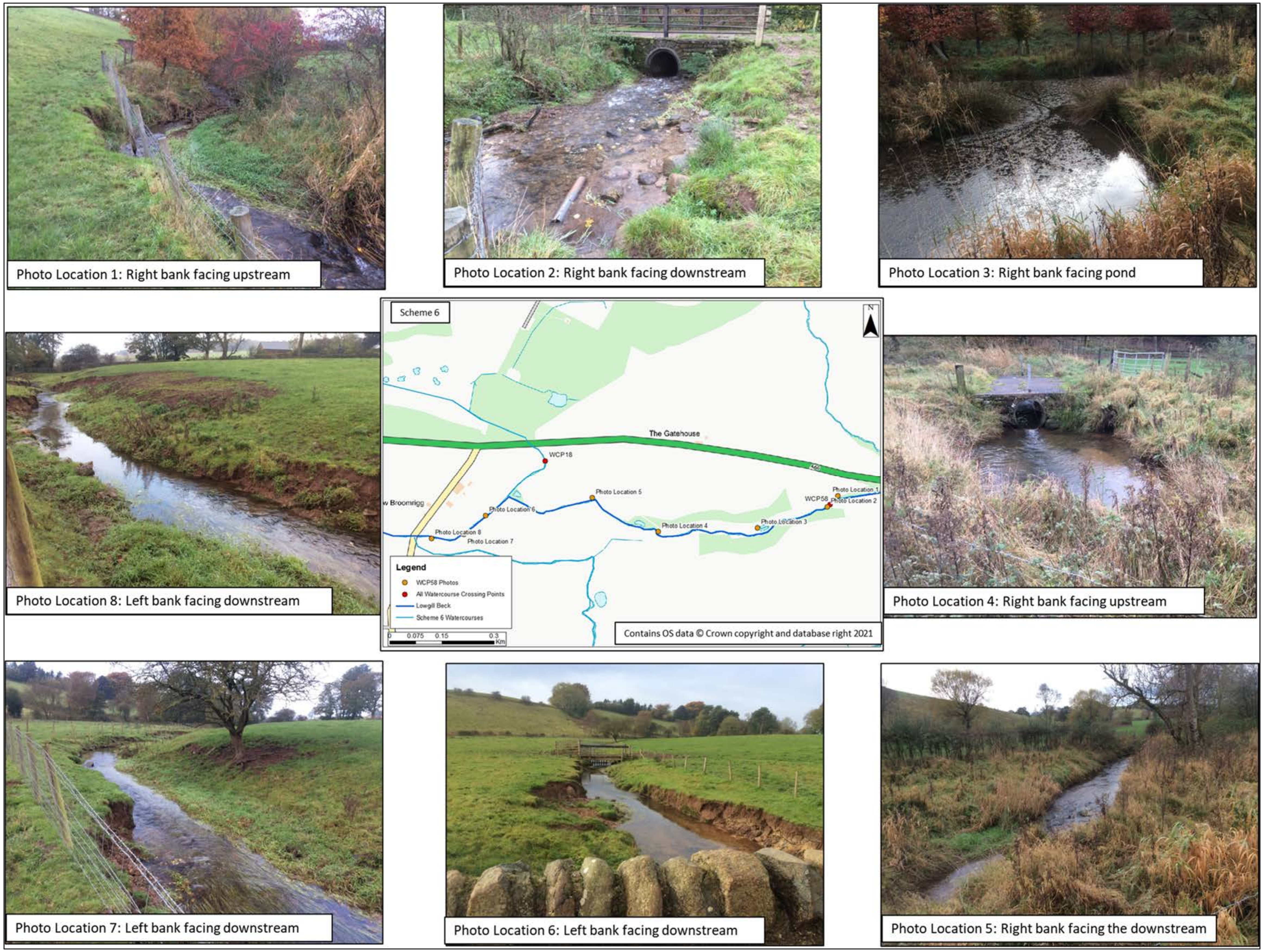

Plate A-42: WCP58(Lowgill Beck) site photograph locations

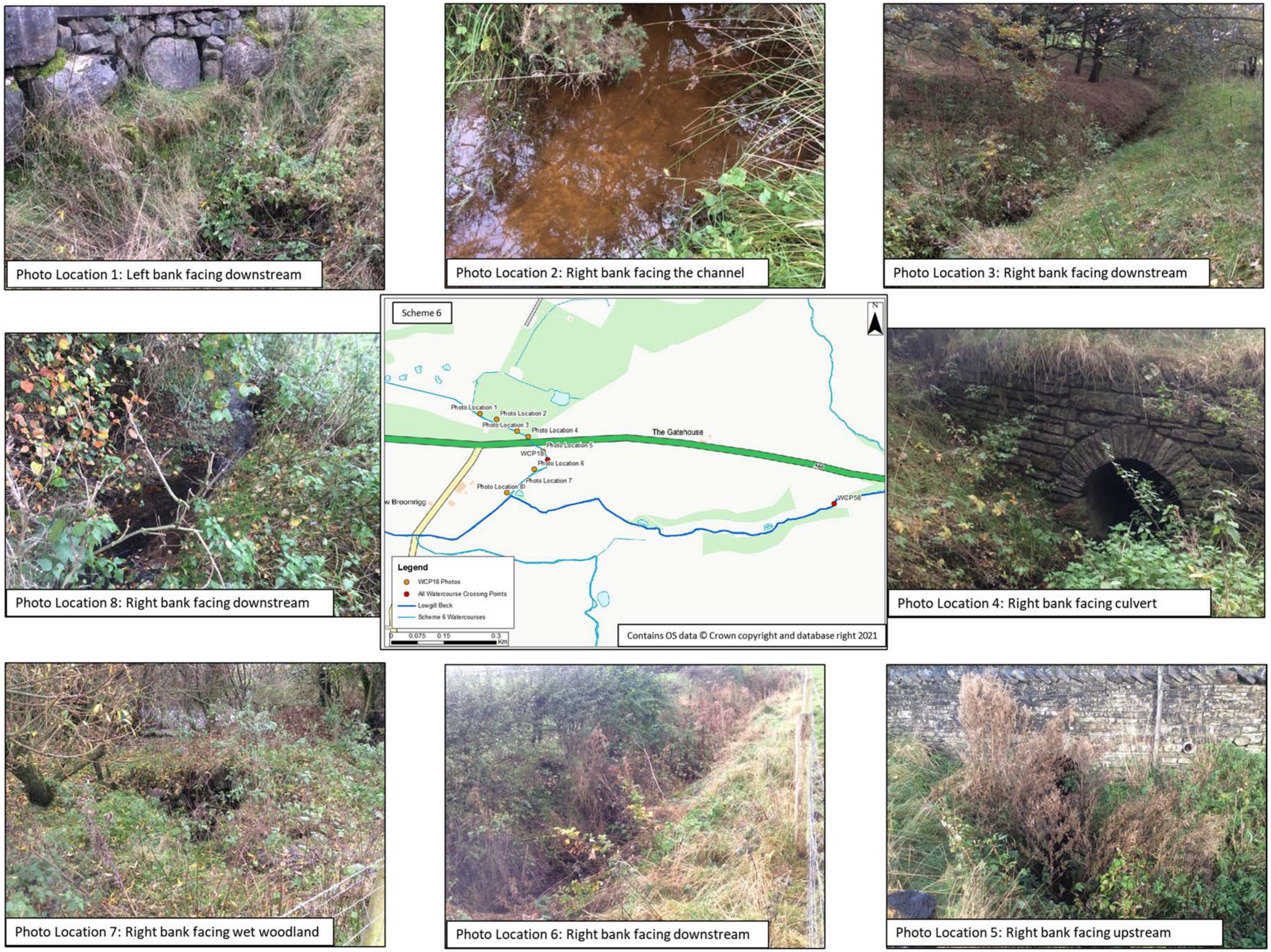

Plate A-43: WCP18 (Unnamed Tributary of the Lowgill Beck 6.1) site photograph locations

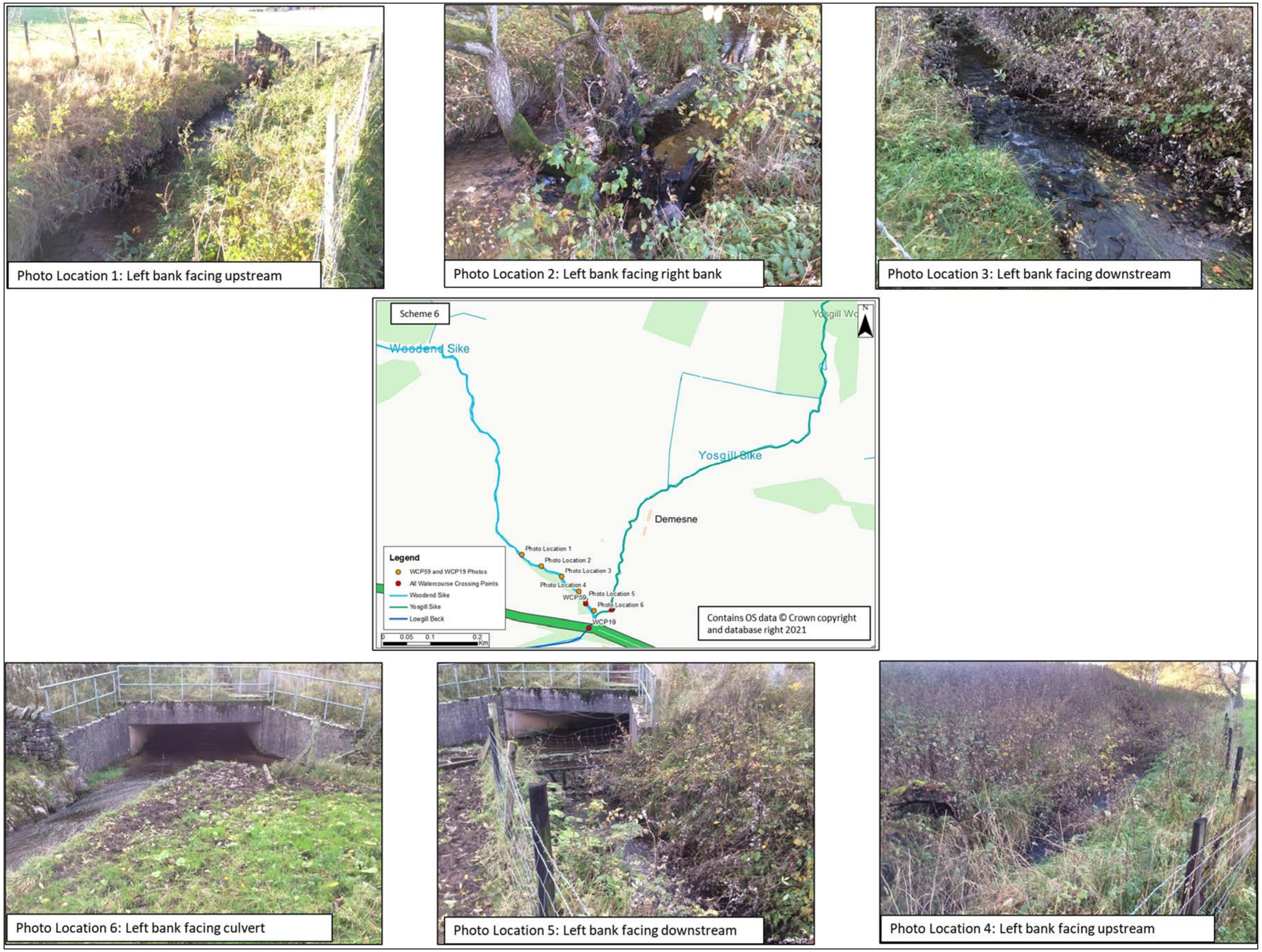

Plate A-44: CP59 and WCP19 (Woodend Sike) site photograph locations

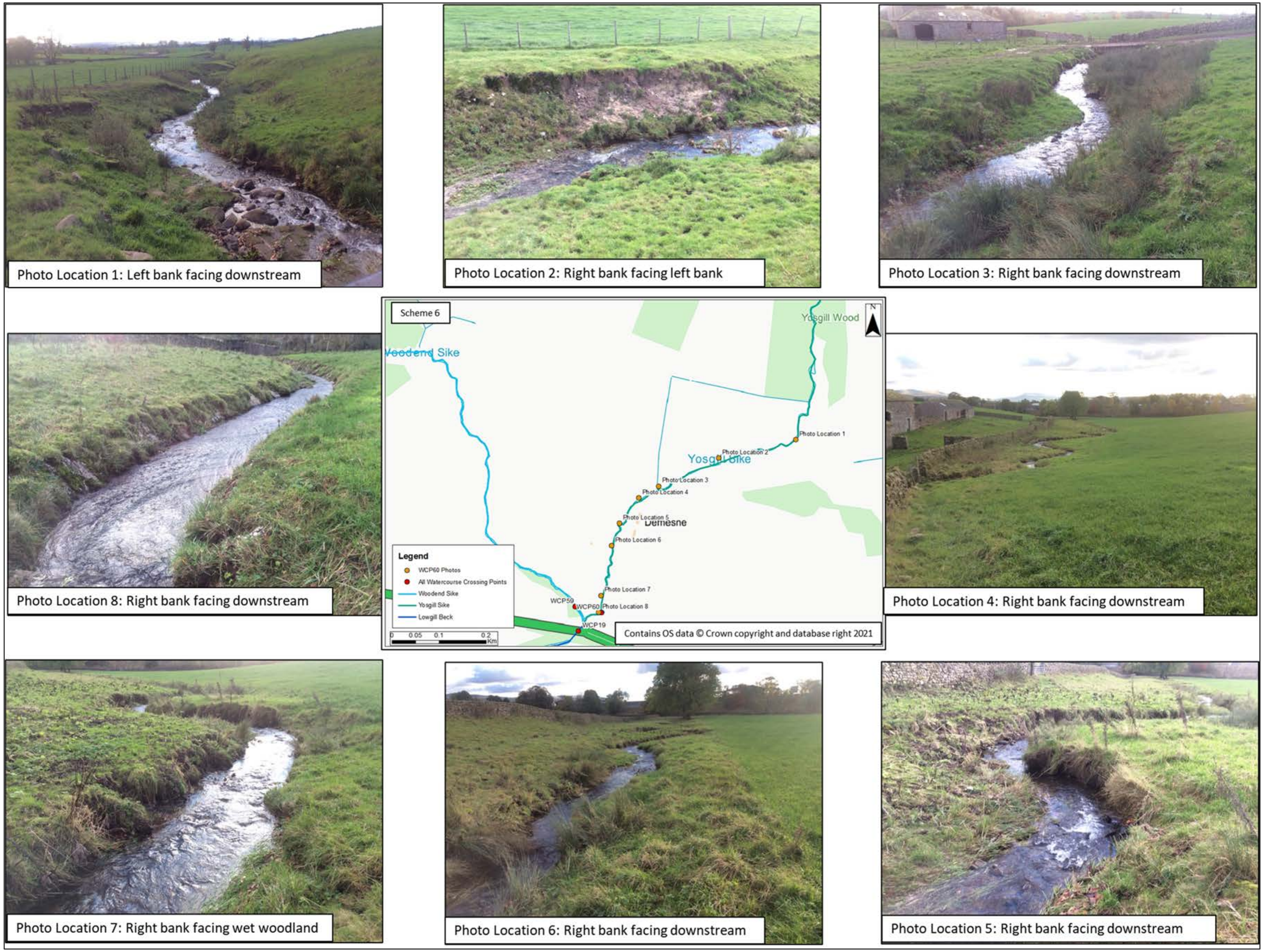

Plate A-45: WCP60 (Yosgill Sike) site photograph locations

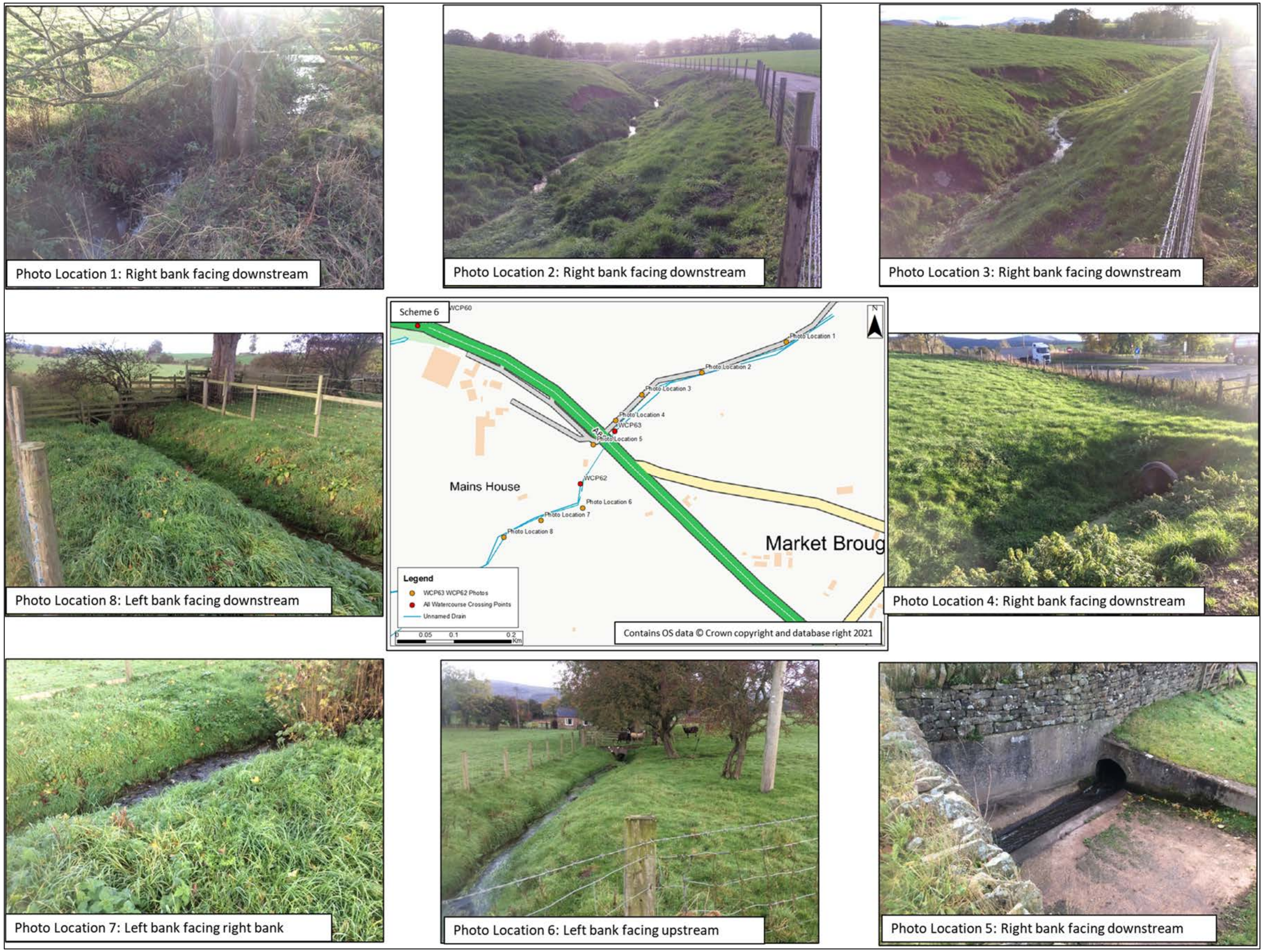

Plate A-46: WCP62 and WCP63 (Unnamed Lowgill Beck 6.7) site photograph locations

Photo Location 1: Left bank facing upstream at culvert

Photo Location 2: Right bank facing left bank

Photo Location 3: Left bank facing downstream

Photo Location 4: Left bank facing downstream

Plate A-47: WCP20 - (Unnamed Tributary of River Greta 7.3) site photograph locations


Photo Location 1: Facing upstream


Photo Location 2: Left bank facing upstream at A66 culvert

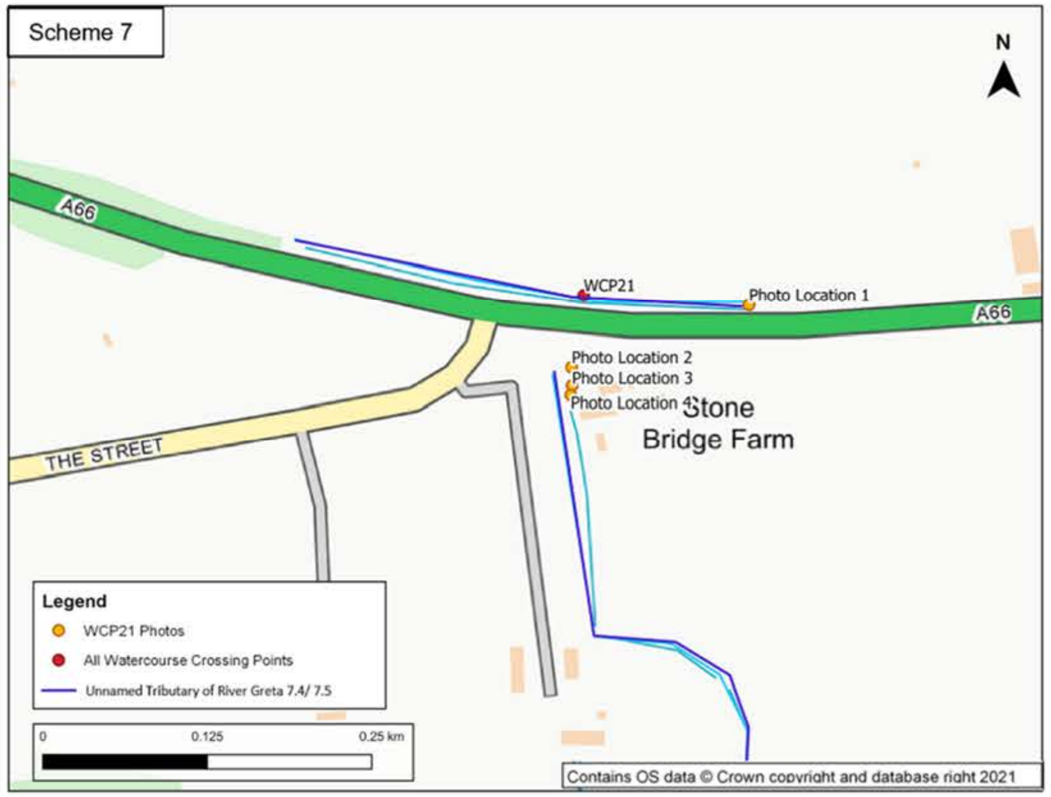


Photo Location 3: Facing upstream at culvert


Photo Location 4: Facing downstream at culvert

Plate A-48: WCP21 - (Unnamed Tributary of River Greta 7.4 and 7.5) site photograph locations


Photo Location 1: Right bank facing upstream


Photo Location 2: Right bank facing left bank


Photo Location 3: Left bank facing right bank


Photo Location 4: Left bank facing right bank

Plate A-49: WCP67 and WCP68 (Punder Gill) site photograph locations

Photo Location 1: Facing upstream

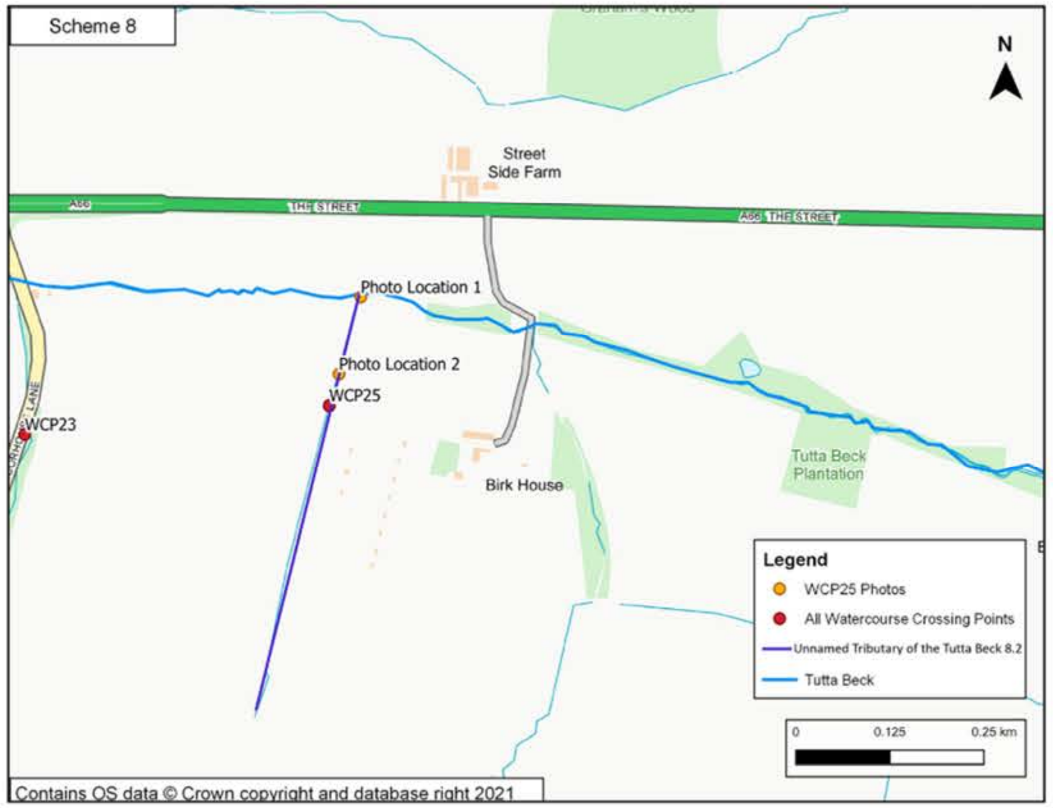

Photo Location 2: Left bank facing right bank

Plate A-50: WCP25 (Unnamed Tributary of Tutta Beck 8.2) site photograph locations

Photo Location 1: Left floodplain

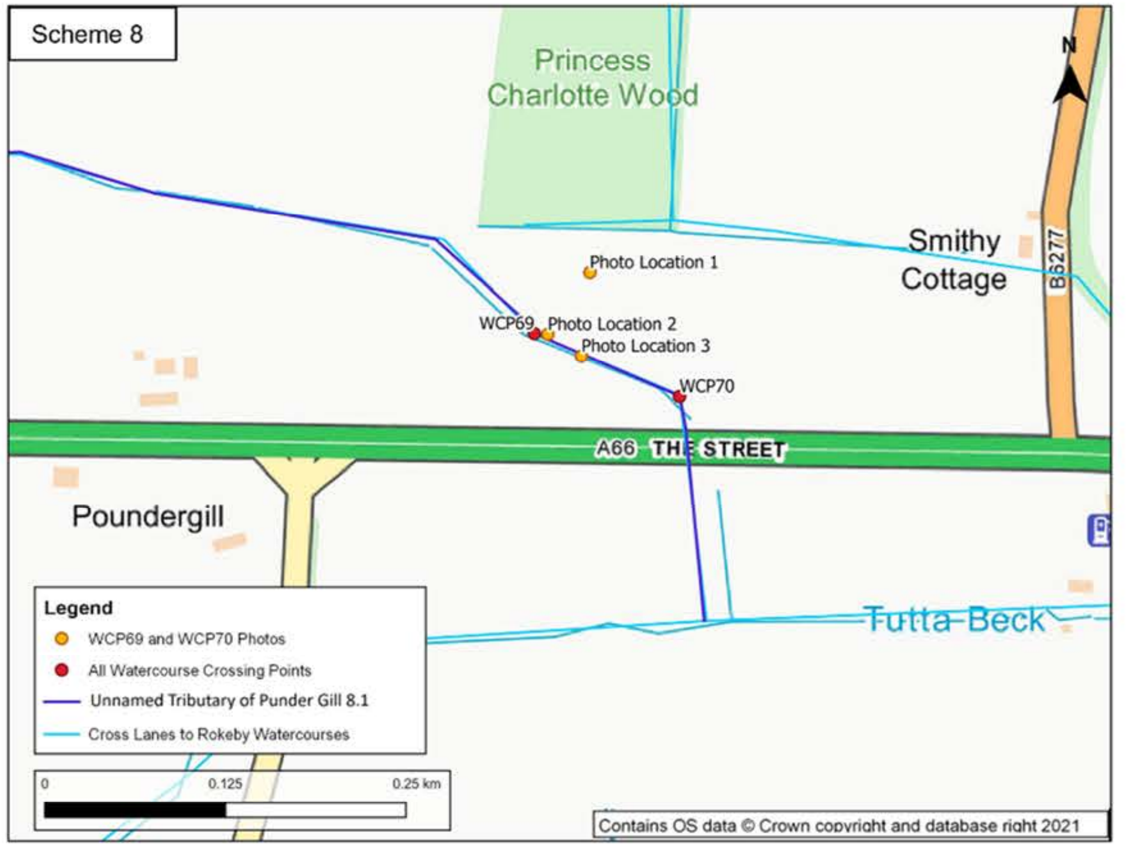

Photo Location 2: Left bank facing upstream

Photo Location 3: Left bank facing watercourse

Plate A-51: WCP69 and WCP70 (Unnamed Tributary of Punder Gill 8.1) site photograph locations

Photo Location 1A: Right bank facing upstream

Photo Location 2A: Left bank facing upstream

Photo Location 1B: Right bank facing upstream

Photo Location 2B: Right bank facing left bank

Plate A-52: WCP71 and WCP23 (Unnamed Tributary of Tutta Beck and Unnamed Tributary of Tutta Beck 8.1) site photograph locations

Photo Location 1: Left bank facing upstream towards the A66

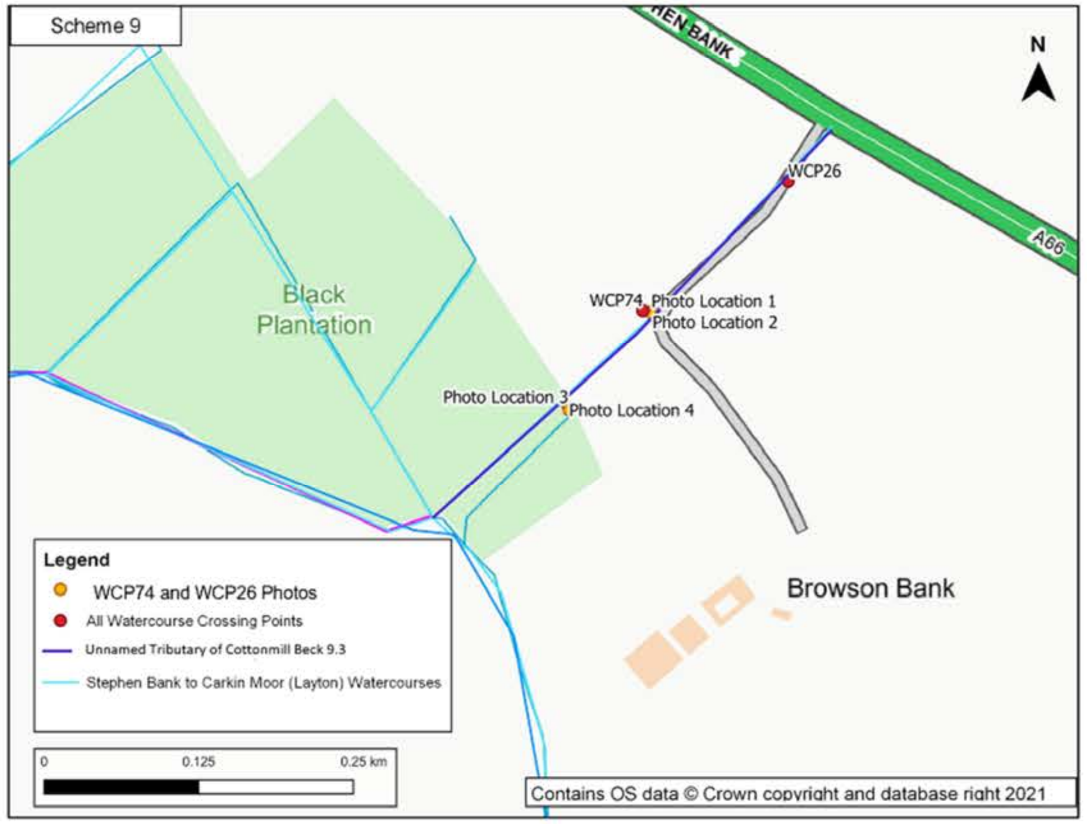

Photo Location 1: Left bank facing downstream at culvert

Photo Location 3: Left bank facing downstream

Photo Location 4: Left bank facing downstream

Plate A-53: WCP74 and WCP26 (Unnamed Tributary of Cottonmill Beck 9.3) site photograph locations

Photo Location 1: Facing Drain

Photo Location 2: Surrounding area

Plate A-54: WCP74 and WCP26 (Unnamed Tributary of Cottonmill Beck 9.3) site visit locations

Photo Location 1: Ephemeral valley facing upstream

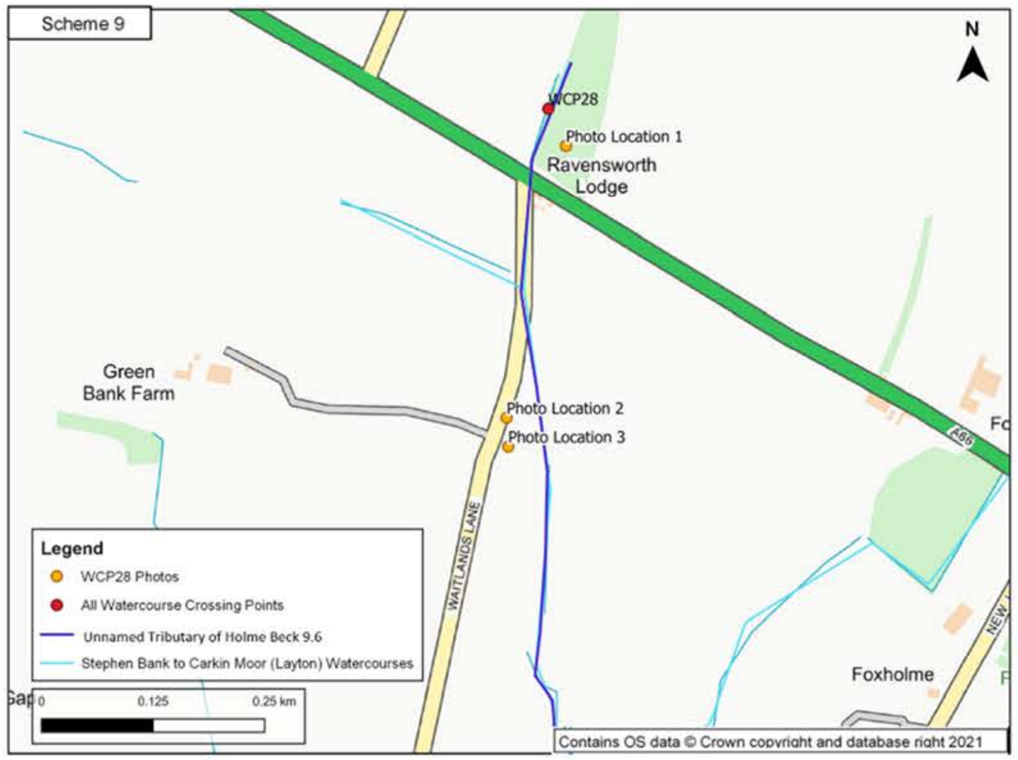

Photo Location 2: Right bank facing downstream

Photo Location 3: Facing downstream

Plate A-55:WCP28 (Unnamed Tributary of Holme Beck 9.6) site photograph locations

Photo Location 1: Right bank facing upstream

Photo Location 2: Right bank facing upstream

Photo Location 3: Left bank facing upstream

Photo Location 2: Right bank facing downstream culvert at A66

Plate A-56: WCP76 (Unnamed Tributary of Holme Beck 9.5) site photograph locations

Photo Location 1: Left bank facing downstream at culvert

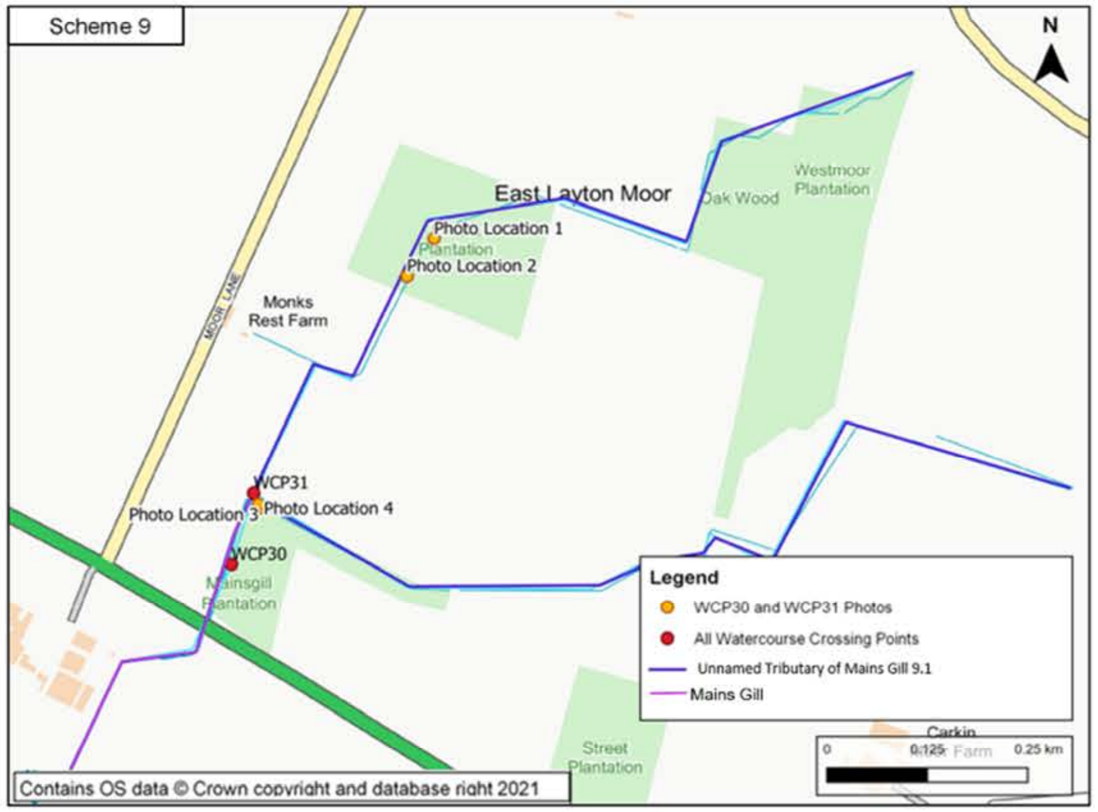

Photo Location 2: Right bank facing left bank

Photo Location 3: Bed substrate

Photo Location 4: Left bank facing upstream

Plate A-57: WCP31 and WCP30 (Unnamed Tributary of Mains Gill 9.1 and Mains Gill) site photograph locations


Photo Location 1: Facing floodplain

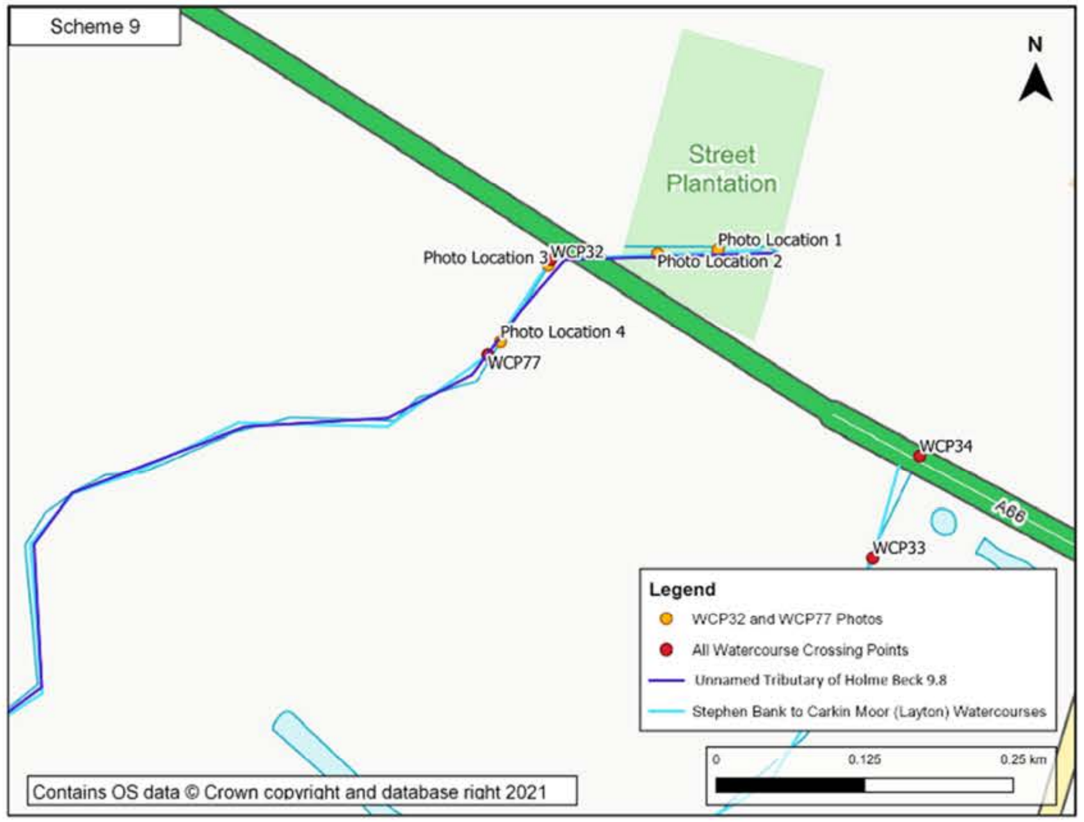


Photo Location 2: Right bank facing upstream


Photo Location 3: Facing upstream at culvert


Photo Location 4: Right bank facing downstream

Plate A-58: WCP32 and WCP77 (Unnamed Tributary of Holme Beck 9.8) site photograph locations

Photo Location 1: Left bank facing upstream towards A66

Photo Location 2: Left bank facing downstream

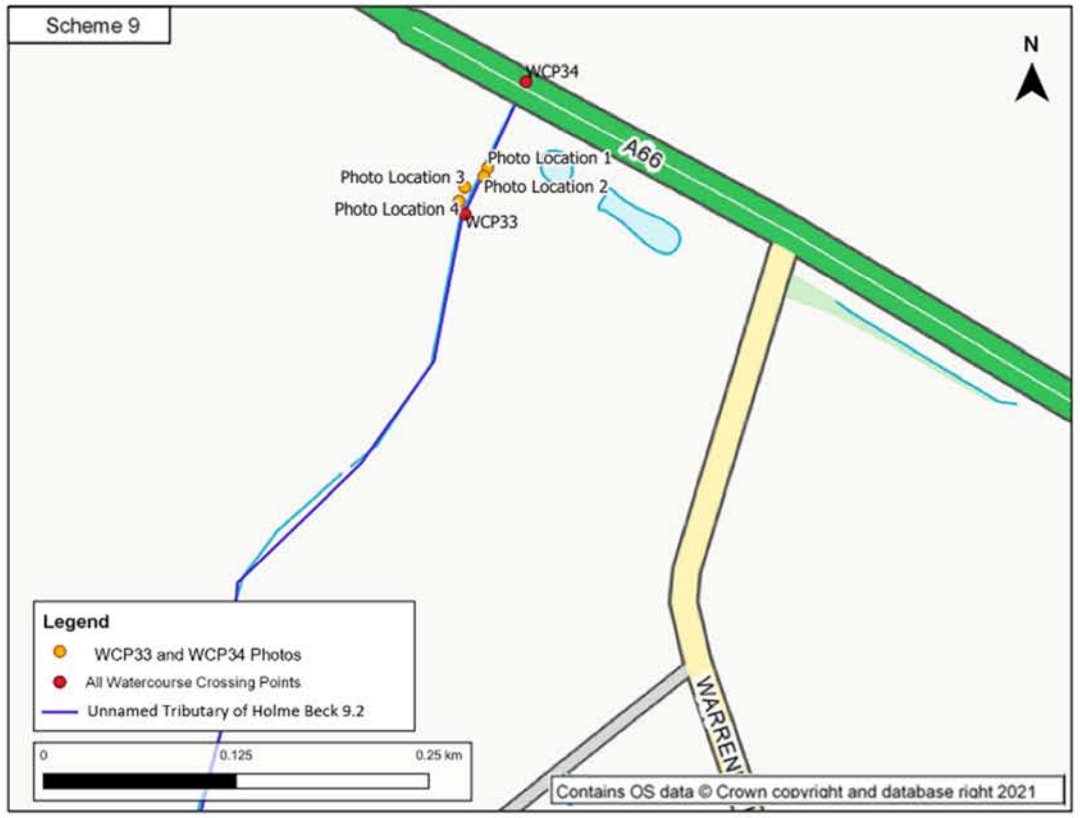

Photo Location 3: Right bank facing upstream towards A66

Photo Location 4: Right bank facing downstream

Plate A-59: WCP33 and WCP34 (Unnamed Tributary of Holme Beck 9.2) site photograph locations

Annex B: Hydromorphology Method Statement

Annex C: DMRB LA 113 - Road drainage and the water environment